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Th14a

Prepared January 11, 2017 for January 12, 2017 Hearing

To: Commissioners and Interested Persons

From: Susan Craig, Central Coast District Manager

Subject: **Additional hearing materials for Th14a**
Condition Compliance Oceano Dunes State Vehicular Recreation Area (ODSVRA) CDP Review

Where checked in the boxes below, this package includes additional materials related to the above-referenced hearing item as follows:

- [x] Staff report addendum
- [ ] Additional correspondence received in the time since the staff report was distributed
- [ ] Additional ex parte disclosures received in the time since the staff report was distributed
- [ ] Other:

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Th14a

Prepared January 11, 2017 for January 12, 2017 Hearing

To: Commissioners and Interested Persons

From: Dan Carl, Central Coast District Director
Susan Craig, Central Coast District Manager
Kevin Kahn, Central Coast District Supervisor
Yair Chaver, Central Coast Coastal Planner

Subject: STAFF REPORT ADDENDUM for Th14a
Oceano Dunes State Vehicular Recreation Area (ODSVRA) Review

Commission staff has received additional correspondence regarding the above-referenced matter in the time since the staff report was distributed (including over 1,000 pages of materials from Friends of Oceano Dunes, and new recommendations from NOAA Fisheries). The purpose of this addendum is to make changes to the staff recommendation.

Modify Condition 4
The first change is with respect to proposed condition 4 found on page 11 of the staff report. Currently, the condition is structured so that DPR and Commission staff would work together on a monitoring framework, which would be reviewed and approved by the Executive Director. Once that framework was approved, then DPR would monitor in accordance with the framework, and then would submit an annual monitoring report for review, with the first report due on December 31, 2018. Although staff still believes that that general structure makes sense (i.e., identify how monitoring is to occur, and then, once established, use that to monitor and then to develop annual monitoring reports), staff now believes that given the importance of that initial framework to ultimate monitoring and reporting success, it should be reviewed and approved by the Commission. In addition, through that review and approval, staff believes that it is also appropriate for the Commission to decide at that time on the time frame for ongoing reporting moving forward, whether annually or some different time frame. Staff believes that the change ultimately will make it easier and more transparent for DPR, including ensuring that all parties are clear on expectations. Thus, condition 4 on page 11 of the staff report is replaced with the following:

4. ***Monitoring and Reporting.*** *DPR and Commission staff shall work together to develop a monitoring framework that will be used by DPR to monitor Park use and management under the CDP, where the information collected pursuant to such monitoring will be provided to the Commission on an ongoing basis. At a minimum, the monitoring framework shall describe the structure, content, and methods for ongoing monitoring of public access and recreational uses, including vehicular recreation (accounting for attendance numbers,*

special events, and user types, etc.), and of dune resources, dune vegetation, and creek and wetlands resources (including but not limited to Arroyo Grande Creek) as well as sensitive species resources.

The framework must be detailed enough to identify the data that must be collected to document the effectiveness of Park management activities in achieving an appropriate balance between providing vehicular recreation and protecting dune and other coastal resources, including evaluating vehicular recreation and coastal resource trends, impacts, and issues facing Park operations, and to support recommendations for changes to Park management to better address any identified impacts. In addition to providing details regarding technical monitoring data collection methods, the framework shall also provide details about how such information will be synthesized and provided to the Commission in the form of ongoing (whether annual or some other duration) monitoring reports that include recommendations for changes as appropriate.

Within six months of the January 12, 2017 CDP re-review (i.e., by July 12, 2017), DPR shall submit the monitoring framework to the Executive Director. After DPR has submitted the framework, or in the event that it has not been submitted by July 12, 2017, the Executive Director shall schedule a Commission hearing to consider and approve the monitoring framework, including the ongoing monitoring report requirements. DPR shall then implement the Commission-approved monitoring framework and reporting.

In addition, although the specificity provided in the findings surrounding the framework and monitoring report are all still applicable to the new condition 4, text throughout the staff report is modified to reflect this change.

Add Condition 5

The second change is with respect to Arroyo Grande Creek crossings. As discussed in some detail in the staff report, the issue of vehicles driving through Arroyo Grande Creek has raised concerns, including by several Commissioners during the last review in 2015. Arroyo Grande Creek supports Steelhead trout and Tidewater goby, both of which are listed species under the Federal Endangered Species Act.[1] On January 10, 2017, staff received recommendations regarding the Arroyo Grande Creek crossing issue from NOAA Fisheries. In those recommendations, NOAA slightly tweaks DPR's operating guidelines with respect to the Creek. In staff's view, these recommendations are reasonable steps to address potential problems, and are similar to what DPR does now. Although staff continues to believe that such issues will need to be addressed through finalizing Park access and staging locations, in the interim staff recommends that the Commission require the changes recommended by NOAA fisheries. Thus, the staff report findings are amended to reflect this discussion and NOAA Fisheries recommendations, and condition 5 is added as follows:

5. Arroyo Grande Creek. *DPR shall implement the following Arroyo Grande Creek protection measures immediately to provide guidance for prohibiting Arroyo Grande Creek crossing within the Park to protect human life, prevent loss of property, protect the waterway from pollution caused by prolonged submersion of vehicles, and to protect designated critical*

[1] South Central Coast steelhead trout are listed as threatened, and tidewater goby are listed as endangered.

habitat for threatened south-central steelhead and other federally-listed aquatic species (including state-listed species):

(a) Creek Crossing Closure Protocol. *DPR shall prohibit creek crossings when one or more of the following conditions exist:*

1. *DPR observation of vehicles crossing the creek shows that vehicles are having difficulty crossing the creek and/or are becoming stuck. The length of observation before deciding on closure can be dictated by either one or a combination of the following:*

   - *The volume of vehicles experiencing difficulty while crossing.*
   - *The ease with which creek conditions disable one or several vehicles.*

2. *The creek banks are not visible because they are covered by overflowing water and are causing vehicles to drop into the creek unexpectedly and become disabled.*

3. *During the steelhead winter and spring migration season (for both adult and juvenile steelhead), including in particular during a large storm event, if complete hydrologic connectivity exists between Arroyo Grande Creek lagoon and the ocean with a water-column depth of approximately 1 foot or more, then DPR staff will survey the creek crossing for adult (smolts) steelhead attempting to access the lagoon (ocean) and will not allow crossing if present. Under those same conditions, vehicles are not permitted to cross during a storm event and up to 48 hours after the storm ceases or until connectivity conditions as described above no longer prevail.*

4. *The Creek water level reaches the quarter way point of vehicle hubcaps.*

(b) Duration of Closure. *Closure shall be in effect until conditions change to the point that experienced staff determines that the hazard to life, property, and/or natural resources likely no longer exists, and none of the closure conditions exist.*

(c) Ranger Role. *The decision to close or reopen the creek to vehicular crossing shall be made with concurrence of the on-duty supervising Ranger when possible.*

(d) Information Provided. *Upon entry into ODSVRA, visitors will be advised about the current creek crossing conditions. The creek crossing conditions will be posted at the Grand Avenue and Pier Avenue access points into the Park, and the Park FM radio station will carry a creek hazard advisory to make Park visitors aware of the Arroyo Grande Creek crossing conditions. Signage shall be provided at the Creek itself describing these measures, including identifying the fact that the days during and following winter and spring storms of significant magnitude, steelhead are either attempting to access the lagoon or leave the lagoon for ocean entry when there is complete hydrologic connectivity between these two habitats.*

(e) DPR Staff Protocol. *The following protocols apply to DPR staff when "On Duty" and using a State vehicle (and can be used to answer questions by the public regarding when DPR considers it appropriate to cross the creek):*

1. *Only 4x4 State vehicles will be driven across the creek when the water level or tide is questionable. Vehicles may be delayed from crossing when there is complete hydrologic connectivity between the lagoon and ocean with water levels one foot or greater during a storm event with heavy rainfall including up to 48-hours after the peak of the storm event assuming hydrologic connectivity remains as described above.*

2. *Only cross the creek if the water level is much lower than the axles or quarter-hubcaps of your vehicle.*

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Th14a

Prepared December 23, 2016 for January 12, 2017 Hearing

To: Commissioners and Interested Persons

From: Dan Carl, Central Coast District Director
Susan Craig, Central Coast District Manager
Kevin Kahn, Central Coast District Supervisor
Yair Chaver, Central Coast Coastal Planner

Subject: Review of the overall effectiveness of the methods being used to manage vehicle impacts in relation to coastal resources at the Oceano Dunes State Vehicular Recreation Area (ODSVRA) as required by coastal development permit (CDP) 4-82-300 as amended, in the Pismo Beach, Grover Beach, and Oceano Dunes areas of San Luis Obispo County

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EXECUTIVE SUMMARY

Background

Oceano Dunes State Vehicular Recreation Area (ODSVRA, or Park), formerly known as the Pismo Dunes State Vehicular Recreation Area, is located on the central California coast in southern San Luis Obispo County. ODSVRA is operated by the California Department of Parks and Recreation's (DPR) Off-Highway Motor Vehicle Division, and encompasses nearly 3,600 acres and approximately six linear miles of sandy beach. Approximately 1,500 acres (or almost 2 square miles) and three linear beach miles of ODSVRA are currently available for off-highway vehicle (OHV) use, and street-legal vehicles can range essentially along the entire 6-mile stretch. ODSVRA provides important public recreational access opportunities, including primarily the unique opportunity to recreationally drive vehicles and OHVs on a sandy shoreline and dune environment. These same sandy resources that make the Park attractive for OHV use also mean that the Park is a resource area, and it has been designated as an environmentally sensitive habitat area (ESHA) by the Coastal Commission, including in the San Luis Obispo County certified Local Coastal Program (LCP). In fact, ODSVRA is part of a larger and significant and sensitive ecological system, the Nipomo-Guadalupe dunes complex, that has been identified as critical habitat for the threatened Western snowy plover, and supports endangered species including the California least tern, Steelhead trout, and Tidewater goby. As a result, there has historically been a tension over how to strike an appropriate balance between providing for vehicular recreation and protecting dune and related coastal resources.

Since its inception the Coastal Commission has been an active partner with DPR, the County, and interested parties in addressing these competing interests, including both through the County's LCP certification process as well as the coastal permitting process. It is the latter process that gives rise to this review. Specifically, back in 1982 the Commission approved coastal development permit (CDP) 4-82-300 to allow DPR to construct fencing to delineate use and restricted areas, to establish interim Park access control (including the construction of two interim kiosks at the two interim entry points), to designate an interim OHV staging area (for off-loading of OHVs in the Park), and to address the carrying capacity of the Park by setting vehicle use limits. The terms and conditions of that CDP were designed to provide for continued study and ongoing adaptive management of the Park related to these core issues and consistent with the access, recreation, and other resource protection policies of the Coastal Act and the LCP. CDP 4-82-300 has been amended several times, the last of which occurred in 2001. Each of the amendments altered the terms and conditions of the CDP in a variety of ways, but the fundamental framework of the CDP today continues to be one of continually updating and improving on the understanding of the variety of issues at play at this Park as they relate to the CDP, and providing a means of addressing them through continued Commission review and DPR adaptive management based on a fundamental balancing between vehicular recreation and resource protection.

Most recently, the CDP was amended in 2001 to add the requirement that there be a Technical Review Team (TRT) to help study and provide recommendations on vehicular use and resource management within ODSVRA (per CDP amendment 4-82-300-A5). The TRT is an interagency/stakeholder group that is required to identify and prioritize research and management questions and projects, including to help define appropriate management techniques for protecting sensitive species, dune and related habitats, and water quality, and to help provide for a comprehensive, long-term monitoring and comparative analysis of the resource impacts associated with varying levels of OHV use, including with respect to peak-use attendance periods. In addition, the 2001 CDP amendment required the formation of a Scientific Subcommittee to help guide the TRT. The TRT is required to prepare annual reports for the review of the Park Superintendent and the Commission. Per the terms of the CDP, the Commission is supposed to annually review the reports, and, if the Commission finds that the TRT has been effective at managing vehicular impacts and protecting resources at the Park, the Commission can allow the TRT to continue to be the primary CDP implementation mechanism for that purpose for another year. If the Commission is not satisfied, it may, through this review process, institute alternative approaches to resource management or institute a new set of management measures. In short, the CDP, as amended, provides the Commission a vehicle for evaluating management measures at the Park in terms of addressing the overall balance between vehicular recreation and dune and related coastal resource protection through the CDP and its re-review.

Past Annual CDP Reviews

This ODSVRA review represents the eighth review in the 15 years since the 2001 amendment that established the TRT. Although the Commission performed six annual reviews between 2002 and 2007, the Commission did not undertake the CDP-identified review between the years 2008 and 2014. The reasons for this gap in reviews were many, but were primarily a result of limited Commission staff resources being instead allocated to other priorities and projects. However, it became clear more recently that it was an appropriate time to ensure timely and regular condition compliance through the review process, in part because interested parties had consistently and repeatedly requested same, and in part due to the changing context and emerging management issues at ODSVRA. In addition, the Commission itself changed members almost completely in the time since the review in 2007, and providing the current Commission this CDP review represented an opportunity to bring the Commission up to speed on the context, issues, and potential next steps related to overall Park management under the CDP.

As such, the Commission re-reviewed the CDP in a public hearing in February 2015. The hearing provided an overview of ODSVRA, described various requirements of the CDP, summarized some of the primary issues facing the Park, and included a discussion of potential next steps to address these issues, all with the goal of addressing the fundamental tension and balance associated with providing for the unique public recreational opportunity that the Park provides at the same time as respecting and protecting Park resources as directed by the CDP. The intent of that hearing was not for the Commission to take specific actions, but rather for the Commission to consider and discuss the various ODSVRA issues and potential next steps as a means of providing guidance to Parks moving forward. The primary issues and potential recommendations related to ODSVRA management discussed at that 2015 hearing were: 1) designation of permanent Park entrance and staging areas; 2) identification of appropriate use limits and carrying capacities, including related to special events; 3) identification of measures to address dust control and air quality, including completion of the pending CDP dust control application process; 4) resolution of ownership and use issues associated with the La Grande property; 5) implementation of a study that provides information on the effectiveness and impacts associated with a year-round exclosure for Western snowy plover and California least tern, including its impacts on recreational vehicular activity; 6) steps necessary to complete an HCP in conjunction with the United States Fish and Wildlife Service (USFWS); and 7) transitioning and/or restructuring the TRT function.

The Commission took public testimony and provided guidance on these key issues at the public hearing in 2015, with the goal of bringing forward potential changes for Commission action in the future designed to address ODSVRA management under the CDP, including potential changes to CDP terms and conditions to effect needed changes. It was also understood that Commission staff would continue to work closely with DPR staff, as well as interested groups and stakeholders, to further study the issues and collaborate on potential changes to address them. Since the 2015 hearing, Commission staff has had numerous discussions with interested parties, including the County and DPR. In particular, Commission and DPR staff have had three separate in-person meetings in Santa Cruz, numerous phone conference meetings, and frequent individual phone calls and emails to foster a collaborative dialogue and common understanding of the issues.[1] As such, this 2017 review builds off of the February 2015 hearing, including by updating the Commission on each of the issue areas previously discussed, as well as offering

[1] In addition, Commission and DPR staff collaborated to identify a Commission meeting that would provide DPR adequate time to prepare (ultimately agreeing on January 2017), and one that could be held local to the ODSVRA area (i.e., in this case, in San Luis Obispo) to facilitate local public participation. Commission staff also provided DPR with a blueprint of issues and potential next steps for this re-review in May 2016, and provided a draft of potential action items to DPR in November 2016 to help facilitate staff to staff discussion. Commission and DPR staff have been working closely from these materials over the course of 2016 to best develop and present action items for this 2017 hearing.

recommendations for Commission action to modify the CDP to address particular issues and to facilitate improved Park management and CDP implementation clarity moving forward.

Changes Recommended Through This CDP Review

Finalize Park access and staging system
As further discussed in this report, while certain issues remain pending and don't appear ripe for Commission action at this time through this re-review (including measures to reduce particulate matter emissions from riding activity that are covered by a separate CDP application that is pending, and the multi-decade efforts to develop a Habitat Conservation Plan (HCP) that has been met with many difficulties), other issues present relatively straightforward actions that can be taken at this time to better address Park management issues and CDP implementation clarity. Notably, one of the fundamental unresolved issues pursuant to the existing CDP is for the Commission to designate the manner in which Park vehicular access and OHV staging is provided. When the Commission approved the CDP in 1982, it designated <u>interim</u> access and staging locations, and required that DPR study and the Commission approve a permanent access and staging system no later than 18 months after certification of the County's Land Use Plan (LUP, which was certified in 1984). Although DPR has studied alternatives in the past, the Commission has never taken action to finalize Park access and staging through the CDP as required. As such, there have been repeated complaints about the interim nature of the existing system and its impacts (e.g., to non-vehicular recreational beach use and to Arroyo Grande Creek habitat resources), and this continues to be an over three-decade old unresolved issue (and a potential violation) of the CDP. As a means of resolving this critical issue moving forward, including how it relates to other pertinent issues associated with coastal resource issues under the CDP (e.g., Arroyo Grande Creek crossings, La Grande property use, etc.) staff is recommending that the Commission require a process for DPR to finalize Park access and staging, namely that Parks update its past studies and then staff will bring this item forward for a Commission action to resolve the access and staging issue under the CDP and to bring closure to the issues and the potential violation.

Transition the TRT
Another fundamental issue relates to the TRT process and its utility moving forward. There is general consensus, including between Commission and DPR staff, that the TRT process is no longer effective to carry out its intended purpose, and there is a need for a different method by which to address Park management and adaptation moving forward under the CDP. Specifically, the CDP has always functioned under the framework of an adaptive management program based on continuous study and evaluation of ongoing coastal resource impacts under the CDP, all with the ultimate intent of balancing vehicular use and resource protection. Originally, the Commission tasked DPR in 1982 with developing a carrying capacity study to provide a baseline for understanding appropriate levels of use and resource protection. Although DPR prepared such a study, it mostly evaluated use levels based on Park enforcement and management capability as opposed to resource protection relating to coastal resource impacts stemming from the regulated development. When the Commission re-reviewed the CDP in 2001, the TRT process was identified as the proxy to replace the CDP's carrying capacity requirements and provide this same function, including to provide the expertise to identify the appropriate balance between vehicular use and resource protection. At that time, the Commission identified <u>interim</u> Park vehicular use limits, and specified that the TRT would, among other things, be tasked with

developing and evaluating the scientific information necessary to support and/or change such limits. For the past 16 years, the TRT has grappled with a variety of Park management issues, but has not evaluated Park vehicle carrying capacity, and thus has never provided the information necessary to modify or support the interim use limits. Thus, the critical tool of providing an effective means for evaluating and identifying the appropriate level of Park use intensity and the appropriate complementary standards for resource protection has proven elusive, extending from the idea for the original carrying capacity study through the TRT. Staff firmly believes that the CDP needs to be modified to provide a more effective and clear method for such oversight.

Modify day-to-day Park operational requirements
Thus, staff is recommending that the Commission modify the CDP's structure in this regard to implement a different way of monitoring, assessing, and adapting Park management moving forward. First, staff is recommending deemphasizing a static use numbers methodology, and instead relying on DPR's expertise in more holistically managing Parks to ensure that levels of use are not overwhelming the resource, or leading to significant problems otherwise. DPR has indicted that it will still use the interim numbers as their baseline, but DPR would have more latitude to actually manage the resource on a day-to-day basis. CDP requirements (e.g., limiting riding to defined areas, prohibiting disallowed activities in non-riding dune areas, protecting archaeological resources, protecting natural resources, requiring ongoing monitoring and reporting, etc.) will continue to apply, both informing and providing a complementary and overarching coastal protection framework for DPR's day-to-day management decisions. With provisions to provide for adaptive dune protection measures, and with ongoing monitoring and reporting provisions (see also below), staff believes that this type of arrangement would provide a clear opportunity to ensure that DPR's day-to-day Park management efforts ensure that vehicular operations, including those related to special events, occur in a way that does not overburden the Park and surrounding areas (including in terms of controlling dust), or lead to significant adverse impacts on coastal resources, including dunes, sensitive species and their habitats, and public recreational access opportunities of all kinds (e.g., beach-going, camping, swimming, hiking, etc.).

Modify monitoring and reporting requirements
Second, staff is recommending that the Commission adopt an annual reporting mechanism to provide a means to evaluate operations on a regular basis, and to make changes as necessary to adapt to changing issues and potential management problems. Specifically, staff recommends that the Commission eliminate the CDP's TRT process and replace it with a yearly monitoring report program designed to better address ongoing Park issues and better foster appropriate adaptations. The changes recommended maintain the basic framework underscoring the TRT concept, in that there remains in place a comprehensive adaptive management component studying and implementing best practices for allowing for riding consistent with resource protection, including through consultation with affected parties, pertinent stakeholders, and other resource agencies. However, instead of channeling this process through the TRT function and a requisite Commission annual review, Parks would instead monitor and document the effectiveness of its management operations through an annual report, all with the overarching goal of achieving an appropriate balance between facilitating vehicular recreation and protecting dune and other coastal resources. The annual reporting mechanism would be preceded by a collaborative effort between DPR and Commission staff to identify monitoring parameters ahead

of time so it is clear to all parties what would be monitored and how, and what would ultimately be part of the annual reports.

The purpose of staff's recommended changes in this respect are to replace the CDP's current oversight structure embedded in the TRT and numeric use limits with one that empowers DPR to make typical park management decisions for the Park, but also in a manner that includes necessary oversight, feedback, and review of ongoing coastal resource impacts as embodied in the CDP as amended. This review necessarily involves the Coastal Commission, as it plays a unique role in ensuring the Park operations under the CDP are carried out in a manner that protects the various Coastal Act resources represented at ODSVRA, including the fundamental balancing between vehicular recreation and resource protection. The changes do not alter the fundamental framework underscoring Park management as one of adaptive management, including utilizing stakeholder input, but rather simplify and modify the governance structure with respect to the monitoring and adaptation framework moving forward. As modified, the CDP offers an improved process to ensure oversight and adaptive management of Park resources, all within the CDP's historic overarching intent of balancing vehicular use with coastal resource protection.

Conclusion

In summary, this report builds on the Commission's 2015 review, and provides a mechanism for the Commission to make changes to address and resolve the issues identified. Although specific issues are targeted, staff notes that nearly all of the issues identified in this report interrelate with one another, and all have significant impacts on the Park's public recreational access and sensitive habitat protection mandates. Thus, there is significant overlap (e.g., access and staging decisions also affect creek crossing and La Grande property use), and staff recognizes that these changes will require ongoing assessment of them moving forward, including as it relates to DPR's pending CDP application related to implementing dust control measures to address public health issues and their HCP. That said, staff believes that the recommended changes improve resource protection and CDP implementation clarity for all involved, and are a key step in the right direction. They also represent good planning and public policy. ODSVRA is a publicly-owned, nearly 3,600-acre piece of California's coast that supports important public recreational opportunities (including day-use visitors, OHV riders, campers, and hikers) as well as sensitive habitats, including coastal dunes and threatened and endangered species. Given the inherent competing interests and values associated with the Park, ODSVRA management is a complicated balancing of various uses and users, and will continue to be into the future. This report and its recommendations provide a mechanism for the Commission to improve the tools used in that process, and offers a platform to both further the discussion and to make positive CDP changes to help facilitate good Park management pursuant to the CDP.

Finally, given the difficulty of managing a heavily used area as large as ODSVRA with oftentimes conflicting management objectives (i.e., OHV recreation use and preservation/enhancement of sensitive dune habitat and protection of threatened and endangered species), it is not surprising that a number of Coastal Act and LCP violation cases and issues have occurred over the years. These cases and issues involve alleged violations of conditions of the base permit (CDP 4-82-300 as amended), alleged violations of the terms and conditions of emergency permits, and various other alleged violations involving unpermitted development activities. This enforcement history at ODSVRA is more fully explained in the "Violations at ODSVRA" section of this report. The alleged violations described herein will not be resolved if the Commission takes the actions recommended by staff for this item. However, the changes proposed as part of this re-review action will help inform the process established by CDP 4-82-300 and set the stage for future actions that could result in resolution of some of these alleged violations.

In any case, staff believes that there are a variety of violations associated with activities at ODSVRA, including with respect to the actions associated with the staff recommendation in this staff report, and it is undisputed that there are open violation cases related to some of these activities. Thus, consistent with Attorney General and Chief Counsel advice (see memos dated June 20, 2014 and August 1, 2014, respectfully), Commissioners should not engage in any *ex parte* communications related to those alleged violations.

Staff's recommended changes are discussed throughout the report, and are also collected in one place in Section II starting on page 9 of this report. The motion for the Commission to make the changes is found at the top of page 9.

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I. STAFF RECOMMENDATION

A. STAFF-RECOMMENDED MOTION AND RESOLUTION

Staff recommends that the Commission, after public hearing, **approve** the following changes to the coastal development permit. To implement this recommendation, staff recommends a **YES** vote on the following motion. Passage of this motion will result in approval of the changes as conditioned and adoption of the following resolution and findings. The motion passes only by affirmative vote of a majority of the Commissioners present.

> ***Motion:*** *I move that the Commission* ***approve*** *the proposed changes to coastal development permit number 4-82-300 as amended subject to the conditions set forth in the staff recommendation, and I recommend a* ***yes*** *vote.*
>
> ***Resolution to Approve changes:*** *The Commission hereby approves the changes to coastal development permit number 4-82-300 as amended and adopts the findings set forth below on grounds that the development, as amended and subject to conditions, will be in conformity with the policies of the certified San Luis Obispo County Local Coastal Program and the Coastal Act. Approval of the changes complies with the California Environmental Quality Act because either 1) feasible mitigation measures and/or alternatives have been incorporated to substantially lessen any significant adverse effects of the development on the environment, or 2) there are no further feasible mitigation measures or alternatives that would substantially lessen any significant adverse impacts of the development on the environment.*

B. STAFF-RECOMMENDED CONDITIONS[2]

Finalize Park Access

Provide a mechanism to finalize access and staging locations with respect to CDP requirements. This condition would modify language related to access into ODSVRA, including with respect to existing CDP special conditions 1 and 2 (see **Exhibit 4**).

1. **ODSVRA Access and Staging.** Within six months of the January 12, 2017 CDP re-review (i.e., by July 12, 2017), DPR shall submit an Access Study for Executive Director review and approval. The Access Study may be based upon DPR's past access analyses (i.e., including the 2006 Alternative Access Study Oceano Dunes State Vehicular Recreation Area. Produced by Condor Environmental Planning Services, Inc.), but shall be updated as necessary to reflect any pertinent new information (including with respect to habitat protections for sensitive species) that may affect its evaluations and/or conclusions. The purpose of the Access Study is to identify the environmentally-preferred final vehicle access and staging system for the Park, including through analysis of the environmental impacts and benefits (including with respect to dunes, habitats, creeks, beaches, neighborhoods, and community character) and feasibility associated with alternative access and staging locations, including evaluating the two existing access points as well as potential alternatives across the same set of analysis factors and levels of detail.

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[2] See **Exhibit 5** for the manner in which these conditions would modify the current conditions of CDP 4-82-300 as amended.

Following Executive Director approval of the Access Study, the Executive Director shall provide a recommendation to the Commission in an agendized public hearing for Commission action to approve the appropriate final access and staging system for the Park. Following Commission approval, the CDP shall be amended to reflect the Commission-approved access and staging system, and, if changes to the interim access and staging system are necessary to implement the approved access and staging system, DPR shall be required to submit materials to implement the Commission-approved access system plan as soon as possible, but no later than within one year of the Commission's approval of the final access and staging system, unless the Commission identifies a different time frame for implementation.

Managing Day-to-Day Operations

Eliminate numeric vehicle use limits, and instead provide for Park management (including for both daily operations and special events) pursuant to best resource and recreation management practices and existing CDP requirements. This condition would modify language related to ODSVRA use limits and use, including existing CDP special conditions 3 and 8 (i.e., special condition 3 of CDP amendment 4-82-300-A5) (see **Exhibit 4**).

2. **Managing Day-to-Day Operations.** Effective immediately (i.e., as of January 12, 2017), the existing interim vehicle use limits specified in CDP special conditions 3 and 8 (i.e., special condition 3 of CDP amendment 4-82-300-A5) shall be eliminated. The intent of this change is to allow DPR to manage the Park as it manages other Parks (consistent with providing ecologically balanced recreation, and through best resource and recreation management practices and adaptation on a daily basis) to protect the Park and its resources, as well as the surrounding area, from the effects of potential overuse. Such management will include limiting motorized recreation to defined areas, prohibiting activities as needed to protect natural resources (including sensitive species and habitats), protecting cultural and archaeological resources, and restoring lands. CDP requirements (e.g., limiting riding to defined areas, prohibiting disallowed activities in non-riding dune areas, protecting archaeological resources, requiring ongoing monitoring and reporting, etc.) will continue to apply, both informing and providing a complementary framework for DPR's day-to-day management decisions. The primary objective of DPR's day-to-day Park management efforts under the CDP shall be to ensure that vehicular operations, including those related to special events, occur in a way that does not overburden the Park and surrounding areas, that does not lead to significant adverse impacts on coastal resources, including dunes, sensitive species and their habitats, and public recreational access opportunities of all kinds (e.g., beach-going, camping, swimming, hiking, etc.), and that provides for maximum public safety, appropriate levels of use, and strong resource conservation.

Dune and Related Resource Fencing

Ensure that CDP requirements for dune fencing within the riding area protect significant vegetated areas and provide for maintaining protected vegetated dune areas within the riding area that are at least as large (or larger) in terms of acreage as is currently the case. This condition would modify language related protective dune fencing requirements, including existing CDP special condition 3 (see **Exhibit 4**).

3. **Dune Management and Fencing.** Fencing at the perimeter of the riding area shall be maintained in a manner designed to best protect dune and other resources in the non-riding area. Significant vegetated areas within the riding area shall be similarly fenced, and riding and other disallowed activities prohibited within these vegetated "island" areas. Such vegetated island fencing shall be adjusted on a regular basis to respond to shifting vegetation, including as necessary to fence off new areas of significant vegetation, with an emphasis and preference on adaptation designed to ensure larger and more contiguous vegetated dune and dune habitat areas, as opposed to smaller and more isolated vegetated dune fragments. In all cases, DPR shall ensure to the maximum feasible extent that the acreage of such vegetated islands in the riding area is not reduced from January 2017 levels (allowing for "islands" that become connected to the perimeter non-riding area through adaptation to be counted toward vegetated island acreage).

Monitoring and Management
Replace the Technical Review Team (TRT) process with a yearly monitoring report process designed to better address ongoing Park issues and better foster appropriate adaptations associated with the CDP. This condition would modify language related to the TRT, including with respect to existing CDP special condition 9 (i.e., special condition 4 of CDP amendment 4-82-300-A5) (see **Exhibit 4**).

4. **Annual Monitoring.** DPR shall prepare an annual monitoring report to be submitted for Executive Director review and written approval by December 31st of each year (with the first such report due by December 31, 2018). At a minimum, the report shall document the effectiveness of the previous year's Park management activities in achieving an appropriate balance between providing vehicular recreation and protecting dune and other coastal resources; it shall provide an evaluation of vehicular recreation and coastal resource trends, impacts, and issues facing Park operations; and it shall provide recommendations for changes to Park management to better address identified impacts.

   Within six months of the January 12, 2017 CDP re-review (i.e., by July 12, 2017), DPR shall provide for Executive Director review and approval a monitoring report framework. At a minimum, the framework shall describe the structure, content, and methods for ongoing monitoring of vehicular recreation and coastal resources at a sufficient level of detail to facilitate both comprehensive understanding of issues and development of appropriate adaptation measures through the annual monitoring report process.

   DPR shall prepare the annual monitoring report in accordance with the Executive Director-approved framework. Through approval of the annual monitoring report, the Executive Director may require changes to Park management that do not arise to the level of requiring a CDP amendment. The Executive Director-approved annual monitoring report shall be presented to the Commission as deemed appropriate by the Executive Director (including if any Executive Director-required changes require a CDP amendment) and/or if DPR and the Executive Director cannot resolve disputes over any Executive Director-required changes.

II. ODSVRA CDP BACKGROUND

A. PARK LOCATION AND DESCRIPTION

Oceano Dunes State Vehicular Recreation Area (ODSVRA, or Park), formerly known as Pismo Dunes State Vehicular Recreation Area, is located on the central California coast in southern San Luis Obispo County (see **Exhibit 1**). ODSVRA is part of the much larger 18-mile-long Guadalupe-Nipomo Dunes complex. The cities of Pismo Beach and Grover Beach form the northern border of the Park. To the east are the Phillips 66 Refinery (formerly ConocoPhillips Refinery), the unincorporated community of Oceano, and private lands that consist of dunes, coastal scrub, and agricultural fields. The southern border of the Park abuts the Guadalupe-Nipomo Dunes National Wildlife Refuge. ODSVRA is mostly owned and entirely operated by the California Department of Parks and Recreation's (DPR) Off-Highway Motor Vehicle Division. The Park is a very popular visitor destination, with annual attendance in the millions and annual vehicular use in the hundreds of thousands.[3]

ODSVRA encompasses 3,590 acres and includes approximately six linear miles of sandy beach. Approximately 1,500 acres of ODSVRA (or almost 2 square miles) and three miles of beach are currently available for off-highway vehicle (OHV) use, and street- legal vehicles can range essentially along the entire 6-mile stretch. The Park varies in width from a few hundred yards along its northerly boundaries near the Pismo Dunes Natural Preserve to up to three miles wide in places along its southerly portion. ODSVRA is divided into different regions based upon allowable activities, including areas set aside strictly for resource protection and preservation, street-legal vehicle use, and a combination of street-legal/OHV use. The separation and delineation of these specific areas was developed through past cooperative efforts of DPR, the Coastal Commission, San Luis Obispo County, and the California Department of Fish and Wildlife (CDFW). The entire ODSVRA area has been identified by the Commission as an environmentally sensitive habitat area (ESHA). Furthermore, the entire ODSVRA area is mapped as a sensitive resource area (i.e., which also constitutes ESHA per the LCP) in the San Luis Obispo County LCP (see **Exhibit 7**). ODSVRA is part of a significant and sensitive ecological system, the Nipomo-Guadalupe dunes complex. In addition, the area has been identified as critical habitat for the threatened Western snowy plover, and supports other sensitive species including the endangered California least tern, Steelhead trout, and Tidewater goby.

There are two interim[4] vehicular entry points for ODSVRA. The northernmost entrance (and the northern boundary for allowed vehicular use of any kind on the beach) is at West Grand Avenue

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[3] DPR's numbers from 2013 show that the Park was visited by an estimated 1.6 million persons, and that it was accessed by some 264,042 street-legal vehicles and 142,376 off-highway vehicles (over 400,000 vehicles all told).

[4] When the Commission approved CDP 4-82-300 in 1982, it designated interim access and staging locations, and required that DPR study and the Commission approve a permanent access and staging system no later than 18 months after certification of the County's Land Use Plan (LUP, which was certified in 1984), in part to allow consideration of potential alternatives for vehicular access and staging for the Park to avoid adverse impacts. Although DPR has studied alternatives in the past, the Commission has never taken action to finalize Park access and staging through the CDP and the LCP as required. As such, there have been repeated complaints about the interim nature of the existing system and its impacts (e.g., to non-vehicular recreational beach use and to Arroyo Grande Creek habitat resources), and this continues to be a three-decade old issue and potential violation of the CDP. See also violation finding below.

within the City of Grover Beach (see **Exhibit 2**). The second entrance is located about one mile south of West Grand Avenue at Pier Avenue within the unincorporated community of Oceano. From both entry points, street-legal vehicles then drive approximately two miles south along the lower beach towards the interim[5] OHV staging and allowed riding areas (see staging and riding areas noted on **Exhibit 2**). In order to get to the OHV staging and riding areas, vehicles must cross Arroyo Grande Creek where it empties into the Pacific Ocean, approximately one-half mile south of Pier Avenue. Arroyo Grande Creek supports Steelhead trout and Tidewater goby, both of which are listed species under the Federal Endangered Species Act.[6] Typically, the only time the Creek has significant flows across the beach is during the rainy season. Other times of the year, it tends to terminate in a lagoon inland of the immediate shoreline. However, when it is flowing, the Creek presents an obstacle to vehicular travel, including to get to the OHV riding and staging areas to the south, and has been the site of problems in this respect as vehicles attempt to navigate through and across the flowing Creek to access the riding areas further south.

Continuing south, vehicles reach the interim OHV staging area, which is one-half mile south of Arroyo Grande Creek at Post 2[7] (see location of marker posts in **Exhibit 2**). This staging area is the designated area where OHVs that have been trailered in by other vehicles can be off-loaded. OHVs may be off-loaded in other areas south of the staging area, but the staging area at Post 2 is the location where OHV use is first allowed as one heads south from the interim entrance points. OHV riding is allowed in most of the Park area south of the staging area, and street- legal vehicles can range essentially along the entire 6-mile stretch of the ODSVRA. The riding area consists of the sandy beach located between the staging area to the fencing constructed north of Oso Flaco Lake, a distance of approximately three miles, as well as the back dunes from approximately Post 4 to Post 8. The back dunes extend in some areas almost two miles inland. Included in the riding area between approximately Post 4 and Post 7 is the La Grande property (see **Exhibit 2**). The La Grande property occupies 584 acres of the Park (or about 40% of the overall riding area), and this area is owned by San Luis Obispo County and currently leased to DPR on a month-to-month basis.

A portion of the Park is closed to OHV use for 7 months out of the year for habitat purposes. Specifically, DPR installs and maintains fencing restricting OHV use to protect nesting California least terns and Western snowy plovers (both of which are listed species)[8] along the shoreline and covering an area of approximately 300 acres from March 1st to September 30th each year. This seasonal nesting exclosure area is referred to as the Southern Exclosure (see **Exhibit 2**). Approximately 250 acres of the exclosure is within an area that is otherwise open to OHV use the other 5 months of the year, extending from approximately Post 6 south to Post 8 to the Oso Flaco Lake area. Although the basic configuration of the Southern Exclosure has remained relatively consistent since 2004, changes in dune topography and public safety issues impact the placement of the eastern fence, resulting in small variations in acreage from year to year.

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5 Id (the staging areas are also interim in the same way as the access areas are interim under CDP 4-82-300).

6 South Central Coast steelhead trout are listed as threatened, and tidewater goby are listed as endangered.

7 The marker posts are located approximately one-half mile apart and are used as riding reference points within ODSVRA.

8 California least tern are listed as an endangered species under both the Federal and State Endangered Species Acts, and Western snowy plover are federally-listed as threatened.

Just south of the Southern Exclosure area and the open riding area is the Oso Flaco Lake area (see **Exhibit 2**). The Oso Flaco Lake area was historically open to riding prior to the creation of the ODSVRA, but was closed off to OHV use due to severe resource degradation in 1982. This area now supports a healthy system of distinct habitats, including freshwater lakes and marsh, a significant riparian system, dune vegetation, and coastal sage scrub. A pedestrian-only access point to the Oso Flaco Lake area is located at the end of Oso Flaco Lake Road.

See site location maps, ODSVRA maps and figures, and photos of the ODSVRA area in **Exhibits 1, 2, and 3** respectively. In addition, DPR also provides access to an interactive virtual tour of the site that is available at http://www.regal360.com/clients/ohv/index.html.

B. PUBLIC RESOURCES CODE SECTION 5090

The statute authorizing Off-Highway Vehicle Recreation Areas (Public Resources Code (PRC) Section 5090 et seq.) was adopted in 1982. The statute recognized the increasing popularity of OHV use and the importance of such use but also recognized that "[t]he indiscriminate and uncontrolled use of those vehicles may have a deleterious impact on the environment, wildlife habitats, native wildlife, and native flora" (PRC Section 5090.02(3)). Thus this enabling legislation provides for a balancing of recreational and environmental factors, mandates an Off-Highway Vehicle Commission composed of a variety of interest groups to oversee designated vehicular recreation areas, and specifically allocates funding to both recreation and conservation projects. The original legislation identified six then existing OHV areas, including ODSVRA (then known as Pismo Dunes). Land proposed for OHV facilities was selected primarily on the basis of its ability to provide satisfactory recreational opportunities for OHV enthusiasts. Natural and cultural elements of the selected lands were considered secondary, and it was identified that they could be managed or modified to adequately protect such resources while also providing for recreational use.

Subsequent PRC Section 5090 amendments in 1987 were aimed at balancing recreational use with environmental considerations. For example, Section 5090.35 was greatly expanded to require DPR's OHV Division to adopt erosion standards adequate to provide for the successful rehabilitation of degraded areas, to prepare an inventory of wildlife habitats, to develop a wildlife protection program, to monitor impacts on soils and habitat, to close and rehabilitate degraded areas, and to fund only those programs that comply with the state conservation standards for erosion control and wildlife habitat protection. The OHV Commission was also then authorized to recommend that sites with natural or cultural values be set aside as sensitive areas and managed in accordance with regulations applicable to other preserves in the state system, including that they could be fenced off if necessary to protect them from OHV activities.

C. SAN LUIS OBISPO COUNTY LOCAL COASTAL PROGRAM

The San Luis Obispo County Local Coastal Program (LCP) Land Use Plan (LUP) was originally adopted by the County in 1981. At that time, the County's proposed LUP proposed to close the entire Park to vehicle use and camping until a management plan was submitted by DPR and approved by the County. The identified management plan was intended to be the vehicle to address resource management in relation to vehicle impacts at the Park. However, in considering the proposed LUP, the South Central Regional Coastal Commission[9] found that the LUP's proposed policies and standards related to OHV use within the Pismo Dunes/Oso Flaco area raised a substantial issue with regard to their effect on ESHA, and thus the LUP was not approved at that time. In denying the LUP, a main area of Commission concern was appropriately locating Park access points and OHV staging areas in order to reduce negative resource impacts, including with respect to impacts on non-vehicular recreational beach use in the more northerly part of the Park, and with respect to concerns about Arroyo Grande Creek habitat resources. At the LUP hearing, the Commission directed Commission staff, the County, and DPR to develop a solution for the access and staging area issue. Thereafter, the agencies worked together with other interested parties to evaluate and develop alternative strategies that would allow for continued OHV and camping uses, while also providing appropriate levels of resource protection, including in relation to access entrances into the Park and associated staging locations. The parties agreed that the proper vehicle to address these issues was via the CDP process in order to ensure that these Park management concerns would not delay the rest of LUP certification (the LUP was subsequently certified in 1984, and the overall LCP certified in 1988). The results of the joint Commission, County, and DPR effort to address the competing vehicular recreation and resource protection objectives are reflected in CDP 4-82-300.

D. Coastal Development Permit 4-82-300

CDP 4-82-300

On June 17, 1982, prior to certification of the LCP LUP, the Commission approved CDP 4-82-300 to allow DPR to construct fencing to delineate use and restricted areas, to establish interim Park access control (via the construction of two interim kiosks at entry locations), to designate an interim OHV staging area, and to address the carrying capacity of the Park by setting vehicle use limits. The fencing, interim staging and access areas, and use limits were permitted as the initial phase of what was seen as a longer term program to manage OHV use within the ODSVRA consistent with the access, recreation, and resource protection policies of the Coastal Act.

CDP 4-82-300 Special Condition 2 (see **Exhibits 4**)[10] required the temporary access kiosks to be located at West Grand Avenue in Grover Beach and Pier Avenue in Oceano (see locations in **Exhibit 2**). Per Special Condition 3, the kiosks were to be manned with DPR representatives giving OHV users information about the new CDP conditions, including restrictions on riding within fenced-off areas, prohibitions on riding within the Oso Flaco Lake area, and restrictions on riding within any other areas designated as private property or that were vegetated, regardless of fencing or signage. Special Condition 3(c) also established that only street-legal vehicles were allowed to drive on the section of beach from these access entrance points south to the start of the Sand Highway,[11] and designated the area south from the start of the Sand Highway to the

[9] As part of Proposition 20 (The Coastal Initiative of 1972) and the Coastal Act (of 1976), there were originally six separate regional Coastal Commissions in addition to a statewide Commission. The regional Commissions were ultimately phased out to leave just one statewide Coastal Commission in 1981.

[10] **Exhibit 4** shows the conditions of CDP 4-82-300 and its five amendments in order, including in strikethrough and underline format to show the ways in which subsequent amendments altered previous conditions. **Exhibit 4** includes a clean copy of the conditions of the CDP as amended through and including 4-82-300-A5 at the end of the exhibit starting on page 38. These latter conditions are the conditions currently in effect.

[11] The Sand Highway is a series of marker posts that head inland from the beach to the backdune area and then run south through the backdunes. The purpose of the Sand Highway is to provide reference points for vehicles traveling through the back dunes.

fencing north of Oso Flaco Creek for OHV use. Special Condition 3(d) required that the number of OHVs allowed at any given time within ODSVRA must be limited to a specified number of users, and directed DPR, San Luis Obispo County, and the Commission's Executive Director to consult with each other to identify the appropriate number of users. Per Condition 3(b), camping units,[12] defined as one camper vehicle per camping unit, were also restricted to a maximum number of 500 units per night to be reserved through the State Park Reservation System.

As part of the CDP 4-82-300 decision, the Commission denied DPR's proposal to place a third interim access kiosk and entrance at the causeway across Oso Flaco Lake. It was determined that, while the entire dune and related habitat complex is unique and valuable, the biological significance of the Oso Flaco Lake area is comprised of an interrelated system of distinct habitats that needed immediate protection. Historic OHV use in these areas had removed the natural vegetation and resulted in the lakes beginning to fill up with sand from the destabilized dunes. The Commission's denial of OHV use in this area also notes that policing and enforcing appropriate use of this third entrance point would have required additional commitments of limited DPR personnel needed at the other, more popular entrance locations.

Special Condition 3(e) also required the placement of approximately 35,000 linear feet (almost seven miles) of fencing around a subset of sensitive resource areas within ODSVRA to protect them from further degradation due to OHV use. The areas that were left open to riding were the open sand sheets that were generally devoid of vegetation at that time, either as a result of OHV use or otherwise. The fencing was to be placed along the boundary of ODSVRA, along the eastern (i.e., inland) boundary of the Sand Highway, and around vegetated islands and archeological resources located within ODSVRA open riding areas (see **Exhibit 2**). Special Condition 4 required a dune restoration program to help restore dune vegetation and habitat within the now non-riding and fenced-off areas that had been degraded over time.

Finally, Special Condition 1(a) established a temporary OHV staging area on the beach just north of the beginning of the Sand Highway. The staging area's location was intended to be interim until a permanent location was identified. Pursuant to the terms of Special Condition 1(b), and reflecting the importance the Commission placed on establishing a permanent staging area, a failure to establish and construct a permanent staging area within three years of the date of certification of the County's LUP or LCP would result in the CDP's review, and modification of use parameters at ODSVRA by the County or the Commission. Furthermore, Special Condition 6 required that, until a permanent staging area is operational, a formal review of the effectiveness of the conditions of the CDP shall take place annually, undertaken by the Commission, County, DPR, CDFW, and the community of Oceano. Special Condition 6 also states that, if after each annual review pursuant to this condition, or after the three-year review required pursuant to Special Condition 1(b), it is found that OHV use is not occurring in a manner which protects environmentally sensitive habitats and adjacent community values consistent with the County's LUP, then OHV use may be further limited.

Essentially, CDP 4-82-300 initiated what was seen as a long-term program to manage OHV use and resource protection under the Coastal Act through the CDP given that OHV use includes

[12] ODSVRA does not include defined camping spaces, rather camps may be established anywhere within that portion of the Park open to OHV use.

ongoing and evolving impacts to coastal resources. The permit created an annual review process to evaluate the effectiveness of DPR in managing recreational use in tandem with resource protection. Based on the effectiveness of DPR in managing ODSVRA in this way, OHV use within the ODSVRA could be modified as required to further protect ODSVRA resources pursuant to the terms and conditions of the CDP. Conversely, if ODSVRA resources and OHV uses were found to have been effectively managed to provide an appropriate balance, OHV use could also be increased to a level not to exceed the enforcement and management capabilities of DPR. Again, see CDP 4-82-300 conditions of approval in **Exhibits 4 and 5**.

CDP 4-82-300-A1

CDP 4-82-300 was first amended on August 26, 1982 (see changes to conditions associated with the first amendment starting on page 8 of **Exhibit 4**), just a couple of months after it was initially approved. The amendment delayed the effective date of implementing the 500 camp site daily limit from Labor Day 1982 to September 15, 1982, or by approximately two weeks. It also moved the location of the interim staging area north approximately ¾ of a mile to the two mile post (Post 2, where it is still located today) and provided more specific fencing requirements. This amendment was the result of a resolution of a dispute between DPR and the County that arose during the original permit as to the appropriate locations for the interim staging area and protective fencing.

CDP 4-82-300-A2

The CDP was amended again a little less than a year later on June 21, 1983 (see changes to conditions associated with the second amendment starting on page 14 of **Exhibit 4**). The recently created California Off-Highway Vehicle Commission, created pursuant to PRC Section 5090, conducted hearings and a joint review of the effectiveness of the resource management requirements outlined in the base CDP as then amended through 4-82-300-A1, and concluded that Parks had effectively controlled OHV use and had made positive gains in resource protection and restoration. Based on these findings, DPR proposed an amendment to the CDP requesting an increase in the maximum number of allowed campers from 500 to 1,500 per day. The Coastal Commission at that time noted and recognized such progress, including: significant areas of protective fencing had been established; the dunes by Oso Flaco Lake had begun to be stabilized, dune vegetation restoration efforts had begun, and the area was once again being used by fishermen, hikers, birdwatchers, and picnickers; a barrier fence was established at Oso Flaco Creek to prevent OHV use; volunteer OHV groups had established an effective patrol force to help park staff; and DPR had budgeted for more seasonal and permanent employees.

However, the Commission also noted that other resource protection measures were not being implemented, including that the Oso Flaco Creek fence was not timely installed, resulting in some degradation of the dune system south of the creek. Therefore, the Commission found that camping spaces should only be increased incrementally, and increased the maximum number of allowed camping units to 1,000 per day. This amendment also changed Special Condition 6 to specify that, if after any required review of Park management, it is found that OHV use is not occurring in a manner that protects ESHA and community values consistent with the LUP, OHV use and the maximum number of camping units allowed can be further limited by the Executive Director with concurrence by the County Board of Supervisors. If the reviews find OHV use is consistent with such standards, then OHV use and maximum camping units may be increased.

CDP 4-82-300-A3
On August 24, 1984 the CDP was amended for a third time (see changes to conditions associated with the third amendment starting on page 19 of **Exhibit 4**). This amendment adjusted the fence lines to allow for OHV use in areas which were historically unvegetated open sand, or which had become so extensively damaged by past vehicular use that revegetation success was deemed unlikely. The Commission found that while the proposed amendment would result in the opening of additional dune area to OHV use, the additional areas did not contain sensitive vegetation or wetland habitats and that opening these areas to vehicular use would not result in habitat damage. The new fence alignment would continue to protect existing vegetated areas and wouldn't restrict OHV use on large areas of open sand suitable for such use.

CDP 4-82-300-A4
On September 10, 1991 the CDP was amended a fourth time (see changes to conditions associated with the fourth amendment starting on page 25 of **Exhibit 4**). OHV use in the Oso Flaco Lake area was prohibited under the base permit in 1982 in order to protect sensitive resources in the area. However, the absence of OHVs and the associated recovery of the dune and related habitats in this area also resulted in increased interest from pedestrians and equestrians. This increased use had begun to lead to some negative impacts in the form of trampling of vegetation. To reduce these trampling impacts, the amendment modified Special Condition 1(c) by prohibiting equestrian use in the Oso Flaco Lake area.

CDP 4-82-300-A5
Condition compliance reviews initiated by the Commission in 1994, partly in response to concerns expressed by the County regarding the intensity of recreational use from camping unit vehicles, resulted in a renewed effort to understand the carrying capacity of the Park and regulate the types and levels of public use accordingly. Special Condition 3(d) of the base CDP required that, by January 1983, DPR would establish limits on the number of OHV day users, in consultation with the County and Commission. Similar to other conditions, this condition envisioned that DPR, the County, and the Commission would cooperatively work together to identify the carrying capacity of the Park, meaning the maximum number of OHV users the Park can handle while meeting all of the CDP's resource protection standards.

The final draft of DPR's ODSVRA OHV Day-Use Carrying Capacity Study was completed on June 30, 1998. The study described how, through a combination of management measures (e.g., fencing, ranger patrols, dune restoration, user education, etc.), DPR believed that OHV impacts on ODSVRA's ecosystems were now confined to existing bare sand areas. DPR's conclusions included: there was strong evidence that the balance between vegetated and non-vegetated portions of the dune system was being maintained; there was an acceptable visitor safety trend; sanitation problems had been resolved; and that non-OHV visitor use was not precluded. However, Commission staff concluded that the study did not adequately define the ecological systems to be protected, and that it did not contain sufficient evidence to determine if, because of OHV use, adverse impacts were occurring in areas that might otherwise normally be vegetated dune or Western snowy plover nesting areas. Impacts on some wet beach fauna, such as grunion, were also not considered. More importantly, the study revealed the difficulty in establishing a fixed vehicle use limit in light of the dynamic environmental management issues at ODSVRA, and the difficulty in establishing whether adverse impacts were occurring in areas that might otherwise normally be vegetated dune or plover nesting areas.

Nonetheless, Commission staff brought forward a CDP amendment with a recommendation to accept the study and adjust the CDP's vehicle use limits. The item was to be heard before the Commission on August 13, 1998. Commission staff recommended the establishment of an interim limit on vehicle day use at a non-holiday maximum of 4,300 vehicles per day, including off-highway vehicles, based on DPR's proposal (where the numbers were based on then estimates of actual use). The proposed interim limits reflected the maximum amount of OHV day use that DPR believed it could manage without significant degradation of coastal resources. Commission staff also recommended that further research and monitoring be conducted to determine actual impact thresholds with respect to ecosystem carrying capacity, including so as to identify levels of use that might differ from these interim numbers and that could be balanced effectively with resource protection needs. Finally, Commission staff recommended that the acceptance of the study and establishment of the interim use limits be conditioned on DPR's agreement to a periodic review process, and establishment of an advisory group that could monitor ODSVRA resource management and vehicle impacts and provide recommendations on Park management issues, including in relation to Park carrying capacity. However, the item was postponed and discussions continued between DPR, the County, and the Commission to determine how to establish vehicle use limits as a resource management technique within ODSVRA.

Following those discussions, DPR applied for CDP amendment 4-82-300-A5 to implement another means to manage vehicle impacts within ODSVRA (see changes to conditions associated with the fifth amendment starting on page 30 of **Exhibit 4**). The amendment proposed by DPR included the establishment of a Technical Review Team (TRT) that could function to develop information to help support Park use decisions as an alternative to the carrying capacity analysis approach. The implementation of the TRT was a shift to a different type of adaptive management, the intent being that the TRT would serve as an advisory board to oversee monitoring of environmental and use trends at ODSVRA and then advise the ODSVRA Superintendent, and ultimately the Commission through the annual review process, on resource management issues. The TRT would include an independent Scientific Subcommittee whose role would be to identify, develop, and evaluate the scientific information needed by decision makers to ensure that the Park was being appropriately managed, including that natural resources were being adequately managed and protected. The TRT and the ODSVRA Superintendent would be required to prepare annual reports summarizing recreational use and habitat trends in the ODSVRA, as well as the TRT's major accomplishments, projects, correspondence, and recommendations. Importantly, one of the priority research projects assigned by the Commission to the TRT was the need for a "comprehensive, long-term monitoring and comparative analysis of the resource impacts associated with varying levels of use, including the highest (peak use) attendance period" (see Special Condition 5 of CDP amendment CDP 4-82-300-A5). In other words, the TRT was tasked with developing information and evidence to support identifying and authorizing a specific level of use for the Park, thus transitioning the earlier CDP requirements for a carrying capacity study that could do the same to the TRT process. The amendment also required the Commission to annually review the "overall effectiveness of the Technical Review Team in managing vehicle impacts at the ODSVRA. If the Commission is satisfied with the review, the amendment will remain in effect for another year. Otherwise, an alternative approach to resource management, or set of management measures, may be instituted through this process" (see Special Condition 2 of CDP amendment CDP 4-82-300-A5).

The TRT was designed to be comprised of no less than nine and no more than 13 voting members.[13] The TRT's role is to, at a minimum: 1) assist the ODSVRA Superintendent in the protection of natural resources by developing recommendations regarding additional monitoring studies, adjustments to day and overnight use limits, and management strategies; and 2) create a Scientific Subcommittee to identify, develop, and evaluate the scientific information needed by decision makers to ensure that the ODSVRA's natural resources are adequately monitored and protected. The Scientific Subcommittee's role is to ensure that the TRT's recommendations to the ODSVRA Superintendent and the Commission are scientifically sound. The Subcommittee is to consist of resource experts representing the five government agencies on the TRT[14] and at least two independent scientists with expertise in Western snowy plover, California least tern, steelhead trout, tidewater goby and other species of concern, as well as with expertise in ecological processes to help analyze technical data and provide scientific recommendations. Specifically, the Scientific Subcommittee's required tasks include: 1) recommend to the TRT the scientific studies and investigations that may be necessary to develop information needed by resource managers; 2) advise the TRT regarding the protection of ODSVRA's natural resources by helping identify and review needed research measures and restoration efforts to rebuild or protect those resources; 3) evaluate monitoring results and reevaluate monitoring protocols contained in ODSVRA annual reports, reports on the breeding, nesting and fledgling success of the Western snowy plover and California least tern populations, and other reports related to the environmental impacts of recreational activities; 4) provide comments on the adequacy of various scientific research studies and make management recommendations to the TRT; and 5) submit full recommendations to the TRT, and make them available to the public, as part of the annual review process.

Special Condition 5 of CDP amendment 4-82-300-A5 also required the TRT to identify and select initial priority research and management questions and projects, including: 1) appropriate management techniques for the Western snowy plover, California least tern, Steelhead trout, and Tidewater goby; 2) appropriate management techniques for protecting water quality and dune habitats from pollutants associated with OHV use; 3) the potential need for continuing or expanding revegetation efforts within the ODSVRA, including expansion of vegetation exclosures; and 4) a comprehensive, long-term monitoring and comparative analysis of the resource impacts associated with varying levels of use, including in relation to peak-use attendance periods.

While the Commission accepted the TRT's formation and role in studying Park issues and developing appropriate recommendations on resource protection, it also decided that interim vehicle use limits needed to be maintained in some form. The amendment thus includes separate

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[13] The TRT was to be made up of representatives from: Coastal Commission staff, San Luis Obispo County, USFWS, CDFW (currently not participating due to budget constraints), DPR's OHV Division, the OHV Community, the Environmental Community, the Business Community, and the Residential Community. The ODSVRA Superintendent is a non-voting member of the TRT.

[14] The represented agencies are the Coastal Commission, San Luis Obispo County, USFWS, CDFW, and DPR.

use limits for street-legal vehicles, OHVs, and camping units. Those interim limits were determined to be 2,580 street-legal vehicles per day, a total of 1,720 OHVs at any given time, and 1,000 camping units per day (defined as one street-legal vehicle that enters the ODSVRA under its own power). In the interim, to allow for historic use patterns, vehicle limits were allowed to be exceeded for Memorial Day, 4th of July, Labor Day, and Thanksgiving weekends.[15] Again, however, these use limits were specifically described as being interim, with the goal being that the TRT, as part of its ongoing research and management program, would study and recommend to the ODSVRA Superintendent and the Commission appropriate vehicle use limits that fundamentally reflect an analysis of vehicular impacts and overall carrying capacity in relation to resource protection otherwise.

The Commission ultimately approved CDP amendment 4-82-300-A5 in 2001. Special Condition 1 of this amendment replaced Special Conditions 3(b) (that restricted camping to a maximum of 1,000 units/vehicles), 3(d) (that required Park use limits to be established by January 1983), and 6 (that required an annual review of OHV use impacts on ESHA and community values). Special Condition 2 of the amendment requires the Commission to annually review the overall effectiveness of the TRT in managing vehicle impacts at the ODSVRA, including evaluating the findings of the TRT's annual review. Special Condition 3 sets forth the Park's interim vehicle use limits. Special Condition 4 established the formation of the TRT, including requirements that it monitor and recommend adjustments to use limits and other resource management measures, and set up a Scientific Subcommittee that will advise the TRT on those resource management measures. Finally, Special Condition 5 requires the TRT and the ODSVRA Superintendent to prepare and submit to the Commission annual reports (covering the period from October to September) summarizing annual recreational use and habitat trends at the ODSVRA, highlighting the TRT's major accomplishments (including progress made towards meeting the objectives of the TRT), projects, correspondence, and recommendations on park management issues, as well as a summary of subcommittee, working group, and task force activities. Thus, the Commission's ability to require modifications to current management measures was initially established by Special Condition 6 of 4-82-300, and retained by Special Condition 2 of CDP amendment 4-82-300-A5.

Current CDP Status

As indicated above, CDP 4-82-300 has thus been amended five times (see **Exhibit 4** for the changes each made to the conditions of the CDP, including a clean copy of the current conditions starting on page 38 of the exhibit). The CDP, as amended through CDP Amendment 4-82-300-A5 in 2001 currently authorizes and requires the following:

- The use of the TRT to study Park management issues and recommend appropriate resource protection measures, and to prepare an annual report summarizing such efforts and recommendations. The Commission is to annually review the effectiveness of the TRT in terms of its effect on ODSVRA management, and to potentially recommend different management approaches if warranted to best address vehicular use impacts and resource protection requirements.

[15] Although these holiday exceedance limits have not been adjusted through changes to the permit, DPR no longer allows exceedances on these holiday weekends due to a litigation settlement agreement.

- The designation of an interim staging area just south of the Two-Mile Post. No non-street legal vehicle is allowed to be operated north of the Two-Mile Post, and therefore must be trailered to the staging area from the interim West Grand and Pier Avenue entrances.

- A permanent staging area is to be selected based upon a review of at least four sites via an environmental impacts analysis. Until a permanent staging area is selected, the Commission or the County may review and modify the CDP as necessary. The Oso Flaco Lakes area cannot be used for the staging area, and equestrian use there is prohibited.

- West Grand Avenue and Pier Avenue are the two designated interim entrance points, which are to be staffed with a Public Information Program that both counts vehicles and also explains where riding is and is not allowed. These access points will remain "interim" until a permanent staging area is selected.

- OHV use is off-limits within vegetated dune areas, the area south of Oso Flaco Creek, and any other fenced-off areas.

- Ongoing programs for protecting and restoring dunes (including vegetated dune areas) and protecting archaeological resources (including via fencing and prohibiting OHV use within in all cases) are required.

Each of the amendments altered the base CDP's terms and conditions in a variety of ways, but the fundamental framework of the permit continues to be one of understanding Park issues and providing a means of addressing them through continued Coastal Commission review and adaptive management pursuant to the terms and conditions of the CDP. One of the most important components of the CDP as amended is the concept of using the TRT to help in this effort. The TRT is meant to be an interagency/stakeholder review team responsible for providing ongoing management recommendations to the ODSVRA Superintendent and the Commission.

In short, the CDP, as amended, provides the Commission a vehicle for evaluating management measures at the Park in terms of addressing the overall balance between vehicular recreation and dune and related coastal resource protection. Under the CDP as amended currently, the primary review focus and springboard is meant to be the TRT's annual report, and the Commission's annual review of it. Using the data and recommendations coming from the annual report, as well as all other relevant and known information pertaining to Park issues and general resource management, the Commission can then review the TRT's overall effectiveness in managing vehicle impacts at the ODSVRA. If the Commission is satisfied with the annual review and the overall effectiveness of the TRT in managing vehicle impacts, the Commission can leave the amendment (i.e., the fifth amendment establishing the TRT and the Park's interim vehicle limits) in effect for another year. If the Commission is not satisfied, it may, through this review process, institute alternative approaches to resource management or a new set of management measures. Specifically, Special Condition 2 of the fifth amendment states (see also **Exhibit 4**):

> *Renewal of Permit. Annually, the Commission shall review the overall effectiveness of the Technical Review Team in managing vehicle impacts at the ODSVRA. If the Commission is satisfied with the review, this amendment will remain in effect for an additional year. A longer permit may be requested in the future. Otherwise, an alternative approach to*

> *resource management, or set of management measures, may be instituted through this review process.*

In addition to the Commission's review authority identified in that condition, Special Condition 1(b) of the base CDP continues to allow for Commission and/or County review or modification of the CDP for failure of DPR to establish a permanent entry staging area, stating:

> *1B. A permanent staging area site shall be selected as expeditiously as possible but in no case later than 18 months from the effective date of the County's LUP certification consistent with the following standards. Construction of this permanent staging area shall begin no later than three (3) years from the date of certification of the County's LUP or its LCP. If construction and operation of a permanent staging area cannot be accomplished within the above time limits, this permit shall be subject to review and modification if necessary or appropriate by the County or the Commission or either in consultation with the other…*

Thus, when the Commission approved the CDP in 1982, it designated interim access and staging locations, and required that DPR study and the Commission approve a permanent access and staging system no later than 18 months after certification of the County's LUP (which was certified in 1984). Although DPR has studied alternatives in the past, the Commission has never taken action to finalize Park access and staging through the CDP as required. As such, there have been repeated complaints about the interim nature of the existing system and its impacts (e.g., to non-vehicular recreational beach use and to Arroyo Grande Creek habitat resources), and this continues to be a three-decade old potential violation of the CDP (see also violation finding). Therefore, the staging area located at Post Mile 2 continues to be categorized as "interim" per this condition, and thus the Commission retains the authority to review and modify the CDP as appropriate to require State Parks to set a final access and staging area for the Park.

Overall, it is clear that the terms and conditions of the base CDP, as amended, are designed to provide for continued study and ongoing adaptive management of the Park related to core issues associated with striking an appropriate balance between facilitating vehicular recreation and protecting dune and related coastal resources consistent with the access, recreation, and resource protection policies of the Coastal Act and the LCP, and to appropriately and adequately mitigate for the ongoing, evolving impacts associated with the Park use. Given the unique circumstances present at ODSVRA and the recognition that appropriate regulation of the Park requires adaptive management, the CDP and its review requirements are structured to provide the Commission with broad authority and discretion in determining whether Park management is or is not effective at meeting such objectives, as well as implementing changes to make it more effective in order to effectively mitigate coastal resource impacts on a continuing basis.

III. ODSVRA CDP REVIEW

This ODSVRA review represents the eighth review in the 15 years since the 2001 amendment that established the TRT. Although the Commission performed six annual reviews between 2002 and 2007, the Commission did not undertake the CDP-identified review between the years 2008 and 2014. The reasons for this gap in reviews were many, but were primarily a result of limited Commission staff resources being instead allocated to other priorities and projects However, it became clear more recently that it was an appropriate time to ensure timely and regular condition compliance through the review process, in part because interested parties had requested same, and in part due to the changing context and emerging management issues at ODSVRA. In addition, the Commission itself changed members almost completely in the time since the review in 2007, and providing for review represented an opportunity to bring the Commission up to speed on the context, issues, and potential next steps related to overall Park management under the CDP.

As such, the Commission re-reviewed the CDP in a public hearing in February 2015. The hearing provided an overview of ODSVRA, described various requirements of the CDP, summarized some of the primary issues facing the Park, and included a discussion of potential next steps to address these issues, all with the goal of addressing the fundamental tension and balance associated with providing for the unique public recreational opportunity that the Park provides at the same time as respecting and protecting Park resources as directed by the CDP. The intent of that hearing was not for the Commission to take specific actions, but rather for the Commission to consider and discuss the various ODSVRA issues and potential next steps as a means of providing guidance to Parks moving forward. The primary issues and potential recommendations related to ODSVRA management discussed at that 2015 hearing were: 1) designation of permanent Park entrance and staging areas; 2) identification of appropriate use limits and carrying capacities, including related to special events; 3) identification of measures to address dust control and air quality, including completion of the pending CDP dust control application process; 4) resolution of ownership and use issues associated with the La Grande property; 5) implementation of a study that provides information on the effectiveness and impacts associated with a year-round exclosure for Western snowy plover and California least tern, including its impacts on recreational vehicular activity; 6) steps necessary to complete an HCP in conjunction with the United States Fish and Wildlife Service (USFWS); and 7) transitioning and/or restructuring the TRT function.

The Commission took public testimony and provided guidance on these key issues at the public hearing in 2015, with the goal of bringing forward potential changes for Commission action in the future designed to address ODSVRA management under the CDP, including potential changes to CDP terms and conditions to effect needed changes. It was also understood that Commission staff would continue to work closely with DPR staff, as well as interested groups and stakeholders, to further study the issues and collaborate on potential changes to address them. Since the 2015 hearing, Commission staff has had numerous discussions with interested parties, including the County and DPR. In particular, Commission and DPR staff have had three separate in-person meetings in Santa Cruz, numerous phone conference meetings, and frequent individual phone calls and emails to foster a collaborative dialogue and common understanding of the issues.[16] As such, this 2017 review builds off of the February 2015 hearing, including by

[16] In addition, Commission and DPR staff collaborated to identify a Commission meeting that would provide DPR adequate time to prepare (ultimately agreeing on January 2017), and one that could be held local to the ODSVRA area (i.e., in this case, in San Luis Obispo) to facilitate local public participation. Commission staff also provided DPR with a blueprint of issues and potential next steps for this re-review in May 2016, and provided a draft of potential action items to DPR in November 2016 to help facilitate staff to staff discussion. Commission and DPR staff have been working closely from these materials over the course of 2016 to best develop and present action items for this 2017 hearing.

updating the Commission on each of the issue areas previously discussed, as well as offering recommendations for Commission action to modify the CDP to address particular issues and to facilitate improved Park management and CDP implementation clarity moving forward.

The following discussion focuses on eight different but overlapping issues. The first section discusses the Park entrance and staging system, and provides a process for finalizing that system under the CDP and the LCP. The second section discusses use limits and ways to address day-to-day operations at the Park moving forward. The third section provides an update regarding ongoing air quality and dust control issues, including next steps associated with DPR's pending CDP application to implement dust control and monitoring measures. The fourth section discusses the issues surrounding the use of the La Grande property for OHV riding, including with respect to ultimately providing closure on such issues through the CDP and the LCP. The fifth section discusses ongoing issues associated with ESHA protection, including in relation to special status species and their habitats. The sixth section provides an update on DPR's HCP efforts, and ways in which the HCP will inform (and be informed by) changes undertaken through the CDP process. The seventh section discusses the TRT, and provides a means of transitioning CDP evaluation away from the TRT process into an annual reporting process. The eighth and final section describes various alleged violations at ODSVRA, including with respect to non-compliance with CDP terms and conditions.

A. Park Entrance and OHV Staging Area System

As detailed above, CDP 4-82-300 as amended identifies the current Park entrance and staging system as interim, and subject to further review and study to designate this system (or alternatives to it) as permanent. To date, the Commission has not yet reviewed and approved final entrance and staging area locations and provisions, and DPR is out of compliance with the CDP for this reason (see also violation finding below). As described above, the conditions of the CDP require DPR to prepare an environmental impact analysis adequate to enable the selection of a permanent staging area location determined to be the least environmentally damaging; require that that permanent system be incorporated into the LUP; require that that permanent system be constructed within three years of LUP certification (i.e., by the late 1980s); and require the permit to be subject to review and modification if necessary or appropriate by the Commission if the permanent system is not constructed by that deadline (which it wasn't).

While any number of sites could be studied, the CDP identifies at least four sites to be analyzed: the Calendar Road area; the stables/agricultural lands area south of Arroyo Grande Creek; agricultural lands north of Oso Flaco Creek adjacent to the Phillips 66 (previously Union Oil) property; and the interim access and staging areas. In addition to requiring that the selected access and staging system be the least environmentally damaging, the CDP requires that the selected access and staging system reduce OHV-related impacts to the residential character of the community of Oceano as compared to the interim locations, that it facilitate the successful separation and regulation of recreational uses within ODSVRA, and that it be able to be developed expeditiously. Because the location of any identified permanent staging areas would necessarily affect the way in which they are accessed via entrances to the Park, the CDP designates the two existing entrance locations at West Grand Avenue and Pier Avenue as temporary. Thus, the CDP requires that DPR evaluate and present options for a permanent Park entrance and staging system for Commission consideration.

The route by which vehicles access the recreational riding area is a long-standing issue that has significant implications on resource protection and access management. Currently, street legal vehicles, with or without OHVs in tow, access the beach from either West Grand Avenue in Grover Beach or Pier Avenue in Oceano. Vehicles then traverse the beach in a southerly direction to access the riding area. This involves driving along a stretch of shoreline used by pedestrians and general beachgoers, many of whom are local residents, but also visitors to the area. This mix of vehicles, pedestrians, and other beachgoers has resulted in user conflicts and public safety issues. When it is flowing, vehicles heading to the OHV riding area must also drive through the mouth of Arroyo Grande Creek, which provides habitat for endangered Steelhead trout and Tidewater goby. Typically, the only time the Creek has significant flows is during the rainy season, and it otherwise terminates in a lagoon inland of the immediate shoreline. However, when it is flowing, the Creek presents an obstacle to vehicular travel, including to get to the OHV riding and staging areas, and has been the site of problems in this respect as vehicles attempt to navigate through and across the Creek to access the riding areas further south. OHVs are currently off-loaded from street legal vehicles at the interim staging area which is located south of Arroyo Grande Creek, and thus it is the street legal vehicles and trailers that make this creek crossing, not OHVs.

The current entrance and staging areas were designated as interim under CDP 4-82-300, with the goal of potentially locating a permanent access and staging area to the south that would avoid conflicts between more passive recreation type use and OHV use, as well as to eliminate the need for vehicles to cross Arroyo Grande Creek.

DPR has studied the access and staging area issue. Specifically, DPR released an Environmental Impact Report (EIR) in 1991 designed to identify the least environmentally damaging staging area and entrance points. The EIR evaluated the potential impacts associated with five alternative access corridors: West Grand Avenue; Pier Avenue; Calendar Road; Railroad Avenue; and Silver Spur Place. Ultimately, the EIR determined that the West Grand Avenue and Pier Avenue sites were the least environmentally damaging and that they should be designated permanent. DPR amended their General Development Plan at that time to state as much. However, as part of the process to establish them as permanent access entrance sites, Special Condition 1(b) requires DPR to update the State Parks General Development Plan *and* for the LCP to be amended. While DPR updated the State Park General Development Plan to reflect the West Grand and Pier Avenue accesses as permanent, DPR never applied to San Luis Obispo County for the requisite LCP amendment nor to the Commission for a CDP amendment, and the Commission has yet to consider the question of which are the most appropriate permanent entrance and staging area alternatives, including taking into account DPR's prior environmental analysis on the issue.

In 2006, DPR completed a second alternative access study. This 2006 study evaluated a total of eight potential accessways: West Grand Avenue; Pier Avenue; Ocean Street; Creek Road; Silver Spur Place; ConocoPhillips; Little Oso Flaco Lake; and Oso Flaco Lake. Ultimately, DPR's study again identified continued use of West Grand Avenue and Pier Avenue as the environmentally preferred alternative. The study was presented to the TRT for discussion, but the TRT never formally reviewed the document or made recommendations on the study.[17] Although DPR went through the process of completing the access study, DPR never pursued amendments to the CDP or LCP to remove the interim nature of the staging area and West Grand Avenue/Pier Avenue entrance access points and to establish them as permanent. Thus, all three areas remain classified as interim, and the conditions of the CDP remain unfulfilled.

DPR has consistently indicated that the two previous studies, particularly the latest study from 2006, have provided the appropriate analysis and conclusions regarding the proper permanent access and staging locations. DPR indicates that, but for some minor updates regarding sensitive species habitat considerations, no additional study is necessary, including because there have been no capital improvements or significant changes made in the Park since the studies were last prepared. Thus, DPR indicates that new studies would not provide any additional relevant information not already known.

However, while the reports are substantial, the most recent is over ten years old (and the original over 25 years old), and they do not take into account more recent changes in context as well as new and emerging issues that could affect the access and staging locations, particularly with respect to the County's La Grande property and dust control/air quality issues.[18] Updated analysis will be necessary to provide the Commission with the necessary level of information with which to make such a critical and important decision as it affects the Park and the CDP and the LCP. In short, the Commission exercises continuing jurisdiction over designation of the Park entrance and staging area because DPR has not satisfied its permit requirements to designate a final Park entrance and staging area (subject to Commission approval) or to amend the certified LCP with these final designations. Furthermore, the terms and conditions of the CDP require the Commission to continue to evaluate and respond to ongoing impacts related to Park access for which DPR must evaluate the least-environmentally damaging alternative (culminating in final designation of the Park entrance and staging area). And DPR needs to consider whether the La Grande property and dust control/air quality issues may be relevant to the access study impact analysis in such a way (that may not have been considered in its prior access studies) that affects a final designation of access and staging systems for the Park, including to adequately mitigate those impacts (i.e., by selection of the final Park entrance and staging area having the least impact to coastal resources).

More broadly, the fact that the CDP identifies Park entrance access and staging as interim and subject to further study only leads to a lack of certainty and clarity for DPR, the Commission, the County, and other interested agencies and parties with respect to Park operations. In addition, the fact that this issue was intended to be resolved decades ago and remains incomplete only serves to fuel debates amongst competing interests about what should be designated as permanent entrance and staging locations. It also means that DPR is not in compliance with the CDP, which

[17] The TRT identified its intention to review the results of the 2006 study as a research priority in 2007 and continued discussion of the issue as a research and management issue in 2008 and 2009. However, neither the TRT nor the Scientific Subcommittee has ever formally reviewed or commented on the study. Since the 2010 annual TRT report, the TRT has not taken any action to resolve the interim status of the entrance access and staging areas, and the issue has no longer been a topic of TRT discussion.

[18] Both of these topics are discussed in more depth later in this report, but, in short, the ultimate disposition of the La Grande property (including ownership and allowed use of it) and the potential need to implement dust control and air quality measures in ways that could affect the Park entrance and staging area point to the need to update past studies in light of current issues and context.

does not serve to further the Commission's or DPR's objectives for effectively managing the Park.

As a means of resolving this critical issue moving forward, the Commission adds **Special Condition 1**.[19] The condition's intent is to require DPR to commence a process for DPR and the Commission to finally and ultimately designate a permanent Park access and staging system, including by ultimately having the Commission make a decision on the final system in a future public hearing. Prior to such hearing, DPR would provide the Executive Director with an access and staging analysis that updates their past studies and evaluates various alternatives across a similar environmental impact framework taking into account all relevant and current impacts and issues, which include the now-recognized dust hazards and use of the La Grande property.[20] The analysis should also include recommendations on ways to mitigate and address any coastal resource impacts associated with identified access and staging areas, including ways to ensure that sensitive species and recreational use of all types is appropriately provided and protected.[21] Ultimately, the LCP will need to be amended to address the final access and staging system identified, including to meet CDP requirements to do so, but also to provide LCP clarity and consistency moving forward, including with respect to the La Grande property.[22]

As conditioned, DPR and the Commission will be able to resolve this outstanding issue in a manner consistent with the CDP's ultimate intent of balancing vehicular use and dune and related coastal resources.

B. Managing Day-to-Day Park Operations and Use Limits

Special Condition 3 of CDP 4-82-300-A5 established interim vehicle use limits that are still in effect, building upon other interim limits established by the Commission previously. As detailed in the original permit findings, the determination of these interim vehicle use limits for ODSVRA lacked rigorous supporting information because determining appropriate use numbers requires extensive study and analysis (which was has never been undertaken) and is dependent on a variety of factors. Instead, the current daily limit of 4,300 vehicles had historically been accepted absent any compelling evidence that it should be some other number. Interim vehicle use limits were subsequently redefined through CDP amendment 4-82-300-A5 as follows based on estimates of then current use (and again <u>not</u> based on a rigorous analysis of the level of use that would be appropriate). Special Condition 3 states:

3. Interim Vehicle Limits.

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[19] Note that it is identified as Special Condition 1 for ease of reference here, but it would actually be Special Condition 1(C) to the CDP when all of the changes are implemented (i.e., given the existing conditions that apply, and the way they are being changed here). The clean set of applicable conditions following Commission action are shown in **Exhibit 5**.

[20] Given that DPR has indicated they do not believe an entirely new access study or even a significant update is warranted, they have offered (and Commission staff has acknowledged) that DPR plans to submit a short addendum to the prior access studies to address staff's concerns. Staff will evaluate whatever materials DPR submits in support of its designation of the final Park entrance and staging system, and the Commission will consider the sufficiency of this evidence when designating the final Park entrance and staging system.

[21] For example, describing impacts and mitigation measures associated with vehicular activity along the beach and within Arroyo Grande Creek when it is flowing to the ocean.

[22] The LCP needs to reflect the final access and staging system, but it may also be necessary to make other complementary LCP changes depending on the nature of the final system and associated provisions.

a. ***Interim Day-Use Vehicle Limits.*** *Except as qualified by 3d, interim limits on motor vehicle use on the beaches and dunes of Oceano Dunes SVRA shall be no more than 2,580 street-legal vehicles per day. This limit does not include off-highway vehicles, or street-legal vehicles attributable to allowed overnight camper use within the ODSVRA.*

b. ***Interim Camping Limits.*** *Except as qualified by 3d, interim limits on overnight motor vehicle use on the beaches and dunes of Ocean Dunes SVRA shall be no more than 1,000 camping units (i.e. 1,000 street-legal vehicles) per night. This limit does not include off-highway vehicles or street-legal vehicles attributable to allowed day-use within the ODSVRA.*

c. ***Interim Off-Highway Vehicle Limits.*** *Except as qualified by 3d, interim limits on off-highway vehicle use on the beaches and dunes of Oceano Dunes SVRA shall be no more than 1,720 off-highway vehicles at any given time. This limit does not include the street-legal vehicles used to tow or trailer the OHVs into the ODSVRA.*

d. ***Holiday Periods.*** *Interim street-legal and off-highway vehicle limits may be exceeded during the four major holiday periods of Memorial Day (Saturday through Monday), July 4th (one day and any adjacent weekend days), Labor Day (Saturday through Monday), and Thanksgiving (Thursday through Sunday).*[23]

At the same time, that amendment acknowledged these as still interim numbers in nature, including directing the TRT to research and develop evidence that would support these numbers or some modified level and area of use at the Park. That never occurred. In addition, there remain additional unaddressed issues pertaining to the Park's vehicle use limits. Special Condition 3(c) limits the number of OHVs to 1,720 "at any given time." There are several practical difficulties involved with both accurately counting OHVs entering the Park and accurately tallying how many OHVs remain at any given time. First, DPR does not keep a tally of the number of vehicles leaving the Park. As a result, there is not a means of knowing how many vehicles may be present at any one time. Second, the entrance kiosks close at night and thus Parks staff is not present onsite to tally the number of OHVs that come in or out. In order to account for OHVs that come into the ODSVRA after the kiosks are closed, DPR multiplies the number of vehicles entering the ODSVRA after the kiosks are closed by a set number that they indicate is intended to represent the average number of OHVs that are brought in per vehicle during the day, but the OHVs are not actually counted. And third, DPR does not verify how many OHVs are brought in via closed trailer where the number of OHVs cannot be identified from the outside, instead relying on the driver of the vehicle to tell them how many are being trailered in. All of these factors contribute to a lack of counting precision, and thus it is not clear that the current system can effectively provide accuracy in use counts.

More broadly, in addition to the logistical difficulties involved with counting users, the limits themselves also underscore a significant unresolved Park management issue. Since the adoption of CDP 4-82-300-A5 in 2001, which both created the TRT and set the most recent set of interim

[23] Special Condition 3(d) allowed for the exceedance of the vehicle use limits prescribed in CDP 4-82-300-A5 during selected holiday periods. However, these exceedance periods are no longer allowed based on a settlement agreement entered into by DPR.

vehicle use limits, the limits were based on use patterns to date at that time, and have never been adjusted. These interim use limits were never anticipated to establish the ultimate carrying capacity for the ODSVRA. Instead, a primary function of the TRT is to “develop recommendations to the Superintendent of the ODSVRA regarding…adjustments to day and overnight use limits…” and, as part of its ongoing research and monitoring efforts, “conduct a comprehensive, long-term monitoring and comparative analysis of the resources impacts associated with varying levels of use, including the highest (peak-use) attendance periods.” Essentially, the condition’s interim vehicle use limits were seen as starting points from which the TRT could recommend adjustments over time based on what was learned through their ongoing research. The CDP anticipated that the TRT would be continually monitoring vehicle use numbers and their corresponding impacts on Park resources, and would then recommend scientifically based limits to be adopted. However, these additional studies have not been conducted, the TRT has not made progress on this key issue, and the TRT does not currently consider use limit monitoring as a primary research or monitoring focus.

In addition, special events at the Park raise similar use and carrying capacity concerns, particularly considering that special events do not appear to be contemplated within any of the historically-used use limits. For example, “Huckfest” is an event that has taken place informally within the ODSVRA for over ten years, and has recently grown in size and formality. The event is an exhibition of vehicles jumping (or “hucking”) off of sand dunes (see photos in **Exhibit 3**). While the impacts of the vehicles jumping off of the dunes may be generally no different from what occurs on a daily basis, the CDP does not currently explicitly account for special events, nor did the Commission specifically consider special events within use limits when it originally approved the CDP. In addition, as the Huckfest event has grown in size it has resulted in other significant coastal resource impacts. The 2014 event included a vendor area, event stage, and a ramp for a motorcycle exhibition. The ticket prices for Park entrance were also increased for the Huckfest weekend to $35 for day use and $100 for camping. This was a significant departure from the typical $5 day use fee and $10 camping fee.

In fact, the 2013 event had a host of issues, as the event drew many more spectators than expected. Some of the issues included traffic congestion in and around ODSVRA entrance points, spectators massing on top of vegetation in fenced-off dune protection areas, and an exceedance of the daily vehicle use limits. Based on the problems associated with the 2013 event, and in anticipation of the 2014 event, Commission staff sent a letter to DPR to ensure that vehicle use limits and resource protection requirements were adhered to. Staff recently received vehicle use numbers from the 2014 event. While the vehicle use limits were exceeded again, there were no reports of spectators or vehicles entering the vegetated islands, which speaks to DPR’s ability to adapt management measures to address these kinds of concerns. In any case, if these types of special events are going to continue and specifically be contemplated within allowable use limits, it will be important that other coastal resource impacts resulting from this (temporary, specific) increase in use limits are appropriately mitigated (e.g., sensitive resources are protected), including through specific special event provisions. The growth in size of the Huckfest event, the portion of the ODSVRA it occupies (and by extension the degree to which it displaces regular use and other types of coastal recreation commensurately), and the increase in price to enter the ODSVRA also raise other potential coastal resource issues that need to be addressed through special event parameters.

It is clear that use limits, including explicit special event parameters, that are based on the fundamental balancing between vehicular use intensity and resource protection are envisioned by the base CDP as amended, particularly the fifth amendment establishing the TRT as a body to proactively study appropriate use limits and make adjustments accordingly. However, this outcome has not occurred. As described above, while the 2001 amendment established interim vehicle use limits based on historic numbers and directed the TRT to study and ultimately determine what the most appropriate numbers should be, the recommended study did not come to fruition. The use limits have remained the same since 2001, and the long-overdue definitive study documenting Park carrying capacity was never prepared. It is possible that the current use limits are the correct limits, but it is also possible they are not.

Furthermore, it is also possible that hard numbers are not the appropriate metric by which to regulate vehicle use in the Park. In other words, the CDP's historic intent is to balance vehicular use and resource protection necessary due to the impacts of the vehicular use. While the number of vehicles within the Park may be one mechanism by which to accomplish this balancing task, it by no means is the only mechanism. Indeed, from 1982 to 2001, the CDP did not have numeric vehicle limits,[24] but instead relied upon other requirements, including protective fencing and prohibitions on vehicle use within vegetated areas, as well as a comprehensive dune restoration and archaeological preservation program, to achieve the envisioned balancing. Even when approving the fifth CDP amendment and establishing the TRT to help study and develop appropriate use limits, the Commission noted that numeric use limits may not be the appropriate metric by which to evaluate resource impairment, particularly in such a dynamic dune environment with changing habitat, weather, and use variables. Specifically, the Commission found:

> *These questions, though, are not necessarily addressed through the establishment of, and reliance on, a static carrying capacity number except inasmuch as this number is understood to be appropriate in light of current information. To the extent that the overall intensity of use is a known factor in creating environmental impacts, resource managers need to be able to adjust this intensity as more information becomes available and we continue to gain a better understanding of the complex system in which we are working…. **Such environmental management issues for the ODSVRA are not addressed by the simple mechanism of establishing a carrying capacity number…. Therefore, it is appropriate to explicitly admit that uncertainty exists and take actions in an experimentally designed context to learn which actions are better than those currently in use**….*[25](emphasis added)

[24] Special Condition 3(d) of the original base permit in 1982 did include a requirement that "a specified number of users" would be allowed in the Park. However, the condition did not specify what that number was (including because it was not known at that time what an appropriate vehicle use number should be). Although the base permit identified camping limits (that were modified in the second amendment in 1983), it did not include other use limits and instead required consultation and agreement on developing such limits by DPR, the Executive Director of the Coastal Commission, and the County. An agreement on a specific use number was not memorialized until the 2001 amendment establishing the interim vehicle use limits and the TRT to study and definitively determine what the most appropriate numbers should be.

[25] CDP 4-82-300-A5 adopted Commission findings, May 7, 2001, page 46.

Thus, while a primary TRT function was to study use limits and their relation to resource protection, it was clear that one specific, static number may not be necessarily the most appropriate metric. Rather,

> *…vehicle use limits may be continually updated to reflect changing conditions and results of various monitoring efforts.*[26]

In other words, it was explicitly understood that a numeric vehicle use limit might not be the fruits of TRT study and research, but rather that different limits may be needed to respond to various thresholds of resource degradation. Or that a different method entirely of ensuring the appropriate balance between OHV use and resource protection could be realized. Unfortunately, this TRT function never materialized; carrying capacity adaptive management was never definitively studied; and the interim vehicle use limits specified in the CDP have never been amended.

All of this history and uncompleted analysis suggests that: developing the right numeric limits is a rather difficult metric to attain; the use of the existing limits provides a type of false validation that use at those levels provides the proper balance (though it has never been substantiated and supported by evidence); and that a different method for addressing this key management issue might be required. One alternate method would be to not rely explicitly on use limits under the CDP, but rather allow Parks to exercise its more typical discretion in managing day-to-day use levels. Specifically, DPR indicates that no other SVRA has numeric use limits, but rather that DPR manages such other areas based on their established best resource management principles, including by restricting vehicle activity from areas suffering from overuse and resource degradation. DPR indicates that such practice is their standard protocol for all of their park units, including ODSVRA, and is no different from addressing overuse of things such as trails, beaches, campgrounds, and other non-vehicular areas, in that Parks as manager and operator of such public recreational areas ensures that all of its resources are used sustainably. In other words, what's always needed first and foremost is best resource management practice to respond to and address on-the-ground concerns as they occur.

Staff has discussed this option with DPR, and believes that eliminating explicit use limits could work at ODSVRA provided the proper bounds were maintained under the CDP. In other words, the CDP includes numerous conditions aimed at addressing and implementing its vehicle use/resource protection balancing objectives. As previously described, the CDP already includes requirements to protect dune and other sensitive species' habitats, as well as conditions requiring continuous study of and recommendations on ways to improve Park management. Properly implemented through continued oversight, these conditions can effectively and directly protect coastal resources on an ongoing basis through a meaningful and effective partnership with DPR.

In short, the Commission exercises continuing jurisdiction over setting use limits because they have only been recognized through the CDP process as interim in nature to date. The terms and conditions of the CDP have always contemplated that these limits would be adjusted, first through the carrying capacity requirements and then through the TRT process. Indeed, the permit

[26] Id (CDP 4-82-300-A5 in 2001, page 60).

as most recently amended tasks the TRT (an entity that only exists within the context of implementing and ensuring compliance with the special conditions set forth in the CDP) with studying and setting updated, evidence-based use limits. However, as discussed below, Commission staff recommends that the Commission now abandon the TRT process as well as the pursuit of a numeric-based methodology for setting use limits to regulate vehicular use within the Park as numeric-based use limits likely do not adequately account for or address on-the-ground impacts to coastal resources that result from actual vehicular use in the Park. Instead, as discussed further below, staff now recommends that use limits be regulated through an adaptive management approach and through existing permit conditions, which collectively will adequately mitigate for significant impacts to coastal resources resulting from the volume of vehicular use allowed in the Park.

Therefore, the Commission adds **Special Condition 2**, which eliminates the CDP's interim day-use, OHV-use, and camping limits. The intent of the condition is that vehicle use at the Park be operated in a manner at all times, including during special events, that does not adversely and significantly impact other Park coastal resources, including dunes, sensitive species and their habitats, and public access and recreational opportunities of all kinds (e.g., camping, swimming, hiking, etc.). The permit modification achieves this requirement by ensuring DPR operates the Park as it manages other parks—using adaptive management based on best established resource management principles, and by complying with other CDP conditions and protections, including aforementioned existing requirements to prohibit riding within vegetated and/or fenced dunes, restoration programs, and sensitive species protections. The condition also ensures that Parks operates all special events within ODSVRA pursuant to these same parameters.

The condition maintains the existing CDP's fundamental premise in that the Park will be adaptively managed to address resource concerns, all with the goal of appropriately balancing vehicle use and resource protection. This adaptive management approach is currently embodied in the TRT's function and purpose in studying and addressing Park management issues. Special Condition 2 simply transfers this function to Parks, who, as resource manager making on-the-ground decisions daily, is the entity most suited to perform such tasks. At the same time, continued Commission oversight is necessary, including as the terms and conditions of the CDP as amended are designed to address ongoing coastal resource impacts related to the volume of vehicular use allowed in the Park at any given time, and are designed to allow the Commission to adapt and require a different methodology for addressing use limits and resultant coastal resource impacts if it determines the currently-proposed adaptive management approach (with additional requirements per the CDP special conditions) is not adequately mitigating coastal resource impacts resulting from the volume of vehicular use in the Park. Practically speaking, the CDP always firmly established this as the Commission's role, and indeed the myriad of issues and regulatory challenges facing ODSVRA affirmatively requires collaboration to ensure that the development at ODSVRA is consistent with the Coastal Act. The Commission need not track daily use numbers so much as understand how levels of use intensity and changes in use intensity overall are affecting coastal resources, and working with DPR to understand such and adapt appropriately. Thus, **Special Condition 4** is also added to ensure Commission review of management decisions for Coastal Act consistency through a monitoring and reporting program (see further detailed discussion of this condition in Section G). The overarching intent is that Special Conditions 2 and 4 work in conjunction with each other to ensure continuous review and study of the manner in which Park resources are being protected, including by giving Parks the flexibility it needs to effectively manage its lands on a day-to-day basis, while also ensuring Commission review to identify and work with Parks on changes needed to ensure Coastal Act consistency over time.

As conditioned, the CDP provides a mechanism that will appropriately ensure that Park resources are managed pursuant to best management practices, the existing CDP's protections, and with necessary safeguards to ensure oversight and review, including from the Commission.

C. Air Quality and Dust Control

Fugitive dust emissions emanating from ODSVRA are resulting in exceedances of State and Federal ambient air quality standards for particulate matter smaller than 10 and 2.5 microns in size, known as PM10 and PM 2.5 respectively. The high particulate matter concentrations have resulted in a public health problem for the people living inland of ODSVRA on the Nipomo Mesa. An air quality monitor, often referred to as the CDF monitor or tower, located one-half mile east of ODSVRA near the residential community of Nipomo, has recorded eight exceedances between 2010 and 2015 of the federal daily PM10 standard of 150 micrograms (one-millionth of a gram) per cubic meter of air (expressed as 150 $\mu g/m^3$), and nine exceedances of the PM2.5 standard of 35 $\mu g/m^3$. The California daily standard for PM10 is 50 micrograms per cubic meter of air. Between 2010 and 2015 there have been 420 recorded exceedances of the California standard. The federal and state standard for annual average emissions of PM2.5 is 12.0 $\mu g/m^3$. This standard too has been exceeded in this time frame.

Several studies have been performed by the San Luis Obispo County Air Pollution Control District (APCD) to help better understand dust emissions emanating from the ODSVRA. APCD's 2004 studies concluded that northwesterly winds from ODSVRA upwind of the Nipomo Mesa were the largest factor resulting in the high particulate matter levels there.[27] However, the study was not conclusive as to the whether OHV use within ODSVRA contributed to the high particulate matter levels. As a result, APCD undertook additional studies in 2010 that concluded that OHV activity is a major contributing factor to the high particulate matter levels recorded on the Nipomo Mesa, and that the primary emissions cause was indirect impacts associated with OHV use.[28] APCD has estimated that 75% of days with particulate matter levels over the California standard are due to OHV use. Although DPR did not accept all of the findings or conclusions of the APCD studies due to objections regarding the study methodologies, APCD adopted Rule 1001 in 2011 to address these air quality impacts (see **Exhibit 8**).[29]

APCD Rule 1001 required DPR to monitor PM10 and to implement appropriate mitigation measures to meet State and Federal air quality standards. In order to comply with Rule 1001,

[27] APCD's Nipomo Mesa Phase 1 Particulate Study (2004).

[28] APCD's South County Phase 2 Particulate Study (2010).

[29] Rule 1001 was the subject of litigation (Friends of Oceano Dunes v. APCD (San Luis Obispo County Superior Court Case CV12-0013)). Most recently, following initial Superior Court (2013) and Appellate Court (2015) decisions, and despite Friends of Oceano Dunes argument that Rule 1001 is entirely invalid, the Superior Court indicated on March 7, 2016 that APCD retains the power to enforce Rule 1001.

DPR must implement an APCD-approved Particulate Matter Reduction Plan (PMRP).[30] Given implementation of the expected PMRP will include a series of development activities, DPR applied for a CDP in 2012 (CDP application number 3-12-050), and Commission staff has worked closely with DPR and APCD ever since on identifying the materials necessary to complete that application and set it for a Commission hearing. As of today's date, the CDP application is not yet filed, with the key piece of information being the analyses (including evaluation of various alternatives) being prepared by DPR through their ongoing EIR process.[31]

In the meantime, DPR has applied for emergency CDPs, including as a means to try to meet the federal daily PM10 standard (if DPR is able to meet this standard, the U.S. Environmental Protection Agency (EPA) has indicated that it will not designate this as a nonattainment area).[32] Due to the significant public health problems posed by the dust and the need for immediate action to address those health effects, and working with the California Air Resources Board (CARB), APCD, and DPR, the Commission has granted four emergency CDPs (ECDPs) between 2013 and 2016 (ECDPs G-3-13-0213, G-3-14-0007, G-3-15-0014, and G-3-16-0023).[33] Each of these ECDPs has provided for different dust control and monitoring measures, with DPR's efforts so far focusing on installing hay bales and fencing as a means of reducing dust, and monitoring equipment as a means of measuring effectiveness, both in and outside of riding areas. As of today's date, many measures remain in place despite ECDP requirements that they be removed and affected areas restored (see also potential violation finding).[34]

Clearly, additional work is to be undertaken as part of DPR's continuing efforts at dust control and Rule 1001 compliance. Commission staff continues to work closely with DPR, CARB, and APCD in this respect, with the hope that DPR will soon reach agreement with APCD on a PMRP, that DPR will complete its EIR efforts, and that the dust control CDP can soon be scheduled for Commission action as a means of addressing the significant dust and public health issues associated with ODSVRA. As the EIR and CDP application process continue to unfold, staff believes that there will be ample opportunity for the kind of evaluation of alternatives that will prove critical for implementing a dust control program that can meet the requirements of APCD Rule 1001 and the Commission's CDP, and that will result in measurable air quality improvements. It will be important for such evaluation to study the air quality impacts associated with a variety of targeted controls, including establishing more vegetated areas in the foredunes as has long been suggested by APCD as the most appropriate measure to reduce ODSVRA dust. Staff remains committed to working with DPR to both perfect its CDP application and to provide whatever assistance it can to help address this significant public health problem. Ultimately,

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[30] DPR is still in the process of working with APCD to final its PMRP, and is currently out of compliance with Rule 1001 requirements and deadlines for approval and implementation of the approved PMRP.

[31] DPR released its Draft Program Environmental Impact Report(Oceano Dunes SVRA Dust Control Program Draft Program Environmental Impact Report, State Clearinghouse #2012121008) in August 2016. Parks received many comments to the draft, including from Commission and APCD staff, and have not yet finaled their EIR.

[32] Some residents of Nipomo have requested that EPA designate this portion of the County as a nonattainment area for the federal PM10 standard. Because implementation of the APCD Rule 1001 will in theory provide necessary controls to protect public health in the region, EPA has indicated that they will first allow DPR to work with APCD on timely implementation of the Rule and assess its impact on air quality, and then will determine what actions EPA should take, if any.

[33] The Friends of Oceano Dunes challenged the Commission's issuance of an ECDP in 2016 for implementation of DPR's dust control and monitoring measures, and this litigation is still pending.

[34] In addition, the ECDPs required a series of monitoring reports to better understand the efficacy of the devices at reducing PM emissions. However, Parks did not provide any of these reports, and this is part of the violation as well.

resolution of this issue will be tied to Commission action on the dust control CDP application at a later date, hopefully in early 2017.

D. La Grande Property

The La Grande property is a 584-acre San Luis Obispo County-owned parcel located just south of the current staging area that is currently used as an OHV riding area. The La Grande property currently makes up about 40% of the area that DPR currently provides for OHV riding at ODSVRA. The La Grande property was on a 25-year lease from the County to DPR that expired in 2009, and it is now leased on a month-to-month basis. The area has long been subject to debate over its proper use, including whether it should be used for riding activity or whether it should be off-limits to such use and rather serve as protected dune habitat. While the La Grande property is currently and has been historically used for riding activity and is located in direct proximity to the existing access and staging areas, immediately north is the Pismo Dunes Natural Preserve, and immediately east is the LCP-protected Dune Lakes area. Thus, the area is at a geographic crossroads between riding and protected dune areas, and its ownership not by DPR but rather the County, has all contributed to the debate over its proper use. In addition, the LUP calls out the La Grande area as a buffer not to be used for riding (though staff acknowledges that, inconsistent with this designation, the LUP also currently allows riding on La Grande Tract west of Sand Highway) (see **Exhibit 9**), and this issue has been the subject of litigation, all as described below.

Furthermore, as previously described, when the CDP was approved in 1982, it designated the two access points at West Grand Avenue and Pier Avenue, as well as the staging area located just north of the La Grande property, as interim. The intent of the CDP was to require, within 18 months of LUP certification, selection of a permanent staging area, with the LUP and CDP amended to codify the selected locations as permanent. Only once a permanent entrance and staging system was operational could the interim access locations also be considered permanent.[35] The CDP thus allowed access routes, staging, and riding within part of the La Grande property on a <u>conditional</u> basis until all such issues were resolved pending further study.

The LUP was certified in 1984, two years after the CDP was approved. The South County Coastal Area Plan, a component of the LUP, included policies addressing the Park in general, and, specifically, the La Grande property (see **Exhibit 7** for these policies and figures). LUP Recreation Policy 9 states that riding activity is only allowed in "identified unfenced vehicular use area…identified in Figure 4." LUP Figure 4, in turn, identifies the Pismo Dunes Natural Preserve, the Oso Flaco Lakes Area (which the CDP identified as off-limits to riding activity), <u>and</u> the La Grande property <u>and</u> the shoreline south of Pier Avenue (i.e., the CDP-identified interim access location and route) as buffer area, which LUP Policy 9 says is "designated natural area…required for habitat protection…." However, LUP Policy 9 also explicitly says that riding within the La Grande property "shall be limited to the Sand Highway west to the sandy beach", which will minimize conflicts with the protected Dune Lakes area to the east and the preserve to

[35] The location of the identified staging area would most certainly affect the location of the appropriate permanent access location(s) because the access location needs to be used to reach the staging area.

the north.[36] The policy concludes by saying that the riding map in LUP Figure 4 "indicates a buffer area along these critical interface areas." Finally, LUP Policy 10 states that the management and use of the La Grande property shall be "reexamined periodically to establish the most appropriate management capability."

The CDP's terms and conditions and the LCP's policies have all further underscored the uncertainty regarding the La Grande property's proper use. While the CDP allowed for part of the property to be used for riding, it also designated the northern access and staging areas adjacent to the property as interim. The fact that that the LCP, which was adopted <u>after</u> the CDP was approved, designates the La Grande property and the beach adjacent to it as natural habitat buffer off limits to riding suggests that the longer term goal is to phase out riding and create a large, continuous protected dune area if that is possible. In this context, the LCP's statement that riding activity is allowed between the shoreline and the Sand Highway (LUP Policy 9), which generally bisects the property such that nearly half of the La Grande property is between the shoreline and Sand Highway,[37] should be read as a statement that the LCP recognizes that riding activity is currently allowed in this area pursuant to the CDP, but should be understood in the broader context that such allowance is <u>interim</u> until both the CDP and LUP are amended to designate the permanent access and staging locations, at which time such use may be phased out to allow the entire northern Park area to be protected dune (as apparently is envisioned in LUP Figure 4). Thus, the LUP (which came after the CDP) identified La Grande as a buffer area as an LCP objective, but it was recognized through the CDP that that objective depended on finalizing access and staging locations, and that the LUP would be amended at that time as necessary to account for such final locations. In other words, the issues surrounding the La Grande tract are intertwined with those associated with finalizing park access and staging, and its final disposition in that sense may be affected by the outcomes of those decisions (see also Section A above).

Commission staff has previously informed the County and DPR of the LCP policies governing the La Grande property's use. In anticipation of DPR's 25-year lease expiration in 2009, DPR sought to acquire the La Grande property from the County. In 2007, prior to the proposed sale, the County requested Commission staff's opinion regarding the relevance of LUP Figure 4 and the LCP more broadly in its application to the proposed La Grande Tract sale. The County requested that staff respond to County staff's then-position that Figure 4 was "background information and advisory, but not regulatory or a critical component of the LCP." In response, Commission staff sent a letter to County staff (see the letter in **Exhibit 6**), stating that, based upon past actions regarding the CDP and the LCP, including the fact that LUP Figure 4 and the LCP were adopted by the Commission <u>after</u> approval and subsequent amendment to the CDP, it was "Coastal Commission staff's opinion that Figure 4 was intentionally included within the certified LUP to reflect the long-term objectives shared by the County and the Commission for this sensitive dune habitat area, **which included phasing out of the northern access route for OHV use and restricting OHV use on County owned land**" (emphasis added). Therefore, "contrary to the County staff's presumption that Figure 4 should be viewed as background information only, it is the Commission staff's opinion that both Figure 4 and the associated LCP policies establish important standards that are applicable to the use and development of the

[36] It is worth noting that Sand Highway basically bisects the La Grande Property such that nearly half of it is west of the Sand Highway.

[37] The Sand Highway location is not shown in the LCP, but is shown in the CDP in Exhibit C (see page 6 of **Exhibit 4**).

County owned lands at issue." The letter concluded that it was Commission staff's opinion that selling the La Grande property to DPR for the stated purpose of retaining OHV use would be inconsistent with the land use designation for that site as an area off-limits to OHV use, as designated by Figure 4 (again, see **Exhibit 6**).[38]

The letter identified that the Commission construed the LCP as conveying an overarching intent at the time of adoption with respect to its treatment of the La Grande property to recognize that riding should eventually be phased out if possible in this area since the objective at that time was to move the access, staging, and riding areas to the south. Assuming that the access and staging areas were moved further south, the La Grande property would no longer be accessible by vehicles coming through the Park from the north, and could instead be a County-owned protected dune area adjacent to other protected areas. The letter notes: "Thus, the relevant LCP policies and Figures reflect the interim status of the OHV and camping use patterns in effect at the time of certification, and the County and the Commission's long term desire to provide increased protection of sensitive dune habitats, among other ways by relocating the OHV staging area to the south, and establishing a buffer area on all County owned lands." Thus, the LCP's treatment of the La Grande property should be understood in the then-identified vision for the access and staging areas to be moved elsewhere away from the northern Park boundary if possible, allowing for this entire area to be protected dune off limits to riding use (though the final access and staging area determinations ultimately will need to be determined through the required access study).

However, since that time, much has changed. While the access and staging areas are still technically interim pursuant to the CDP, they have been operating there for 35 years, much longer than the initially-identified 18-month post-LUP adoption timeframe to select the permanent access and staging locations. In other words, while the LUP was written at a time when the understanding was the CDP would be quickly amended to determine the final Park management and use configuration, such an amendment never happened. The Park has been operating in its interim manner for so long that many have forgotten this original premise. However, the LUP's policies and directives must be understood within this historic context, and its relationship to finaling the Park access and staging system. That is not to say that the vision of access, staging, and riding activity relocated elsewhere within the Park and prohibiting vehicle use in the La Grande property is not still viable and LUP compliant, nor does it mean that the final access, staging, and riding areas necessarily must be relocated elsewhere, as Parks must provide an updated access alternatives analysis to objectively determine and designate the permanent access and staging areas (see previous findings above on this point and **Special Condition 1**). Rather, it is a recognition that the LUP was written at a time when the paradigm of

[38] Prior to the sale, the County's Planning Commission concluded that the proposed sale of the La Grande property to the State would be inconsistent with Figure 4 of the South County Area Plan. On April 17, 2007, the County Board of Supervisors partially denied The Friends of Oceano Dunes appeal of the Planning Commission's decision. The denial meant that the Board upheld the Planning Commission's decision confirming that the sale would be inconsistent with the General Plan and LCP. Two lawsuits resulted from the proposed sale, which were ultimately consolidated (Friends of Oceano Dunes v. County of San Luis Obispo, and Sierra Club v. State of California. In the Sierra Club suit, the plaintiff (Sierra Club) sought a traditional writ of mandate to compel the State to operate ODSVRA in compliance with the County's LCP. The Sierra Club contended that the Figure 4 buffer map delineates the La Grande property as a buffer zone and that the LCP prohibits all OHV use in the buffer zone. The Sierra Club argued that the State is operating in the La Grande property in violation of the County's LCP, and claimed that the State must revise its general development plan to comply with the LCP. The Court ultimately found that it could not reach the merits of this case because the lawsuit was not a timely challenge to a specific agency action.

Park management, including determining where access, staging, and riding were to be located, was different and in flux under the LCP. Furthermore, LUP Policy 10 includes language specifying that management of La Grande shall be periodically reexamined to determine the most appropriate management capability, suggesting that, in this dynamic and difficult Park management context, different conclusions about La Grande's use could be ascertained in the future. This policy's inclusion gives credence to the idea that while LUP Policy 9 stood for allowing riding in La Grande between the sea and Sand Highway, particularly at the time the policy was written, other conclusions about proper use could be made in the future given the changing nature of Park management.

It is clear that the uncertainty and issues surrounding the La Grande property need to be resolved, particularly with respect to how the property's use relates to the designation of permanent access and staging locations, and vice versa. The Commission is in a position to help resolve these issues, particularly with respect to designating permanent access and staging areas pursuant to Special Condition 1, and properly evaluating the CDP under relevant LCP policies. Commission staff will continue to work with Parks and the County on these critical interrelated issues, including developing LCP amendments to address final decisions on Park access and staging locations, as well as future use of the La Grande Tract.

E. ESHA PROTECTION

Background

As previously stated above, and despite ongoing OHV and vehicular use, ODSVRA represents a rich coastal resource area, and it has been designated as an environmentally sensitive habitat area (ESHA) by the Coastal Commission, including in the certified LCP. In fact, ODSVRA is part of a larger and significant and sensitive ecological system, the Nipomo-Guadalupe dunes complex, that has been identified as critical habitat for the threatened Western snowy plover, and supports endangered species including the California least tern, Steelhead trout, and Tidewater goby. Although the California and State Endangered Species Acts (ESAs) are directly administered by other resource agencies, the Coastal Commission has an independent authority under the Coastal Act to protect coastal resources in general, and ESHA specifically. In discharging this responsibility, the Commission has typically found that ESA-listed species and their habitats are protected as ESHA, including listed species habitat that are present at ODSVRA. The terms and conditions of the ODSVRA CDP have always recognized this fundamental Coastal Act concern as it relates to these species, and its provisions for ongoing review and adaptation reflect the need to reevaluate management measures on a regular basis to ensure the Coastal Act is upheld. That is not to suggest that the Commission is somehow attempting to administer the ESA, as some have suggested, because it is not. Instead, the Commission is exercising its well established role for protecting ESHA, including as has been long and frequently been upheld by the Courts with respect to Section 30240 of the Coastal Act. In other words, the development regulated by the CDP (including physical development as well as changes in the intensity of use of land resulting from Park's ongoing management of vehicular use) has impacts to significant coastal resources (including ESHA) which also have independent significance under the California and Federal Endangered Species Act. However, consideration of the coastal resources under those regulatory frameworks is relevant and necessary to their consideration under Coastal Act ESHA protection policies (Section 30240).

Significant concerns have been raised over the years regarding the manner in which ESHA is being protected at ODSVRA. In fact, it is probably the most significant issue contemplated by the CDP as amended, and indeed the CDP is premised on finding the proper balance between allowing for vehicular use and protecting ESHA. Such issues are exacerbated by the fact that the Park includes significant habitat for a series of ESA-listed and other sensitive species, both located in and out of the vehicular riding areas. The fact that DPR has been unable to complete an HCP (see also HCP section that follows), only amplifies concerns about habitat protections, particularly related to Western snowy plover, California least tern, Steelhead trout, and Tidewater goby.[39]

DPR's Sensitive Species Management

At the same time as there exist challenges in protecting listed species, DPR has also committed significant resources to its habitat measures. DPR works with USFWS and CDFW to ensure necessary habitat management measures are in place. For example, CDFW works closely with DPR on its plover and tern habitat protection programs. Since DPR does not have authorization to take any listed or threatened species (and since CDFW is not allowed to authorize any take for tern except for authorized research pursuant to its designations as endangered under the California ESA and as Fully Protected under Fish & Game Code Section 3511), CDFW routinely works with DPR to ensure that protective measures are in place to avoid take as much possible. Each year, DPR provides to CDFW and USFWS a "Nesting Season Management Plan to Avoid Take of the California Least Tern (CLT) and Western Snowy Plover at Oceano Dunes State Vehicular Recreation Area". The Plan each year states "…DPR believes that it can continue to operate the SVRA and provide protection (attempting no take) of the listed species through the implementation of various protections, monitoring, and management measures as described…". The Plan then identifies a number of protective measures to guard against take of plover and tern, measures which are based on prior biological opinions and previous years' Plans. These measures include buffers around nests (a minimum of 100 meters), fencing requirements, and restrictions on vehicular activity at night.

In addition, since its inception, a primary TRT and Scientific Subcommittee research task has been to study appropriate management techniques for snowy plover, least tern, steelhead trout, and tidewater goby (as specifically required per Special Condition 5(a) of the CDP's fifth amendment). As part of this research, the TRT reviews and comments on the annual *Nesting of the California Least Tern and Western Snowy Plover at Oceano Dunes State Vehicular Recreation Area* report, prepared by DPR staff. Recent nesting reports have shown that the ODSVRA fledge[40] rates for both plover and tern have generally been above USFWS's recovery goal of one fledged chick per adult male. The 2014 nesting report, as summarized by the TRT's annual report, generally also echoes such findings:

> *WSP had a good hatching success with 82.6% (compared to an 77.8% hatch rate for 2013), and a chick fledging success rate of 35.8% (compared to a 55.4% fledging rate for*

[39] California least tern are listed as an endangered species under both the Federal and State Endangered Species Acts, Tidewater goby are listed as engendered under the Federal Endangered Species Act, and both Western snowy plover and South Central Coast steelhead trout are federally-listed as threatened.

[40] For Western snowy plover, a chick is considered "fledged" if it survives to 28 days; for California least tern, 21 days.

> *2013 and a 25.0% fledging rate for 2012). **The WSP fledge rate was an estimated 1.63 juveniles fledged per male**, exceeding the U.S. Fish and Wildlife Service (USFWS) recovery goal of one fledged chick per adult male but falling below the previous year's rate of 2.03. CLT had a 2% decrease of breeding pairs from the 2013 season with a minimum of 47 pairs compared with 48 in 2013. Fifty-eight of the 76 chicks fledged for a rate of 76.3% and **1.23 chicks fledged per pair**.* (emphasis added)

The report further found that the Oceano Dunes area has seen "remarkable growth" in the adult plover breeding population, but least tern breeding numbers remain flat for unknown reasons.

DPR also performs numerous management measures to aid in sensitive species' protection. For example, DPR fences off a designated area during the March through September least tern and snowy plover nesting season. This area, called the Southern Exclosure, is a roughly 300-acre protected area closed to public entry, including for OHV use, for those seven months. In addition to this designated area, DPR indicates that it also fences off any least tern or snowy plover nests found in the open riding area. Single nest exclosures of differing sizes may also be used to protect snowy plover nests in areas where vehicles are not permitted (e.g., the Oso Flaco Lakes area). With respect to Arroyo Grande Creek, which provides habitat for Steelhead trout and Tidewater goby, DPR currently limits vehicle crossing of the creek when it is flowing. DPR provides drivers with a memo stating "it is prohibited to cross Arroyo Grande Creek in any other manner than by crossing the creek as close to the ocean waterline as possible and parallel to the ocean waterline. Driving upstream or downstream in the creek channel or in any other manner in the creek channel is prohibited. If the creek crossing is posted 'closed', crossing the creek is prohibited." According to DPR, the Creek is typically closed to crossing when its depth would extend above the axles of vehicles attempting to cross. USFWS recently informed Commission staff that the measures that DPR is taking by posting no-access signs by the back lagoon where goby are found are likely sufficient to prevent take of goby.[41]

Resource Agency Concerns

However, because of the complicated and dynamic natural environment at ODSVRA, including containing dunes, wetlands, creeks, and beaches, all of which are habitat for multiple listed species, the manner in which DPR manages habitat function is not without concern. Additionally, sensitive species are harmed at ODSVRA, and continuing habitat impacts are a cause for some alarm. For example, a March 29, 2016 USFWS letter informed DPR that three snowy plovers were killed by vehicles over the preceding 30-day period (see USFWS letters in **Exhibit 10**). The letter reiterated that DPR does not have take authority. The letter goes on to state:

> *State Parks has been developing a Habitat Conservation Plan (HCP) as part of an application for an Incidental Take Permit from the U.S. Fish and Wildlife Service (Service), while at the same time implementing measures intended to avoid impacting*

[41] Personal communication with Chris Dellith of USFWS on December 12, 2016 and Brittany Struck of USFWS on December 14, 2016. However, in general, Steelhead trout can be found to move upstream during flows as shallow as six inches, which is lower than some vehicle axles. And it is not clear with what frequency DPR staff is present at the Arroyo Grande Creek during times of flow to enforce the rules regarding crossing the Creek. In addition, because vehicles can enter and exit the Park after hours, and because DPR is not able to monitor crossing at all times, there may be more inappropriate crossing than has been identified to date.

> *federally-listed species, particularly, the western snowy plover and the federally endangered California least tern (Sterna antillarum browni). However, as evidenced by the recent mortalities, as well as other mortalities of both western snowy plovers and California least terns that have occurred since 2001, the measures being implemented are not adequate to fully avoid take, and thus violations of the section 9 take prohibitions of the Federal Endangered Species Act continue to occur*.

The letter concludes by stating that “violations cannot continue”, and that the way to ensure compliance with the ESA is to both complete the HCP process (discussed below) as quickly as possible, and to institute enhanced avoidance and minimization measures to avoid take, including potentially reduced speed limits and better enforcement of existing limits, additional beach closures, and cessation of special events. Since this letter’s issuance, USFWS indicates that there have been three more plover mortalities caused by vehicle activity.[42]

In addition, while CDFW reviews and approves the previously discussed yearly plover and tern management plans as including sufficient measures to avoid take, take does occur, including as evidenced by seven documented tern deaths in 2014. Further illustrating this issue, in a March 3, 2016 CDFW letter, CDFW indicates that over the past fifteen years there have been 10 documented incidents of take of California least tern (see CDFW letters in **Exhibit 10**). The letter concludes that the proposed 2016 Nesting Plan for least tern “reduces previous protections for CLT at ODSVRA.” The letter goes on to state that two additional measures provided in guidance letters to DPR in 2002, 2004, 2006 and 2015 should be incorporated. The letter concludes that implementation of the measures identified by DPR in addition with measures supplied in the letter “will result in take of CLT at ODSVRA being unlikely.”

NOAA fisheries is also working with DPR to address issues concerning Steelhead trout and Tidewater Goby in relation to vehicles crossing Arroyo Grande Creek. In an email to DPR dated December, 16, 2016, NOAA Fisheries informed DPR of a desire to revisit NOAA’s 2008 letter regarding take of Steelhead trout, and discuss the possibility of incorporating seasonally-specific minimizations measures for vehicle crossing of the Arroyo Grande Creek during times when the creek breaches the sandbar and flows to the ocean, a time when steelhead are more likely to be using the creek while vehicles are still allowed to cross the creek.

All of this information highlights three primary points. The first is that notwithstanding DPR’s efforts there are significant problems at ODSVRA with respect to sensitive species ESHA protection, including as evidenced by take of listed species, and by the range and depth of resource agency concerns. Second, is that managing the various habitats and species at the Park is a difficult endeavor on its own accord, and that such management must be performed within a vehicular recreation area only exacerbates that difficulty. And third is that because of this inherent difficulty, collaboration is necessary both to understand these complex issues and in order to best address them. Individual agencies cannot operate in isolation from one another, but need to instead share information and best practices in order to collaboratively work with DPR on instituting potential adaptation measures. Unfortunately, the current CDP’s structure does not offer a strong enough platform for this direct collaboration, including because such collaboration

[42] See USFWS letter dated December 22, 2016 in **Exhibit 10**.

is only channeled through the TRT process and subject to its operating parameters. For example, Commission staff only recently became aware of USFWS and CDFW concerns regarding take (as described above and in the agency letters in **Exhibit 10**) after staff contacted them seeking their input on current Park habitat management status. That such information only became available in this manner highlights the need for CDP changes to best perfect resource management coordination and collaboration. This collaboration and the adaptive management emanating from it forms the basis of the staff-recommended CDP changes (see also prior sections regarding day-to-day operations, and the HCP and TRT sections that follow).

TRT Scientific Subcommittee Concerns
As described above, currently DPR fences off the Southern Exclosure from March through September. However, for the five month period from October through February, the Southern Exclosure area is open to public use, including camping, street-legal vehicles, and off-highway vehicles. This recreational use results in large areas of flattened terrain and barren sand with very limited scattered natural debris and vegetation. The nesting report recommends, at a minimum, extending the Southern Exclosure area's fencing 100 feet inland in order to improve shoreline habitat, noting that there was an increase in plover and tern nests in the years 2012-2014 when compared with 2011, likely a result of moving the fence eastward at that time. Moving the fence eastward and extending the exclosure area should have similar benefits for snowy plover productivity. Therefore, the report recommends that for the 2015 breeding season, the Southern Exclosure fence be moved eastward 100 feet of its typical location.

For many years, the TRT's Scientific Subcommittee has consistently recommended that DPR study whether a year-round closure of a designated area within the Park would improve plover and tern habitat quality and productivity. Specifically, the Subcommittee has focused on making the Southern Exclosure permanent. Essentially, the Subcommittee has concluded that habitat nesting quality is potentially compromised due to the fact that a seven-month closure and the subsequent five-month use period may not allow enough time for the habitat to recover from OHV use. DPR has not to date implemented that recommendation, nor has the Commission required it via past CDP reviews. DPR indicates that the size of the riding area has been reduced from 25,000 acres prior to 1983 to less than 1,500 acres today, in large part to protect sensitive habitats. DPR's 2014 annual report states "the park believes it is having good results with the current management program", while also stating that any additional closure of the Park to OHV use would be inconsistent with its legislative mandates to provide for vehicular riding and its management goals of providing public recreational opportunities. Therefore, DPR has not been supportive of the proposed year-round exclosure for snowy plover and least tern habitat protection.

While ongoing research and management of plover and tern habitat protections is a principal concern of the CDP due to ongoing impacts vehicular use on these coastal resources and good resource management in general, such additional analysis as part of a year-round exclosure <u>study</u> is not necessarily warranted in this case. On a basic level, it can be reasonably concluded that designating a particular area off limits to vehicles year-round would effectively help to enhance its habitat, including by ensuring that the habitat is allowed additional restoration time. Indeed, the number of plover and tern nests increased in previous years when the exclosure boundaries were increased, underscoring the inherent concept that additional protected area will benefit sensitive species. Thus, it is probably not necessary for DPR to undertake a specific study to essentially find what can already be reasonably concluded, in that increasing protections for plover and tern habitat, whether spatially or temporally, will help benefit their survival.

One option available to the Commission to better protect these species in light of the TRT Scientific Subcommittee's recommendations is to require the Southern Exclosure to be made permanent. Doing so, however, would reduce vehicular riding area significantly (by some 300 acres). Although staff recognizes the habitat benefit of such an approach, staff remains cognizant of the CDP balance that is meant to be achieved between vehicular use and resource protection. Although making the Southern Exclosure a year-round exclosure, recognizing the benefits to these listed sensitive species, may be justified, it is more appropriate to consider such an action within the framework of the modified monitoring and reporting process, where the costs and benefits of such an action can be weighed in light of the overall balance that the Commission is trying to help Parks achieve at ODSVRA between recreational vehicular use and resource protection.

Conclusion

There remain significant ongoing issues related to sensitive habitat management at ODSVRA. All of this points to the fact that while DPR undertakes a comprehensive management program to assist plover and tern populations, and applies other measures to protect other listed species, it has not fully mitigated impacts to these important ESHA resources, as discussed above. These impacts are being continually reviewed and monitored by partner resource agencies with relevant jurisdiction offering their expertise, review, and analysis of best practices so as to respond to and best protect these species and their habitats. At the same time, and particularly given the almost ten-year period when Commission staff was not significantly participating in ongoing and TRT related Park management issues, the Commission is in a sense now playing 'catch-up' at the current time. Staff believes that the Commission is best served holding off on taking any specific major actions associated with the CDP at the current time explicitly related to ESHA and sensitive species. Instead, staff believes that the changes to the monitoring program recommended herein will allow for a more robust evaluation of the various habitat issues intertwined with vehicular use at ODSVRA under the CDP, and that changes associated with ESHA and sensitive species are better contemplated through that process. That is not to say that staff will not endeavor to work with our partner resource agencies and DPR to help facilitate good changes to better protect resources (such as those recommended by USFWS, CDFW, and NOAA Fisheries above), but more that dramatic changes (such as the proposed year-round Southern Exclosure) are best understood in relation to robust and detailed information regarding the costs and benefits of any particular action as they relate to the CDP balance meant to be achieved between providing for vehicular and other forms of recreation, and protecting sensitive species and their habitats and other ESHA. Other significant changes may also be evaluated through finalizing the access and staging system for the Park (e.g., issues associated with Arroyo Grande Creek crossings and use of the La Grande property), and are thus intertwined in that way. Thus, in addition to the reasons stated above (regarding access and staging) and below (regarding the HCP and transitioning the TRT), staff recommends that the Commission adopt the revised conditions identified in this report to alter and better facilitate consideration of Park management changes at the appropriate junctures, particularly as it relates to annual reporting and adaptation processes, under the CDP. See these other report sections for more detail on such changes.

One minor change that staff does recommend is to augment CDP dune protections with respect to fencing. Currently, there is some confusion over what DPR is required to do in relation to vegetated areas in the riding area. The CDP requires fencing be a minimum of 100 feet from the vegetated areas being fenced, but does not define what constitutes a vegetated area (e.g., a single plant or a larger accumulation of plants). The CDP allows for a reduced buffer, but only where it can be demonstrated that a lesser buffer will offer equivalent protections for the fenced area, subject to Executive Director approval. This process has not recently been invoked. To help in providing definition, the Commission adds **Special Condition 3.** Special Condition 3 does not alter the basic parameters associated with such fencing, including the requirements associated with the 100 foot buffer and the requirements for a lesser buffer requiring Executive Director approval, but it does update dune fencing protections associated with these vegetated areas. The intent is that significant vegetated areas within the riding area be fenced, and riding and other disallowed activities would remain prohibited within these vegetated "island" areas. Such vegetated island fencing will need to be adjusted on a regular basis to respond to shifting vegetation, including as necessary to fence off new areas of significant vegetation, with an emphasis and preference on adaptation designed to ensure larger and more contiguous vegetated dune areas, as opposed to smaller and more isolated vegetated dune fragments. In all cases, DPR will need to ensure that the acreage of vegetated islands in the riding area is not reduced from January 2017 levels (allowing for "islands" that become connected to the perimeter non-riding area through adaptation to be counted toward vegetated island acreage). Such a condition is to be understood in relation to Special Condition 2's DPR-led adaptive resource management program, as well as Special Condition 4's monitoring and adaptation requirements. All of these conditions are meant to best manage sensitive Park resources in an adaptive fashion under the CDP.

As conditioned, the CDP offers an updated platform for adaptive dune habitat management, keeping with the CDP's intent on balancing vehicle recreational activity and resource protection.

F. Habitat Conservation Plan

DPR has been in the process of developing a HCP for ODSVRA for over 15 years. The HCP is required by the USFWS for the protection of listed species at ODSVRA, such as the Western snowy plover, California least tern, steelhead trout, and tidewater goby. The primary purpose of the HCP is to ensure that park management, maintenance, and development activities protect these threatened and endangered plant and animal species consistent with the federal and state Endangered Species Acts.

According to DPR, the HCP is now on the revised third administrative draft under review by the USFWS and CDFW, and upon review and insertion of additional refinements, DPR plans to release a public review HCP draft (there has not to date been a publicly available review draft). Staff and DPR have been in dialogue about overarching HCP issues and programs, including how such HCP requirements may affect the CDP and Parks' ongoing management program. The Commission was clear in 2015 that it strongly believes that DPR needs to make progress on the HCP to ensure that sensitive habitats and endangered and threatened species are protected as required by the ESA at ODSVRA. Future action on the HCP by USFWS may be subject to Commission review pursuant to the federal consistency provisions established by the Federal Coastal Zone Management Act to determine the consistency of the HCP with the Coastal Act. In addition, all development activities contemplated by the HCP will be subject to CDP requirements and/or inform new CDP conditions needed to ensure sensitive habitat protection.

Therefore, because the HCP is integrally related to Park management and resource protection, including with respect to how particular mandates emanating from the HCP will affect the Park's CDP and vis versa, it is critical that the HCP be completed as soon as possible. The HCP will also play a critical role in determining what actions USFWS and CDFW require DPR to undertake so as to ensure protection of threatened and endangered species, and how such actions already are or need to be codified in the CDP's resource management context (including with respect to Special Conditions 2 and 4's adaptive management and oversight requirements). The HCP also provides a rich information base that needs to be understood in relation to the ongoing monitoring and annual reporting changes identified herein, and can help provide DPR a means of meeting such requirements in a way that is as streamlined as possible.

Thus, the HCP will play a key role in determining the requisite resource management measures Parks must undertake to balance vehicular use with resource protection, and may become the impetus behind future CDP amendments as the intensity of use of the park is potentially modified. While no specific Commission action is necessary at this time with respect to the HCP in context of this CDP, the Commission may need to weigh in on specific HCP-required management actions in the future as they affect development at the park. Commission staff remains ready to work with DPR, USFWS, and CDFW on these critical issues.

G. Transitioning the TRT

The final section of each annual DPR review contains the TRT facilitator's recommendations regarding the future of the TRT. From 2008 to 2014, the facilitator noted the TRT members' desire to abandon the TRT as a functioning advisory group. The reasons identified in the past to dissolve the TRT are many, including a sense that its role had been fulfilled, that public involvement would be available through other venues and processes, and that, after nearly 16 years, this volunteer-based advisory group had simply outgrown its effectiveness. The facilitator also noted that there has been less openness for compromise on particular decisions and that, overall, the TRT no longer serves as an effective park management tool. The level of TRT participation has declined, and some members, such as the CDFW, have not participated on the TRT for years, despite the fact that the CDP requires CDFW's membership. Coastal Commission staff has only recently, since 2013, returned to participate in the TRT. And critically, the TRT's recommendations are just that, advisory recommendations. And those recommendations are provided to the Commission and Parks without any ability for the Executive Director to review and approve them, as is typically the case with ongoing CDP reporting processes like this. This means the TRT recommendations reflect the TRT, but not necessarily the direction recommended by DPR or the Executive Director. The current structure thus does not provide DPR or the Commission with the needed flexibility to adapt to and respond to identified concerns. As such, DPR staff has concurred on the overarching notion that the TRT has outlived its effectiveness in relation to the CDP, and has voiced interest in a replacement alternative management structure. All of this points to the fact that it is time for the TRT to be phased out and replaced with an alternative program for adaptive Park management and Commission review to ensure development associated with adaptive management is consistent with the Coastal Act.[43]

As noted at the outset, a fundamental component of this review relates to the TRT and whether to allow it to continue to function as identified by the amended CDP. Pursuant to the explicit text of the CDP, If the Commission finds that the TRT has been effective at managing vehicular impacts at the Park, then the Commission can allow the TRT to continue to be the primary CDP implementation mechanism for that purpose for another year. If the Commission is not satisfied, it may, through this review process, institute alternative approaches to resource management or institute a new set of management measures. At this time, staff recommends that it is timely to institute alternative management criteria at ODSVRA so as to best accomplish the CDP's overarching intent of balancing recreational vehicle use with resource protection, as they relate to ongoing coastal resource impacts associated with the terms and conditions of the CDP.

As described throughout this report, the fundamental premise of the CDP since its approval in 1982 has been this balancing of recreational vehicle use and resource protection. That is, ongoing uses at the Park implicate complicated, and sometimes competing, Coastal Act priorities of providing for public recreational uses, and vehicular use in this case, while also ensuring protection of fragile coastal ecosystems, including habitats of threatened and endangered species. Striking that appropriate balance, including articulating the correct oversight and management structure to ensure development is consistent with the Coastal Act, has been a key tenet of the CDP. For the past 16 years, the CDP has been structured around the TRT as the body to help provide the guidance necessary to oversee Park management. The TRT sought to implement this balancing by convening a team of stakeholders and interested parties, some with competing interests (e.g., riding community and environmental community) and some with regulatory authority over specific Park actions (e.g., USFWS and the Coastal Commission), in order to foster a collaborative dialogue about various resource management issues. The intent was to convene these stakeholders in a manner that would allow for shared perspective and understanding of management issues and a common forum for discussion of potential actions to address such issues. Notably, as described previously in this report, the most basic framework for the TRT to implement identified management solutions was in an adaptive approach. The idea was to enable the TRT to continuously study Park management issues, including with respect to use limits, habitat protections, and public access enhancements, and make changes to implement needed actions on a continuous basis.

While there is a common understanding that the TRT as a formal, CDP-codified advisory body has run its course, the ideas embedded in the TRT's structure have not. That is, the TRT's two tenets of studying ongoing Park management issues, and responding to and addressing issues on

[43] In December 2015, some TRT members voted to retain the TRT's structure until the HCP is adopted. This stance was reiterated in December 2016 (see **Exhibit 9**). However, Commission staff does not concur with this approach, including because it is unknown when the HCP will be completed (it has been in draft form for over 15 years), and it is not clear what it will include and require, including how it will affect the CDP (see previous discussion on this issue in Section F). Furthermore, the TRT's function as advisory management entity and the HCP's function as regulatory document prescribing specific habitat management requirements are not equivalent. In other words, it is unclear that the relationship between these two will adequately address necessary issues, including how the TRT's adaptive management oversight function would or could be embodied in a regulatory document such as the HCP. These are two distinct concepts, and thus Commission staff believes that eliminating the TRT and replacing it with alternative Park oversight and management does not in any way infringe upon or impede HCP completion.

a continuous, adaptive manner, are and should remain the cornerstones of Park resource management. These tenets should continue to form the basis for continued review under the CDP, just implemented in a different manner than the current TRT makeup. In fact, Parks staff have indicated a desire to have some type of ODSVRA advisory group, and it may be that the TRT (or some variation thereof) could form the basis for such an advisory group, but only insomuch as that group's explicit relationship to the CDP and its requirements, including in relation to ongoing monitoring, assessment, and reporting, is revised such that it is not mandated by the CDP.

DPR, as owner and operator of ODSVRA and intimately aware of its daily operations and issues, is clearly the entity with the knowledge and capability to manage the Park pursuant to its best professional judgment. As described earlier in this staff report, Parks manages all of its statewide lands based on their established best resource management principles, and as manager and operator of such public recreational areas ensures that all of its resources are used sustainably. What's always needed first and foremost is best resource management practice to respond to and address on-the-ground concerns, including through an adaptive management approach of what they learn in the field. However, the CDP has never stood for, nor does the complicated nature of the issues facing ODSVRA management allow, Parks to manage the Park free of any other regulatory oversight. Parks can and should be the lead entity and thus given discretion in day-to-day operations and management, including making on-the-ground decisions in an adaptive manner to best manage its lands, but such authority is still subject to applicable oversight and review per the terms and conditions of the CDP. Again, while such oversight need not come from a formal TRT-type body, there must be a mechanism to allow for adequate and appropriate review of Parks' management decisions by both stakeholder groups that are directly implicated by Park decisions and by the various agencies that have direct regulatory authority over Park management, including the Coastal Commission.

In light of the above, the Commission adds **Special Condition 4**, which eliminates the TRT's requirement from the CDP and replaces it with a yearly monitoring reporting program designed to better address ongoing Park issues and better foster appropriate adaptations. The condition maintains the basic framework underscoring the reasons for the TRT in the first place, in that there remains in place a comprehensive resource management component studying and implementing best practices for resource protection in light of vehicular and other recreational use impacts, including though consultation with affected parties, pertinent stakeholders, and other resource agencies. However, instead of channeling that process through the TRT function and a requisite Commission annual review of the TRT's efforts, the condition requires Parks to document the effectiveness of its resource management operations in protecting coastal resources on a yearly basis, all with the overarching goal of achieving an appropriate balance between facilitating vehicular recreation and protecting dune and other coastal resources, subject to Executive Director review and approval. The condition is further intended to require Parks to evaluate overall trends and issues facing the Park's operations authorized by the CDP, including evaluating and demonstrating compliance with the terms and conditions of the CDP and including recommendations for potential changes and adaptations to Park management (and to the CDP) to address identified issues, impacts and trends. Importantly, such recommendations must include input from responsible agencies and known interested parties.

Special Condition 4 provides for DPR to submit an annual monitoring report to the Executive Director for review and approval. At a minimum, the report is intended to document the effectiveness of the previous year's Park management activities in achieving an appropriate balance between providing for vehicular recreation and protecting dune and other coastal resources; it is intended to provide an evaluation of vehicular recreation and coastal resource trends, impacts, and issues facing the Park's operations; and it is intended to provide recommendations for changes to Park management to better address identified impacts. The report will need to be robust, detailing DPR's management efforts associated with vehicular and other public recreational access use as well as dune and other habitat management at ODSVRA. The intent is to be able to describe the previous year's operations (including providing supporting data on day-to-day operations and use), and to evaluate and demonstrate compliance with the terms and conditions of the CDP associated with the balancing inherent in that CDP. The annual report is also designed to include recommendations for potential changes and adaptations to Park management (and to the CDP if appropriate) to address identified issues, impacts and trends, as well as to address any conflicts between recreational use and resource management, including through providing input from local, state, and federal resource agencies and known interested parties about how to best provide public recreational access opportunities of all kinds while simultaneously protecting native species and habitat function and health.

The annual monitoring report is designed that so the Executive Director may require changes to Park management through approval of the report (provided they do not rise to the level of requiring a CDP amendment). Recognizing that there may be changes that require a CDP amendment, or that the Executive Director believes are more appropriately resolved by the Commission, the report is designed so that it may be presented to the Commission as deemed appropriate by the Executive Director. Importantly, that means that there is not a required annual review in front of the Commission. Rather, and as is more typical of these kinds of monitoring reports required of other projects through the Commission's regulatory program, review and approval of them by the Executive Director has been authorized by the Commission, avoiding the need to for a Commission hearing on such reports unless one is needed and warranted. To account for the possibility that DPR and the Executive Director may not agree on Executive Director-required changes to Park management through the annual review of the report, the report is designed so that such disputes are brought to the Commission for resolution (again, as is typical for Commission permits otherwise via standard CDP condition 3 related to interpretation).

In order to ensure that the annual monitoring report can effectively be accomplished, and to provide certainty to all parties as to expectations associated with that annual reporting process, **Special Condition 4** also provides for Commission staff and DPR to work together over the next six-months to develop a monitoring report framework. The intent is for the framework to describe the structure, content, and methods for ongoing monitoring of vehicular recreation and coastal resources at a sufficient level of detail to facilitate both comprehensive understanding of issues and development of appropriate adaptation measures through the annual monitoring report process. At a minimum, the framework needs to include descriptions of the public recreational access uses to be described and monitored and how that will be accomplished, including but not limited to summary of attendance numbers, special events, and user types (including different types of vehicles). The intent is for this part of the framework to include sufficient detail so as to effectively monitor the Park's status in providing for public recreational access opportunities of all kinds, vehicular and otherwise, and to ensure that recommendations for better Park public recreational access management are included and can be efficiently incorporated into Park policy and practices through the annual report process.

In addition, the framework needs to provide for the complementary evaluation associated with dune and other habitat resources. Such evaluation needs to include a description of the habitat management activities and efforts to be described and monitored and how that will be accomplished, including with respect to sensitive species and their habitats (including Western snowy plover, California least tern, Steelhead trout, Tidewater goby, California red-legged frogs, and California grunion), dune resources and vegetation, and creek, lake, and wetland resources. The framework needs to also identify the monitoring approaches to be applied for each respective species and habitat, including countenancing recommendations from other affected resource agencies (e.g., USFWS, CDFW, NOAA Fisheries, etc.) on how best to protect sensitive species. The intent is for this part of the framework to include sufficient detail so as to effectively monitor the Park's status in protecting dune and other habitats in general, but also sensitive species and their habitats specifically, including by documenting status and trends associated with dune and related habitats and sensitive species' health (including by providing in the report all pertinent species and habitat monitoring reports compiled in compliance with the HCP as well as all pertinent habitat management recommendations from resource agencies submitted to DPR), as well as to offer a platform for agency collaboration and cooperation.

In short, **Special Condition 4** provides for a monitoring program under the CDP that appropriately details vehicular and other public recreational use and the way in which it interacts with and needs to be balanced by dune and other coastal habitat protections, including related to sensitive species, under the CDP. A primary thrust of the monitoring reporting process is to document the wide variety of public recreational access activities that occur in the Park in sufficient detail to invoke solutions to any conflicts that may exist among these activities, as well as to monitor such activities that suggest possible conflicts between them and natural resource management, and which could lead, and have led, to the degradation of those resources.[44] It also provides a means to effectively integrate the variety of habitat programs in place at the Park as they relate to the CDP, including importantly the HCP process that has been underway for some time. In fact, it appears clear that the HCP will inform and be informed by annual monitoring under the CDP, and there is a real opportunity for close collaboration to ensure that these two efforts dovetail completely and can support one another. The monitoring report process will need to make this connection, including providing DPR reporting currently submitted to other local, state, and federal resource agencies as part of the HCP development process, or other processes involving natural resources, along with correspondence from these resource agencies to DPR.

[44] An example is related to the issues associated with the aforementioned Arroyo Grande Creek vehicular crossings during parts of the year when fish are active in the lagoon, and during periods of lagoon breaching. Among other things, monitoring should account for identification of lagoon/creek depth, the volume and timing of vehicles that drive through the lagoon/creek, and any noticeable impacts on the lagoon/creek morphology and protected species due to such crossings. In addition, other lagoon/creek management activities should be detailed, such as any active lagoon breaching or beach shaving to cause the lagoon to breach, flood control activities upstream, and activities undertaken by DPR to reduce impacts to fish in the lagoon/creek system.

The purpose of this condition is to replace the CDP's current oversight structure embedded in the TRT with one that empowers DPR to make management decisions for its Park, but also in a manner that includes oversight, feedback, and review. This review necessarily involves the Commission, as it plays a unique role in ensuring the Park is operated in a manner that protects coastal resources, including the fundamental balancing between vehicular recreation and habitat protection through the terms and conditions of the CDP. The condition does not change the fundamental framework underscoring Park management as one of adaptive management based on oversight, but rather simply modifies the governance structure of how this framework is to be carried out. As conditioned, the CDP offers a better vehicle to ensure oversight and adaptive management of Park resources, all with the CDP's overarching intent of balancing vehicular use with coastal resource protection.

H. VIOLATIONS AT ODSVRA

As discussed above in this staff report, DPR is not in compliance with numerous terms and conditions of its coastal development permit (CDP 4-82-300 as amended). Special Condition 1(b) of CDP No. 4-82-300 designates the current OHV staging area as interim and requires a permanent staging area to be designated through amendment of the San Luis Obispo County LUP and the CDP within 18 months of effective certification of the LUP (i.e., by October 12, 1985). Special Condition 1(b) also requires construction of the designated permanent staging area within three years of LUP certification (i.e., by April 12, 1987). Special Condition 2 of CDP No. 4-82-300 designates the two access points at West Grand Avenue and Pier Avenue to be interim and used only until either a permanent staging area is operational or until the CDP and the LUP are amended to permanently designate their locations. All of the deadlines for compliance with these conditions have long since passed and DPR has failed to designate and operate a permanent access and staging system as required. This represents a three decade old violation of the CDP.

Moreover, there have been a series of alleged violations regarding compliance with other terms and conditions of CDP 4-82-300. Many of these are related to allegations that DPR has exceeded allowed vehicular use limits, including in relation to special events. As indicated in the previous findings, the methodology for documenting vehicle use numbers at the ODSVRA make measuring use limit compliance challenging. For these reasons, Commission staff has not been able to verify or discount such allegations and, therefore, has not pursued formal violation investigations. As discussed earlier, one intent of the proposed changes to the CDP identified herein is to allow for DPR to more holistically manage use at the Park without static use numbers, that are themselves based on historical guess work estimates of past use. Such a system, along with other CDP requirements (e.g., limiting riding to defined areas, prohibiting riding and related activities in non-riding dune areas, protecting archaeological resources, requiring ongoing monitoring and reporting, etc.), and the provisions to provide for adaptation through ongoing monitoring and reporting provisions, should ensure that intensity of use is appropriately addressed. As such, the changes to the CDP proposed here should, if adopted, likely make past allegations of use limit exceedance moot.

Other allegations have been made regarding disallowed vehicle (and other) activity within vegetated dune areas inconsistent with CDP requirements that all dune vegetation be fenced off and protected.[45] As with exceedance of use limits, these allegations have been difficult to pursue. For one thing, some are anecdotal observations without supporting documentation. In other cases, photos of dune plants being trampled have been provided, but it is unclear where such activities occurred within the almost 2 square-mile riding area. In other cases, photos of special events have shown trampling of dune vegetation, but were received after the event was completed.[46] In all cases the dynamic nature of the dunes and the spatial extent, and sometimes transitory nature, of dune vegetation in general make following up on such allegations difficult, particularly when the vegetation in question is a single plant in the riding area, as has been the case in some allegations. The proposed changes to the CDP regarding dune vegetation and protection should ensure that the CDP objectives are better addressed on these points moving forward.

Another category of enforcement issues can be attributed to DPR's various dust control and wind monitoring activities over the years. Starting sometime around 2011, DPR began installing wind and air quality monitoring equipment and various dust control measures (such as hay bales and fencing) without CDPs.[47] Some such activities took place in riding areas, and some took place in non-riding protected dune areas. All took place in areas the Commission has deemed ESHA. Ultimately, DPR applied for and received several emergency CDPs (ECDPs) for such activities (in 2013, 2014, 2015, and 2016). These ECDPs provided for a variety of monitoring and dust control activities, but only on a temporary basis and only if a regular CDP is acquired within a certain timeframe. DPR has applied for the required follow-up CDP, but has not yet completed its application due to outstanding materials, with the critical omitted information being developed currently by DPR through their EIR process that has not to date been completed.[48] Thus, the various development activities temporarily authorized by ECDPs have never been permanently authorized by a regular CDP and all such activities and related development to date under these ECDPs now constitute violations. In addition, multiple individual terms and conditions of said ECDPs were not adhered to, including lack of compliance associated with biological and Native American/Archeological monitors, and these inconsistencies also represent violations. In addition, many of the individual ECDP conditions requiring removal of dust control and monitoring equipment, and restoration of such areas, have never been complied with, and each of these represent a violation as well.[49]

In addition, as detailed in the findings above, there have also been complaints over the years that DPR has allowed OHV riding in the La Grande property when it is prohibited in this area by the LCP. As discussed above, the issues surrounding the use of the La Grande property are related to finalizing the access and staging system for the Park, and this, as well as past Commission actions allowing OHV use in much of that area as part of the interim system, have made pursuing such allegations significantly more complicated. DPR's use of the La Grande property has also

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[45] Including enforcement case V-3-10-024.

[46] Although Commission staff has in such cases identified the issue to DPR, and asked that changes be made in future events, staff has not pursued formal enforcement investigations for such cases.

[47] See, for example, enforcement cases V-3-11-014 and V-3-11-017.

[48] CDP application 3-12-050.

[49] For example, most recently, ECDP G-16-0023 required removal and restoration associated with 2016 and prior years activities by August 31, 2016. However, to date, DPR never provided the required restoration plan, nor removed the straw bales, nor provided any documentation of any removal and restoration of other dust control development. Thus, these constitute violations of the ECDP.

resulted in at least two lawsuits over same, but the issues have yet to be resolved.[50] Again, as discussed above, it is likely that completion of a permanent access and staging system through this CDP would also allow for La Grande issues to be finally addressed in that process, and ultimately through the LCP context.

Finally, there have been a series of violation allegations over the years related to activities near the two interim accessways, including allegations that the ramps to the beach have been inappropriately augmented, and that signs limiting vehicular use areas have been inappropriately moved to allow vehicular use where it is not allowed under the CDP.[51] And there have been anecdotal and other allegations (both with and without photos) of vehicles driving through Arroyo Grande Creek, leading to habitat impacts, as well as vehicle impacts in the riding area itself (with respect to impacts to both sensitive bird species and marine mammals). Again, these types of allegations have been difficult to follow-up on after the fact, and Commission staff has not to date pursued formal enforcement investigations of them, including because other regulatory agencies also with jurisdiction have been involved (e.g., USFWS and CDFW with snowy plover).

The above-described violations are not resolved by the Commission's action on this item. However, the changes being made as part of this re-review action will help inform the process established by CDP 4-82-300 and set the stage for future actions that could result in resolution of some of these violations. This is particularly critical in terms of the process identified for finalizing the location of the ODSVRA access and staging system, including because access and staging are interrelated with other key issues (e.g., Arroyo Grande creek crossings, La Grande property use, etc.). Other violations and related issues will likely be resolved through separate permit actions (e.g., in terms of dust control and the not yet filed CDP application 3-12-050). In all cases, the above-described violations have been referred to Commission enforcement staff for appropriate action.

[50] Id (see above La Grande Property section of this report).

[51] See, for example, enforcement cases V-3-98-004 and V-3-10-042.

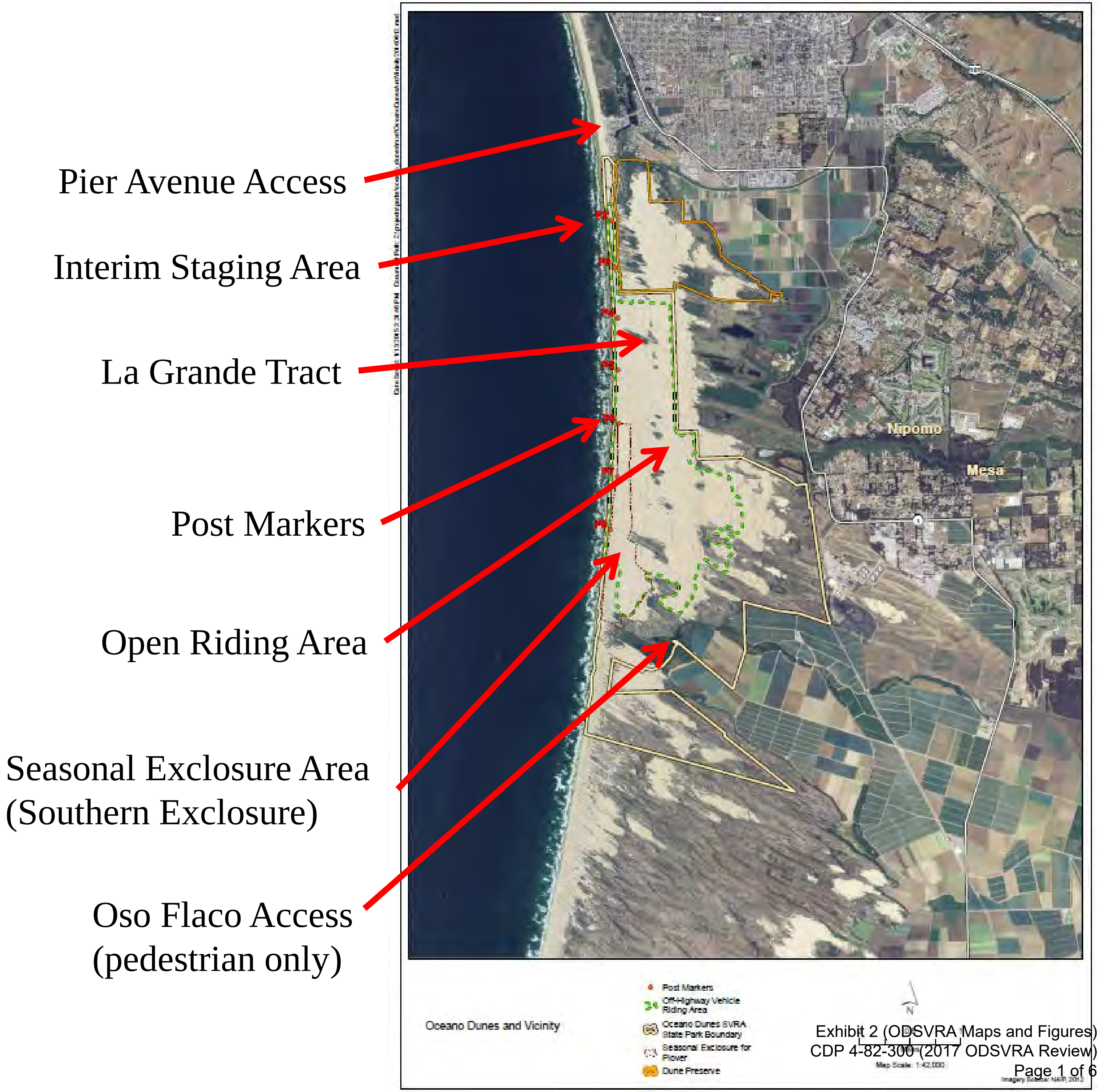
Appendix A: Substantive File Documents

- 2006 Alternative Access Study Oceano Dunes State Vehicular Recreation Area. Produced by Condor Environmental Planning Services, Inc.
- Oceano Dunes SVRA Dust Control Program Draft Program Environmental Impact Report, State Clearinghouse #2012121008
- Arroyo Grande Lagoon and Adjacent Waters Fishery and Aquatic Resources Summary 2015 Monitoring Report
- NOAA Fisheries Approval of Steelhead Take Avoidance Plan

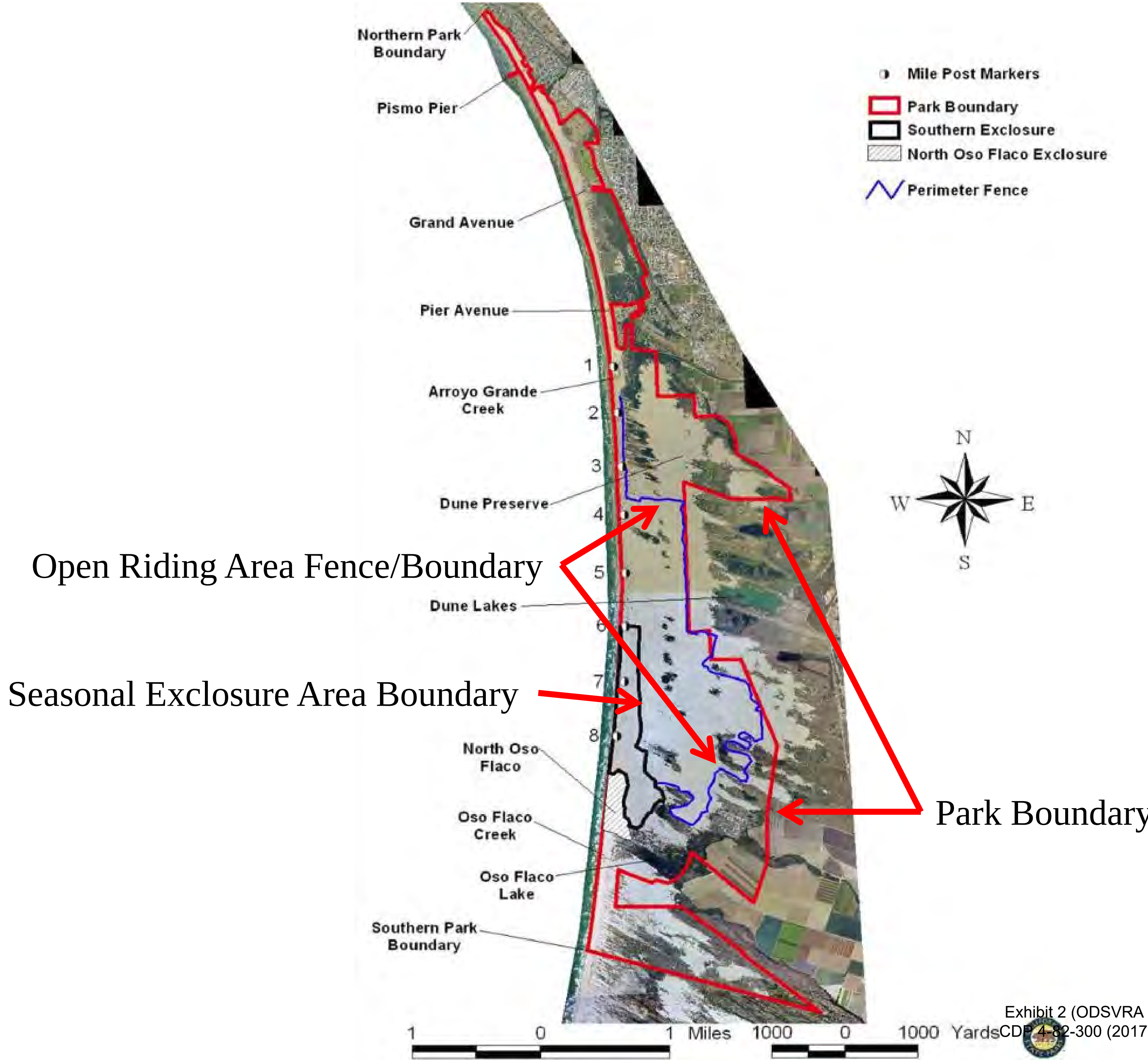
Appendix A: Staff Contact with Other Agencies and Parties

- California Department of Parks and Recreation (Oceano District & Off-Highway Motor Vehicle Division) and their various consultants
- California Air Resources Board
- California Department of Fish and Wildlife
- San Luis Obispo County Department of Planning and Building
- San Luis Obispo County Air Pollution Control District
- United States Fish and Wildlife Service
- NOAA Fisheries
- Friends of Oceano Dunes
- Sierra Club
- Mesa Community Alliance

ODSVRA Location Maps



Pier Avenue Access
Interim Staging Area
La Grande Tract
Post Markers
Open Riding Area
Seasonal Exclosure Area
(Southern Exclosure)
Oso Flaco Access
(pedestrian only)
Nipomo
Mesa
Oceano Dunes and Vicinity
Post Markers
Off-Highway Vehicle Riding Area
Oceano Dunes SVRA State Park Boundary
Seasonal Exclosure for Plover
Dune Preserve
N
Map Scale: 1:42,000



Northern Park Boundary
Pismo Pier
Grand Avenue
Pier Avenue
Arroyo Grande Creek
Dune Preserve
Dune Lakes
North Oso Flaco
Oso Flaco Creek
Oso Flaco Lake
Southern Park Boundary
Mile Post Markers
Park Boundary
Southern Exclosure
North Oso Flaco Exclosure
Perimeter Fence
N
W
E
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Open Riding Area Fence/Boundary
Seasonal Exclosure Area Boundary
Park Boundary
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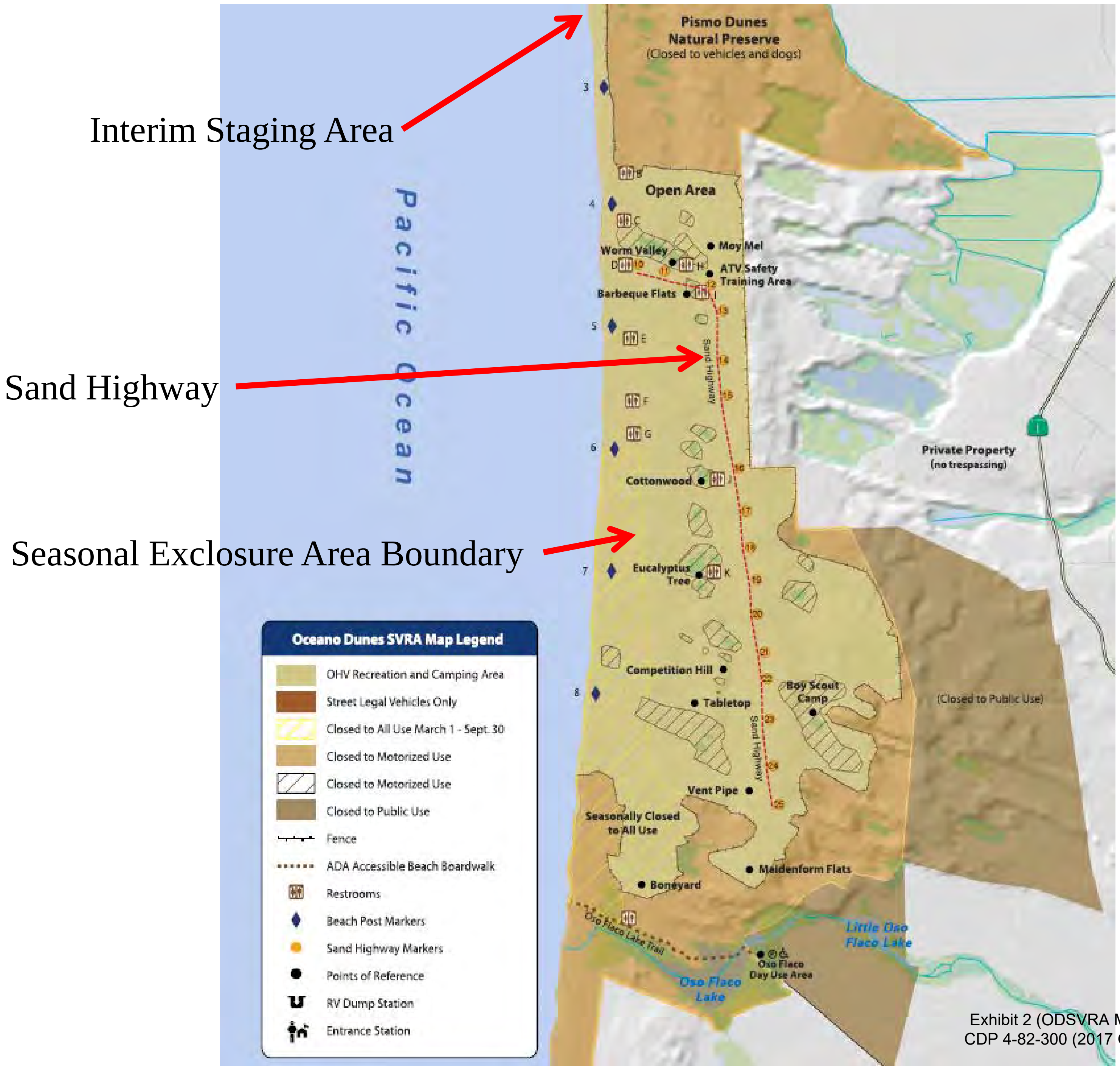
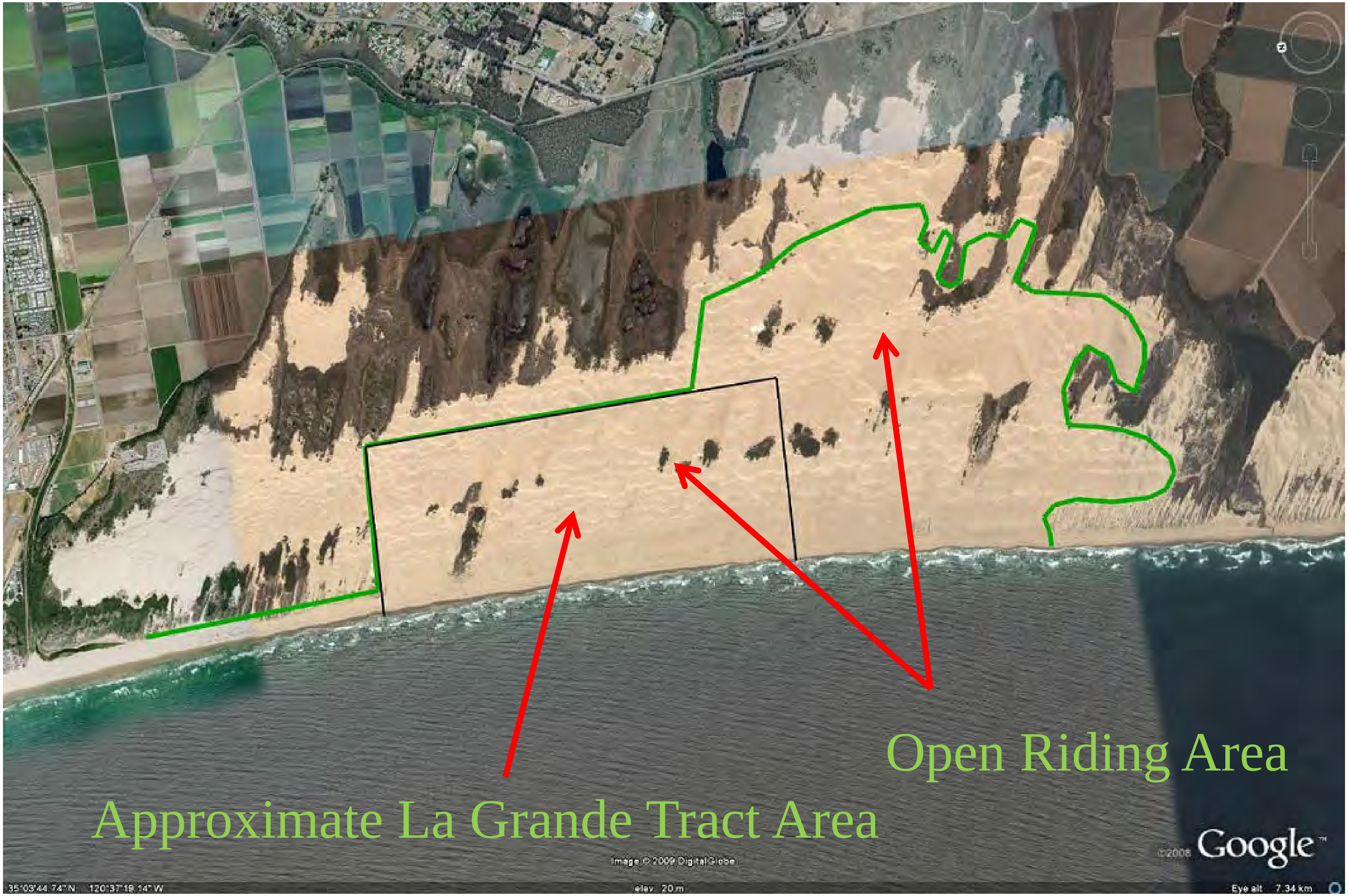
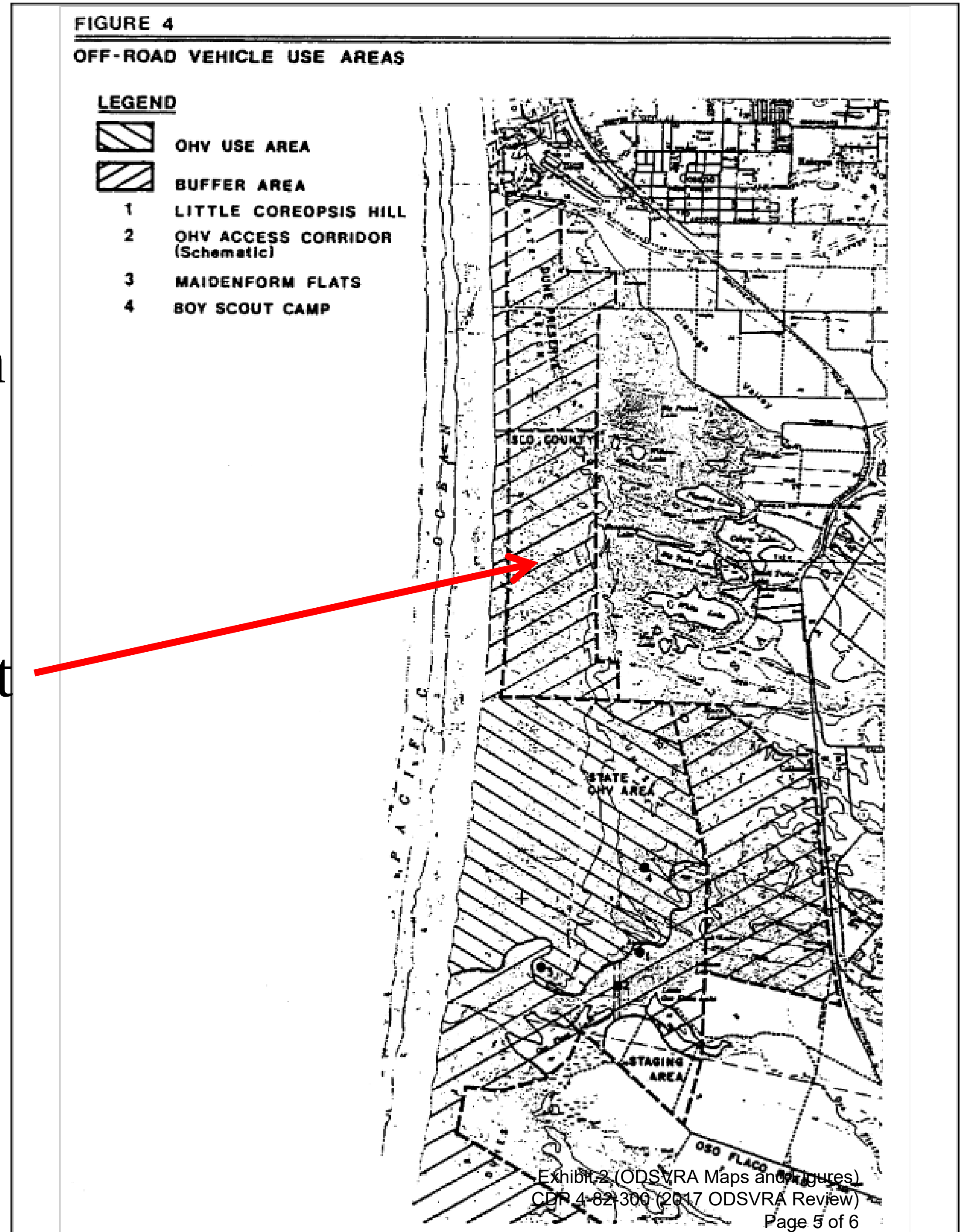


Exhibit 2 (ODSVRA Maps and Figures)
CDP 4-82-300 (2017 ODSVRA Review)

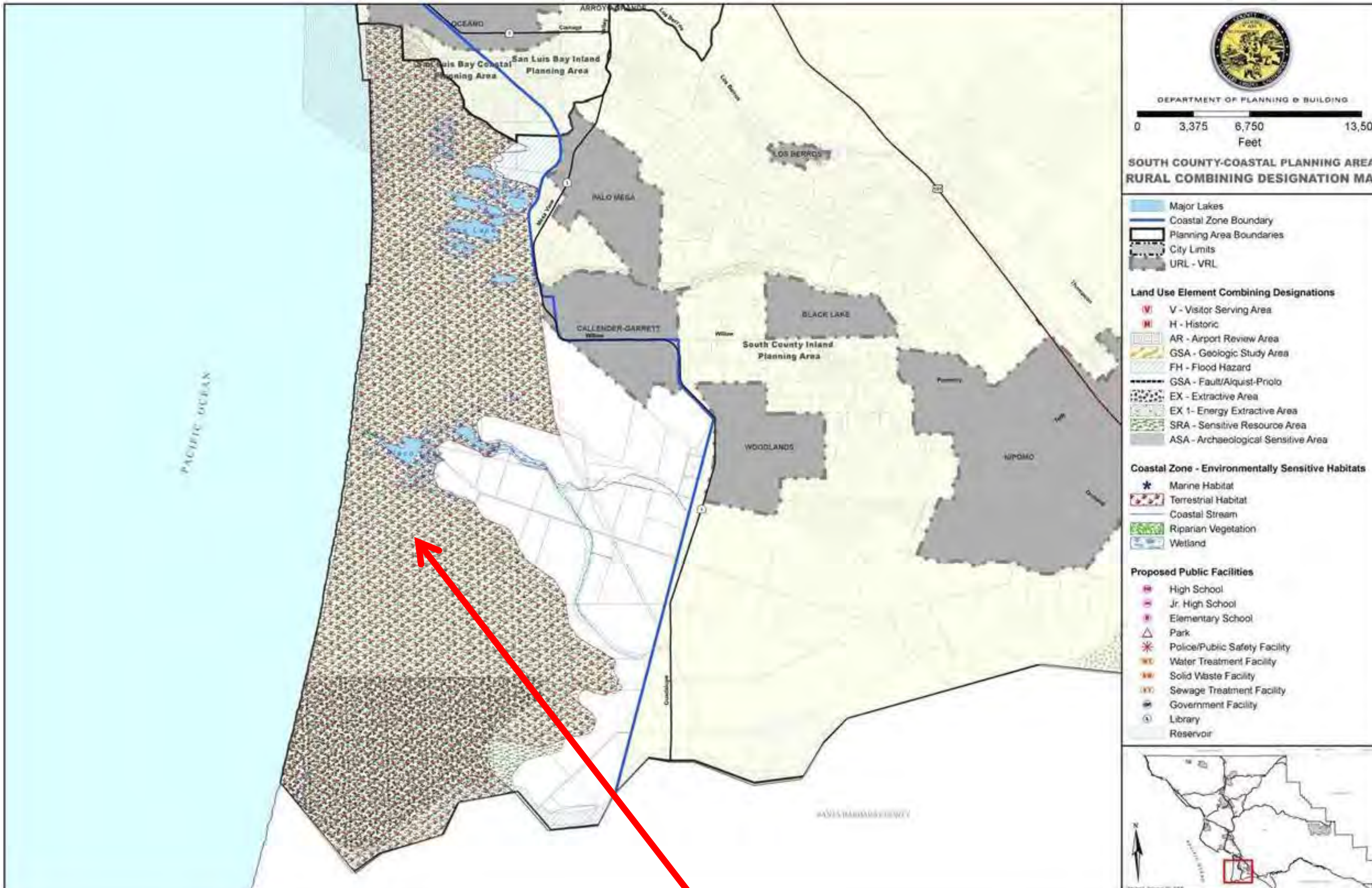

Open Riding Area
Approximate La Grande Tract Area
Image © 2009 DigitalGlobe
Google

South County Area Plan Figure 4

La Grande Tract



San Luis Obispo County LCP ESHA Map



Sensitive Resource Area (SRA) and
Terrestrial Habitat ESHA Designation

Aerial Near Pier Avenue Access and community of Oceano

Exhibit 3 (ODSVRA Photos)
CDP 4-82-300 (2017 ODSVRA Review)

Aerial Near Interim Staging Area

Aerial of Open Riding Area

Oso Flaco Lake Area

Huckfest

Straw bales deployed as dust mitigation measures

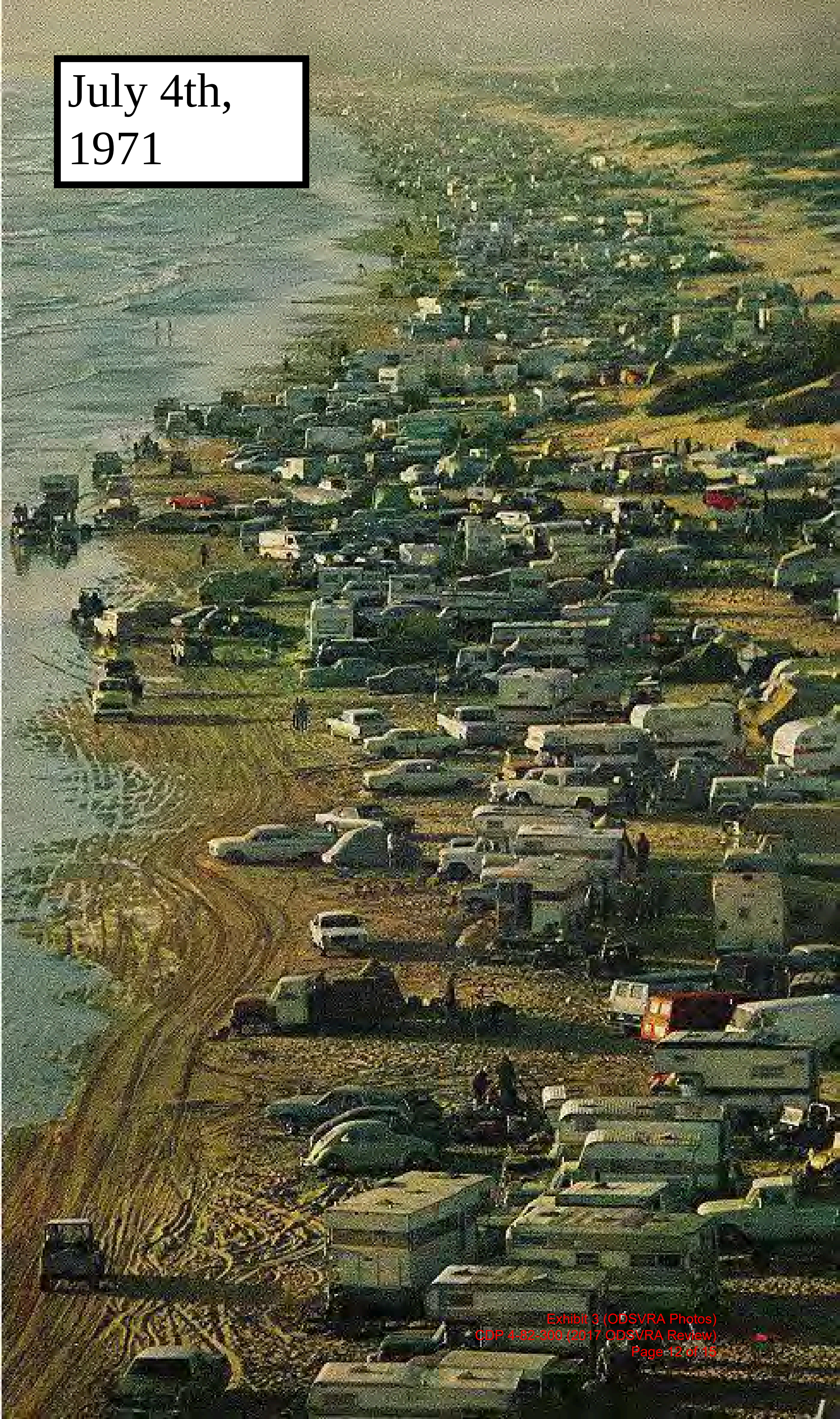
Straw bales deployed as dust mitigation measures

Straw bales deployed as dust mitigation measures

Straw bales deployed as dust mitigation measures


ODSVRA personnel maintaining access to the park

Dune riding


July 4th, 1971

March 1st, 2011


March 1st, 2011

March 1st, 2011

CDP 4-82-300, approved in 1982

1. Staging Area Location:

A. An interim OHV staging area shall be operational no later than Labor Day weekend 1982 in a designated area on or adjacent to the beach south of Sand Highway (Exhibit C). This staging area shall remain operational subject to the stated conditions and standards herein until such time as a permanent staging area is constructed.

Upon implementation of the interim staging area, all OHVs, ATCs and other non-street legal vehicles shall be trailored to and from Grande and Pier Avenues. At all times such vehicles when under their own power, shall be prohibited north of the northerly terminus of Sand Highway.

B. A permanent staging area site shall be selected as expeditiously as possible but in no case later than 18 months from the effective date of the County's LUP certification consistent with the following standards. Construction of this permanent staging area shall begin no later than three (3) years form the date of the certification of the County's LUP of its LCP. If construction and operation of a permanent staging area cannot be accomplished within the above time limits, this permit shall be subject to review and modification if necessary or appropriate by the County or the Commission or either in consultation with the other. Prior to construction, the County's LUP and the State Parks General Development Plan shall be amended to include the selected site with all additional standards or conditions for its design and operation. At the present time, there are several known locations which shall be considered and evaluated for staging area use, these locations are: Callendar Road area; the stables/agricultural lands area south of Arroyo Grande Creek; Agricultural lands north of Oso Flaco Creek adjacent to the Union Oil property; on the beach as per the interim staging area described herein (see Exhibit C). Other potential sites may also be evaluated. The site selection process shall include an environmental impacts analysis adequate to enable the selection of the least environmentally damaging location for the use. Accordingly, the on and off-site impacts of each alternative shall be measured against the impacts of the others. In selecting the site and amending the County's LUP and the State Parks General Development Plan to incorporate the selected site, the following standards must be found to have been met: 1) that the site selected is the least environmentally damaging alternative; and 2) that all feasible design and operational related mitigations have been incorporated to minimize adverse environmental impacts. Additional standards for site selection are in their order of importance: locating a site which reduces to the maximum extent feasible OHV related impacts to the residential character of the community of Oceano; locating a site which facilitates the successful separation and regulation of recreational uses within the park itself; locating a site which can be constructed and operational expeditiously.

C. Oso Flaco Lakes Area: An off-highway vehicle staging area shall not be constructed at the Oso Flaco Lake site indicated on Exhibit C. As part of the fencing proposed in this project, the Oso Flaco causeway to the PSVRA shall be permanently closed to vehicular traffic. Pedestrian and equestrian access only shall be allowed over

the causeway or in the vicinity of the Oso Flaco Lakes. The state owned agricultural lands south of Oso Flaco Lakes may be utilized for the development of a campground for passive recreational use of the dune areas within the Park excluded from OHV use. The State Parks and Recreation Department shall amend its General Development Plan accordingly. Uses in this camping area shall be permitted only if consistent with the resource protection policies of the San Luis Obispo County Land Use Plan; 100 foot buffering setbacks from the lakes, creek and wetlands shall be applied at a minimum with greater setbacks required if necessary, only resource dependent uses and passive recreational activities shall be permitted.

2. Control of Access to the Park: Effective immediately upon issuance of this permit and until either a permanent staging area is operational or this permit and the County's LUP is amended to accommodate possible necessary minor adjustments in the operation of these conditions, access and egress to and from the park shall be controlled and monitored in the following manner:

   A. All vehicular access and egress shall be via Grande Avenue and Pier Avenue, an effective vehicle barriers shall be placed at the southern end of the Oso Flaco causeway to assure that no OHV access over the causeway is permitted.
   B. Manned vehicle contact stations (kiosks) shall be placed at the Pier and Grande Avenue access points.

3. Control of uses within the Park: By the July 4 week-end of 1982 and as soon as possible prior to that date, the Parks and Recreation Department shall institute a Public Information program for vehicular recreational users within the Parks units. At the Grande and Pier Avenue's kiosks, occupants of all vehicles entering the Park will be provided a pass or ticket to the park and the following information:

   A. The following rules are effective immediately with violators subject to citation and fines:
      - All non-street legal vehicles shall be prohibited from the area north of Sand Highway after dusk each day.
      - Vegetated dune areas, whether they are fenced or unfenced, are strictly off-limits to all vehicles.
      - All areas posted as Private Property or Restricted Use are off-limits to vehicle activity.
      - All vehicle activity is prohibited south of the Oso Flaco Creek (or south of the fence line that is constructed).

   B. Beginning with LABOR DAY WEEKEND 1982 Beach Camping within the Park units shall be restricted to a maximum of 500 units* with each unit available only through a reservation obtained through the State Parks Reservation System (Ticketron). On that weekend and thereafter, admittance to the Park for the purpose of overnight camping will be denied to individuals without a valid reservation unless vacant unreserved camping spaces are available.

*One unit equals a campsite for a single camper vehicle.

C. Beginning LABOR DAY WEEKEND, specific areas of the Park will be designated for specific types of vehicles. The designations will be as follows:
    - Area north of Sand Highway to Grande Avenue designated for and restricted to street legal vehicle use.
    - Area south of Sand Highway to the fenced or posted area north of Oso Flaco Creek designated for OHV use.

D. On or before January 1983, the following will occur: OHV day use will be limited to a specified number of users established in consultation with agreement by the County of San Luis Obispo and the Executive Director of the Coastal Commission and the Department of State Parks. OHV day use fees may be collected.

E. Protective Fencing of Dunes, archeological resources, and wet environments shall be accomplished in the following manner subject to review and approval by the Executive Director of the Coastal Commission in consultation with the County of San Luis Obispo and the State Department of Fish and Game.

(a) Fencing proposed and approved herein, plus fencing of the area shown as Area A on Exhibit D plus the perimeter fencing along the Sand Highway and the Eastern Boundary of ODSVRA shall be accomplished by November 30, 1982. All other vegetated areas indicated on Exhibit D shall be fenced by Aug 31, 1983.

(b) One primary objective of the fencing is to prohibit vehicle access to the dune area south of Oso Flaco Creek. Accordingly, the east/west aligned fence north of Oso Flaco Creek shall continue seaward to the mean low water line so that vehicles do not pass to the south. The continuation of this line to mean low water may require different construction than normal fencing – possibly driven piles.

(c) Except for the following, fencing alignments shall be placed a minimum of 100 feet from the vegetated areas being fenced:

1. Along Sand Highway where the fence would encroach into the Sand Highway travel corridor.

2. Along the seaward side of the foredunes paralleling the beach where fencing may be placed in a manner similar to that already existing along the westerly line of the State Dune Preserve.

3. In other areas where it is demonstrated that a placement closer to vegetation will not diminish the effectiveness of the fence to stabilize the dune, protect the vegetation and provide necessary conditions for dune rehabilitation and restoration. Said demonstration shall be in the form of competent analysis of the dynamics of dune sand transport and natural condition necessary for dune

stabilization. Reduction in the minimum setback under this condition shall be reviewed and approved by the Executive Director of the Coastal Commission.

(d) If fenced corridors to the Oso Flaco are constructed, they shall only be for use of state parks personnel and for the purpose of emergency, normal patrol duties, management and enforcement. Accordingly, these corridors shall have locked gates as shown on Exhibit D.

(e) Since a barrier to OHV movement south of Oso Flaco Creek is to be constructed on the north side of the creek, any construction of fencing south of Oso Flaco Creek or lakes shall be only for the purpose of preventing OHV intrusion into the State Park holdings from adjacent private lands. Such fencing shall therefore be perimeter fencing around parcels 8, 7, 3, and 4 and shall require a coastal development permit. Fencing applied for herein south of Oso Flaco which is not perimeter fencing shall not be constructed, or if constructed shall have been to an alignment approved herein by November 30, 1982.

4. Restoration

A dunes restoration program shall be undertaken by the DPR. The program shall be reviewed and approved by the Executive Director of the Coastal Commission. Restoration of vegetated dunes within the fenced-off areas shall be undertaken as expeditiously as funds and technical knowledge allows. Plantings shall begin no later than January 1983 with notification of the County and the Executive Director of the Coastal Commission. The restoration program shall be an ongoing program with the experimental or initial phase completed within three (3) years of the date of certification of the LUP and the full program in effect on that date or before.

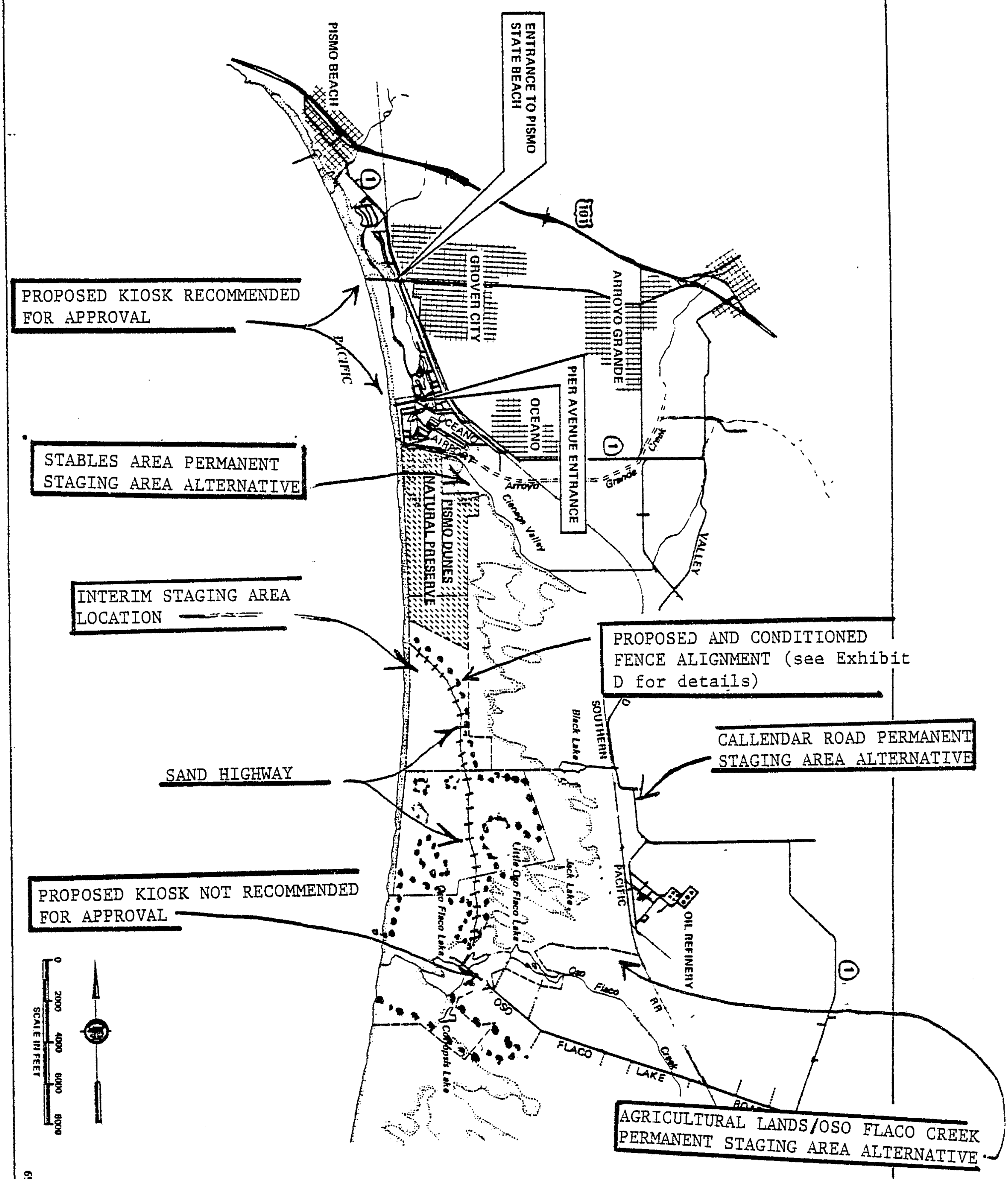
5. Protection of Archeological Resources

Archeological resources within the PDVRA shall be protected by fencing. Accordingly, as part of the current fencing project, site No. SLO 199 shall be fenced for protection. Other sites shall be fenced as their locations become known.

6. Six months after the issuance of this permit, and annually thereafter until a permanent staging area is operational, a formal review of the effectiveness of the conditions of the permit shall take place. This review shall be undertaken jointly by designated representatives of the California Coastal Commission, the California Department of Fish and Game, the County of San Luis Obispo, the Community of Oceano, the California Department of Parks and Recreation and user groups.

If after each of the annual reviews, or after the three year review required in condition 1(b) above, it is found that the Off-Highway Vehicle (OHV) use within the Pismo Dunes State Vehicle Recreation Area (PDSVRA) is not occurring in a manner which protects environmentally sensitive habitats and adjacent community values consistent with the requirements of the San Luis Obispo Local Coastal Program Land Use Plan, then OHV access may be further limited pursuant to the access and habitat protection policies of the County certified Land Use Plan. If the above reviews find that OHV use within the PDSVRA is consistent with the protection of environmentally sensitive habitats and adjacent community values, and/or that additional staff and management revenues become available to the California Department of Parks and Recreation, levels of OHV use of the PDSVRA may be increased to a level not to exceed the enforcement and management capabilities available to the Pismo Beach State Parks Units.

EXHIBIT C



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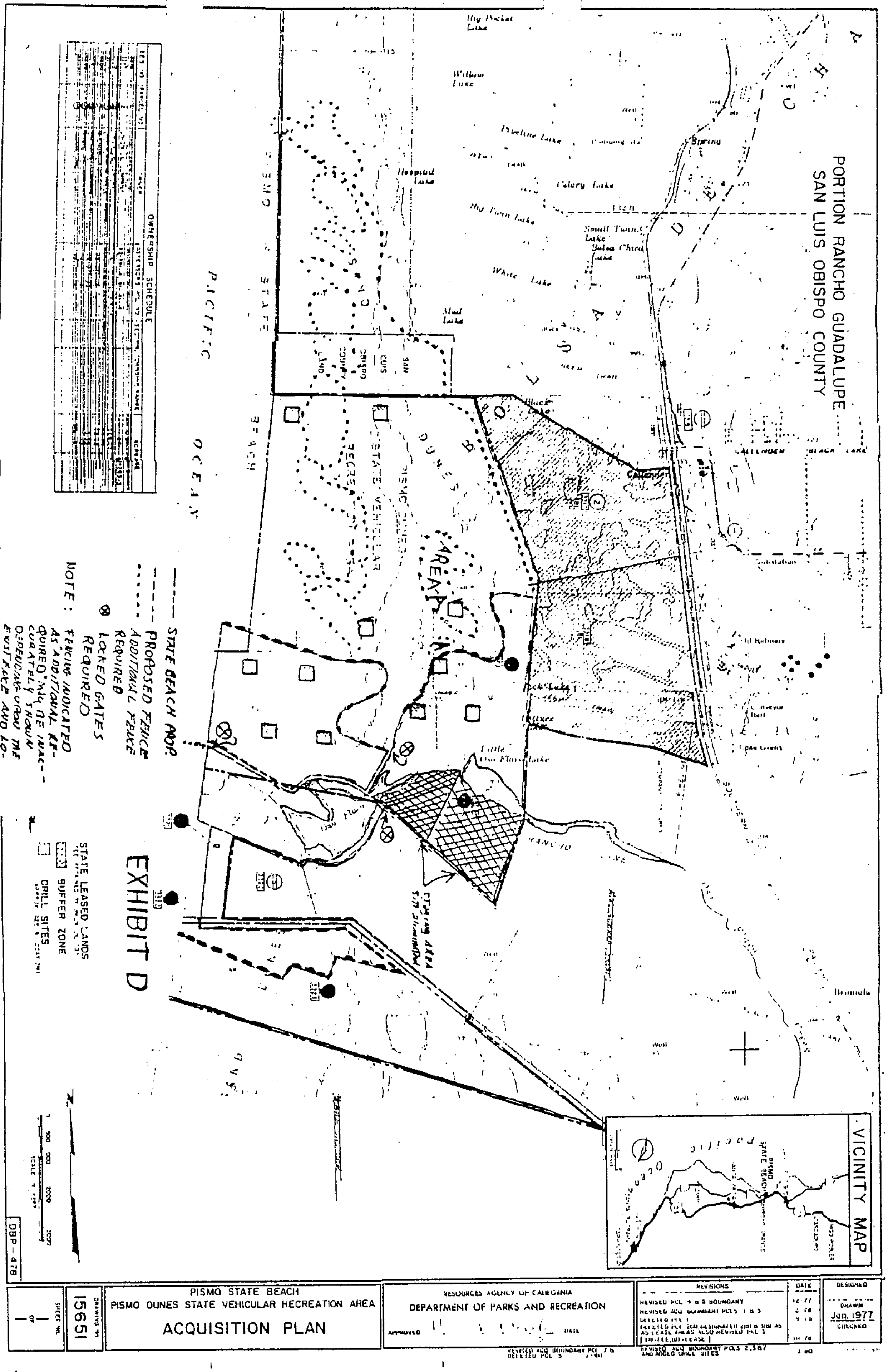
PISMO STATE BEACH AND PISMO DUNES STATE VEHICULAR RECREATION AREA
FIGURE 12
RECREATION ELEMENTS

14366

RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF PARKS AND RECREATION


PORTION RANCHO GUADALUPE
SAN LUIS OBISPO COUNTY
PACIFIC OCEAN
EXHIBIT D
STATE BEACH PROP.
PROPOSED FENCE
ADDITIONAL FENCE REQUIRED
LOCKED GATES REQUIRED
NOTE: FENCING INDICATED AS ADDITIONAL REQUIRED MAY BE INACCURATELY SHOWN DEPENDING UPON THE EXISTENCE AND LOCATION OF VEGETATION.
STATE LEASED LANDS
BUFFER ZONE
DRILL SITES
OWNERSHIP SCHEDULE
VICINITY MAP
DBP-478
15651
PISMO STATE BEACH
PISMO DUNES STATE VEHICULAR RECREATION AREA
ACQUISITION PLAN
RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF PARKS AND RECREATION
REVISIONS
Jan. 1977

CDP 4-82-300-A, approved in 1982

1. Staging Area Location:

A. An interim OHV staging area shall be operational no later than ~~Labor Day weekend~~ September 15th 1982 in a designated area on or adjacent to the beach south of ~~Sand Highway~~ the two mile post (Exhibit C). This staging area shall remain operational subject to the stated conditions and standards herein until such time as a permanent staging area is constructed.

Upon implementation of the interim staging area, all OHVs, ATCs and other non-street legal vehicles shall be trailored to and from Grande and Pier Avenues. At all times such vehicles when under their own power, shall be prohibited north of the northerly terminus of Sand Highway.

B. A permanent staging area site shall be selected as expeditiously as possible but in no case later than 18 months from the effective date of the County's LUP certification consistent with the following standards. Construction of this permanent staging area shall begin no later than three (3) years form the date of the certification of the County's LUP of its LCP. If construction and operation of a permanent staging area cannot be accomplished within the above time limits, this permit shall be subject to review and modification if necessary or appropriate by the County or the Commission or either in consultation with the other. Prior to construction, the County's LUP and the State Parks General Development Plan shall be amended to include the selected site with all additional standards or conditions for its design and operation. At the present time, there are several known locations which shall be considered and evaluated for staging area use, these locations are: Callendar Road area; the stables/agricultural lands area south of Arroyo Grande Creek; Agricultural lands north of Oso Flaco Creek adjacent to the Union Oil property; on the beach as per the interim staging area described herein (see Exhibit C). Other potential sites may also be evaluated. The site selection process shall include an environmental impacts analysis adequate to enable the selection of the least environmentally damaging location for the use. Accordingly, the on and off-site impacts of each alternative shall be measured against the impacts of the others. In selecting the site and amending the County's LUP and the State Parks General Development Plan to incorporate the selected site, the following standards must be found to have been met: 1) that the site selected is the least environmentally damaging alternative; and 2) that all feasible design and operational related mitigations have been incorporated to minimize adverse environmental impacts. Additional standards for site selection are in their order of importance: locating a site which reduces to the maximum extent feasible OHV related impacts to the residential character of the community of Oceano; locating a site which facilitates the successful separation and regulation of recreational uses within the park itself; locating a site which can be constructed and operational expeditiously.

C. Oso Flaco Lakes Area: An off-highway vehicle staging area shall not be constructed at the Oso Flaco Lake site indicated on Exhibit C. As part of the fencing proposed in this project, the Oso Flaco causeway to the PSVRA shall be permanently closed to vehicular traffic. Pedestrian and equestrian access only shall be allowed over the causeway or in the vicinity of the Oso Flaco Lakes. The state owned agricultural lands south of Oso Flaco Lakes may be utilized for the development of a campground for passive recreational use of the dune areas within the Park excluded from OHV use. The State Parks and Recreation Department shall amend its General Development Plan accordingly. Uses in this camping area shall be permitted only if consistent with the resource protection policies of the San Luis Obispo County Land Use Plan; 100 foot buffering setbacks from the lakes, creek and wetlands shall be applied at a minimum with greater setbacks required if necessary, only resource dependent uses and passive recreational activities shall be permitted.

2. Control of Access to the Park: Effective immediately upon issuance of this permit and until either a permanent staging area is operational or this permit and the County's LUP is amended to accommodate possible necessary minor adjustments in the operation of these conditions, access and egress to and from the park shall be controlled and monitored in the following manner:

   A. All vehicular access and egress shall be via Grande Avenue and Pier Avenue, an effective vehicle barriers shall be placed at the southern end of the Oso Flaco causeway to assure that no OHV access over the causeway is permitted.
   B. Manned vehicle contact stations (kiosks) shall be placed at the Pier and Grande Avenue access points.

3. Control of uses within the Park: By the July 4 week-end of 1982 and as soon as possible prior to that date, the Parks and Recreation Department shall institute a Public Information program for vehicular recreational users within the Parks units. At the Grande and Pier Avenue's kiosks, occupants of all vehicles entering the Park will be provided a pass or ticket to the park and the following information:

   A. The following rules are effective immediately with violators subject to citation and fines:
      - All non-street legal vehicles shall be prohibited from the area north of ~~Sand Highway~~ the two mile post after dusk each day.
      - Vegetated dune areas, whether they are fenced or unfenced, are strictly off-limits to all vehicles.
      - All areas posted as Private Property or Restricted Use are off-limits to vehicle activity.
      - All vehicle activity is prohibited south of the Oso Flaco Creek (or south of the fence line that is constructed).

   B. Beginning ~~with LABOR DAY WEEKEND~~ September 15, 1982 Beach Camping within the Park units shall be restricted to a maximum of 500 units* with each unit available only through a reservation obtained through the State Parks Reservation System (Ticketron). ~~On that weekend and t~~Thereafter, admittance to the Park for the purpose of overnight camping will be denied to individuals without a valid reservation unless vacant unreserved camping spaces are available.

*One unit equals a campsite for a single camper vehicle.

C. Beginning ~~LABOR DAY WEEKEND~~ September 15, 1982, specific areas of the Park will be designated for specific types of vehicles. The designations will be as follows:
   - Area north of ~~Sand Highway~~ the two mile post to Grande Avenue designated for and restricted to street legal vehicle use.
   - Area south of ~~Sand Highway~~ the two mile post to the fenced or posted area north of Oso Flaco Creek designated for OHV use.

D. On or before January 1983, the following will occur: OHV day use will be limited to a specified number of users established in consultation with agreement by the County of San Luis Obispo and the Executive Director of the Coastal Commission and the Department of State Parks. OHV day use fees may be collected.

E. Protective Fencing of Dunes, archeological resources, and wet environments shall be accomplished in the following manner subject to review and approval by the Executive Director of the Coastal Commission in consultation with the County of San Luis Obispo and the State Department of Fish and Game.

   (a) Fencing proposed and approved herein, plus fencing of the area shown as Area A on Exhibit D plus the perimeter fencing along the Sand Highway (or along the ridge just eastward of the Sand Highway) and the Eastern Boundary of ODSVRA shall be accomplished by November 30, 1982. All other vegetated areas indicated on Exhibit D shall be fenced by Aug 31, 1983.

   (b) One primary objective of the fencing is to prohibit vehicle access to the dune area south of Oso Flaco Creek. Accordingly, the east/west aligned fence north of Oso Flaco Creek shall continue seaward to the mean low water line so that vehicles do not pass to the south. The continuation of this line to mean low water may require different construction than normal fencing – possibly driven piles.

   (c) Except for the following, fencing alignments shall be placed a minimum of 100 feet from the vegetated areas being fenced:

      1. Along Sand Highway where the fence would encroach into the Sand Highway travel corridor.

      2. Along the seaward side of the foredunes paralleling the beach where fencing may be placed in a manner similar to that already existing along the westerly line of the State Dune Preserve except that a minimal number of breaks in the foredune fencing outside of the dune preserve may be allowed of OHV access to the backdune area. The fencing protecting the foredunes need not be a closed perimeter fence completely surrounding the foredune vegetation if it can be demonstrated to the Executive Director that such perimeter fencing is not necessary for effective preservation and stabilization of foredunes.

3. In other areas where it is demonstrated that a placement closer to vegetation will not diminish the effectiveness of the fence to stabilize the dune, protect the vegetation and provide necessary conditions for dune rehabilitation and restoration. Said demonstration shall be in the form of competent analysis of the dynamics of dune sand transport and natural condition necessary for dune stabilization. Reduction in the minimum setback under this condition shall be reviewed and approved by the Executive Director of the Coastal Commission.

(d) If fenced corridors to the Oso Flaco are constructed, they shall only be for use of state parks personnel and for the purpose of emergency, normal patrol duties, management and enforcement. Accordingly, these corridors shall have locked gates as shown on Exhibit D.

(e) Since a barrier to OHV movement south of Oso Flaco Creek is to be constructed on the north side of the creek, any construction of fencing south of Oso Flaco Creek or lakes shall be only for the purpose of preventing OHV intrusion into the State Park holdings from adjacent private lands. Such fencing shall therefore be perimeter fencing around parcels 8, 7, 3, and 4 and shall require a coastal development permit. Fencing applied for herein south of Oso Flaco which is not perimeter fencing shall not be constructed, or if constructed shall have been to an alignment approved herein by November 30, 1982.

4. Restoration

A dunes restoration program shall be undertaken by the DPR. The program shall be reviewed and approved by the Executive Director of the Coastal Commission. Restoration of vegetated dunes within the fenced-off areas shall be undertaken as expeditiously as funds and technical knowledge allows. Plantings shall begin no later than January 1983 with notification of the County and the Executive Director of the Coastal Commission. The restoration program shall be an ongoing program with the experimental or initial phase completed within three (3) years of the date of certification of the LUP and the full program in effect on that date or before.

5. Protection of Archeological Resources

Archeological resources within the PDVRA shall be protected by fencing. Accordingly, as part of the current fencing project, site No. SLO 199 shall be fenced for protection. Other sites shall be fenced as their locations become known.

6. Six months after the issuance of this permit, and annually thereafter until a permanent staging area is operational, a formal review of the effectiveness of the conditions of the permit shall take place. This review shall be undertaken jointly by designated representatives of the California Coastal Commission, the California Department of Fish and Game, the County of San Luis Obispo, the Community of Oceano, the California Department of Parks and Recreation and user groups.

If after each of the annual reviews, or after the three year review required in condition 1(b) above, it is found that the Off-Highway Vehicle (OHV) use within the Pismo Dunes State Vehicle Recreation Area (PDSVRA) is not occurring in a manner which protects environmentally sensitive habitats and adjacent community values consistent with the requirements of the San Luis Obispo Local Coastal Program Land Use Plan, then OHV access may be further limited pursuant to the access and habitat protection policies of the County certified Land Use Plan. If the above reviews find that OHV use within the PDSVRA is consistent with the protection of environmentally sensitive habitats and adjacent community values, and/or that additional staff and management revenues become available to the California Department of Parks and Recreation, levels of OHV use of the PDSVRA may be increased to a level not to exceed the enforcement and management capabilities available to the Pismo Beach State Parks Units.

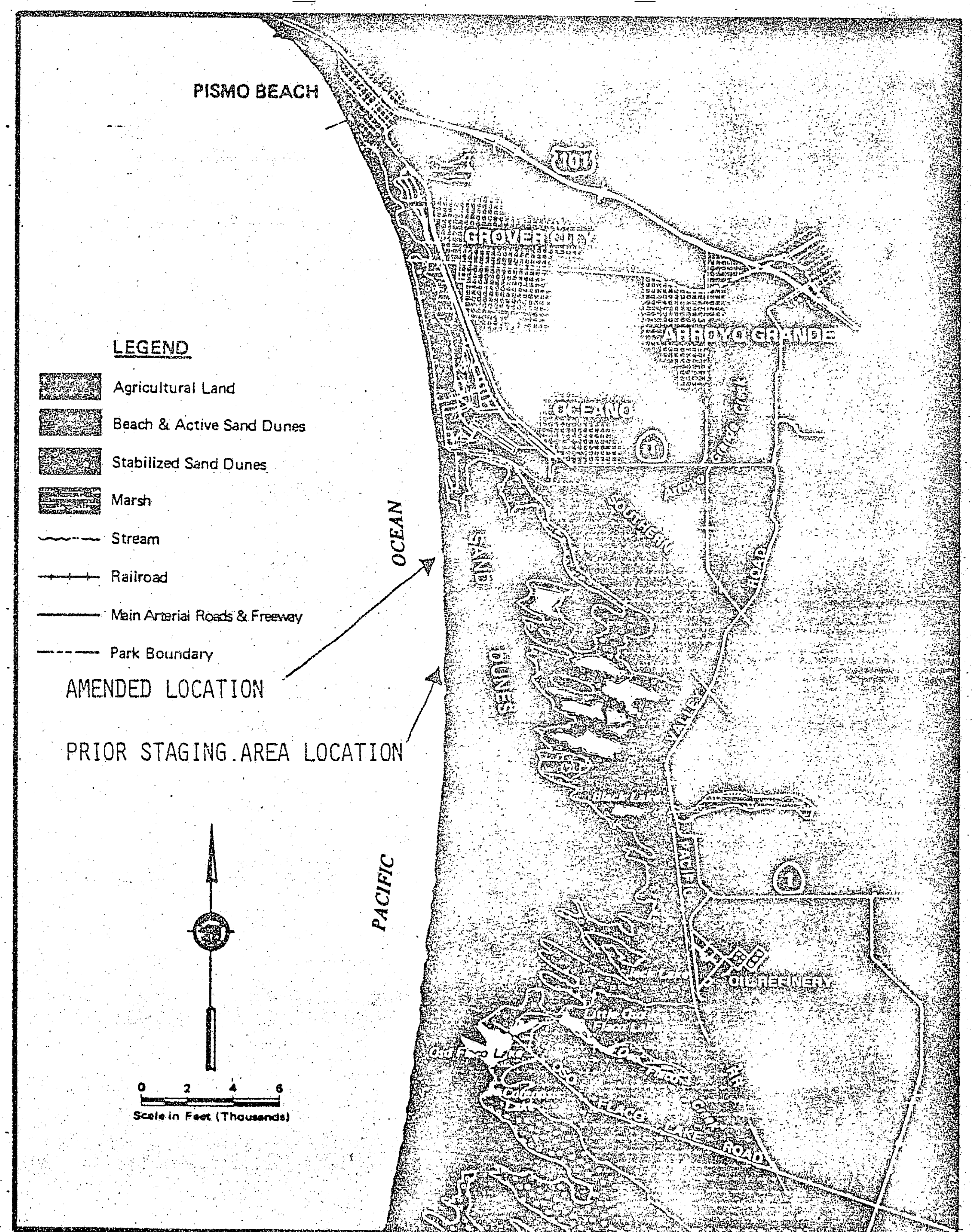


FIGURE 3

PHYSICAL CHARACTERISTICS

CDP 4-82-300-A2, approved in 1983

1. Staging Area Location:

A. An interim OHV staging area shall be operational no later than September 15th 1982 in a designated area on or adjacent to the beach south of the two mile post (Exhibit C). This staging area shall remain operational subject to the stated conditions and standards herein until such time as a permanent staging area is constructed.

Upon implementation of the interim staging area, all OHVs, ATCs and other non-street legal vehicles shall be trailored to and from Grande and Pier Avenues. At all times such vehicles when under their own power, shall be prohibited north of the northerly terminus of Sand Highway.

B. A permanent staging area site shall be selected as expeditiously as possible but in no case later than 18 months from the effective date of the County's LUP certification consistent with the following standards. Construction of this permanent staging area shall begin no later than three (3) years form the date of the certification of the County's LUP of its LCP. If construction and operation of a permanent staging area cannot be accomplished within the above time limits, this permit shall be subject to review and modification if necessary or appropriate by the County or the Commission or either in consultation with the other. Prior to construction, the County's LUP and the State Parks General Development Plan shall be amended to include the selected site with all additional standards or conditions for its design and operation. At the present time, there are several known locations which shall be considered and evaluated for staging area use, these locations are: Callendar Road area; the stables/agricultural lands area south of Arroyo Grande Creek; Agricultural lands north of Oso Flaco Creek adjacent to the Union Oil property; on the beach as per the interim staging area described herein (see Exhibit C). Other potential sites may also be evaluated. The site selection process shall include an environmental impacts analysis adequate to enable the selection of the least environmentally damaging location for the use. Accordingly, the on and off-site impacts of each alternative shall be measured against the impacts of the others. In selecting the site and amending the County's LUP and the State Parks General Development Plan to incorporate the selected site, the following standards must be found to have been met: 1) that the site selected is the least environmentally damaging alternative; and 2) that all feasible design and operational related mitigations have been incorporated to minimize adverse environmental impacts. Additional standards for site selection are in their order of importance: locating a site which reduces to the maximum extent feasible OHV related impacts to the residential character of the community of Oceano; locating a site which facilitates the successful separation and regulation of recreational uses within the park itself; locating a site which can be constructed and operational expeditiously.

C. Oso Flaco Lakes Area: An off-highway vehicle staging area shall not be constructed at the Oso Flaco Lake site indicated on Exhibit C. As part of the fencing proposed in this project, the Oso Flaco causeway to the PSVRA shall be permanently closed to vehicular traffic. Pedestrian and equestrian access only shall be allowed over

the causeway or in the vicinity of the Oso Flaco Lakes. The state owned agricultural lands south of Oso Flaco Lakes may be utilized for the development of a campground for passive recreational use of the dune areas within the Park excluded from OHV use. The State Parks and Recreation Department shall amend its General Development Plan accordingly. Uses in this camping area shall be permitted only if consistent with the resource protection policies of the San Luis Obispo County Land Use Plan; 100 foot buffering setbacks from the lakes, creek and wetlands shall be applied at a minimum with greater setbacks required if necessary, only resource dependent uses and passive recreational activities shall be permitted.

2. Control of Access to the Park: Effective immediately upon issuance of this permit and until either a permanent staging area is operational or this permit and the County's LUP is amended to accommodate possible necessary minor adjustments in the operation of these conditions, access and egress to and from the park shall be controlled and monitored in the following manner:

   A. All vehicular access and egress shall be via Grande Avenue and Pier Avenue, an effective vehicle barriers shall be placed at the southern end of the Oso Flaco causeway to assure that no OHV access over the causeway is permitted.
   B. Manned vehicle contact stations (kiosks) shall be placed at the Pier and Grande Avenue access points.

3. Control of uses within the Park: By the July 4 week-end of 1982 and as soon as possible prior to that date, the Parks and Recreation Department shall institute a Public Information program for vehicular recreational users within the Parks units. At the Grande and Pier Avenue's kiosks, occupants of all vehicles entering the Park will be provided a pass or ticket to the park and the following information:

   A. The following rules are effective immediately with violators subject to citation and fines:
      - All non-street legal vehicles shall be prohibited from the area north of the two mile post after dusk each day.
      - Vegetated dune areas, whether they are fenced or unfenced, are strictly off-limits to all vehicles.
      - All areas posted as Private Property or Restricted Use are off-limits to vehicle activity.
      - All vehicle activity is prohibited south of the Oso Flaco Creek (or south of the fence line that is constructed).

   B. Beginning with the 4th of July weekend 1983 ~~September 15, 1982~~ Beach Camping within the Park units shall be restricted to a maximum of ~~500~~ 1,000 units* with each unit available only through a reservation obtained through the State Parks Reservation System (Ticketron). Thereafter, admittance to the Park for the purpose of overnight camping will be denied to individuals without a valid reservation unless vacant unreserved camping spaces are available.

*One unit equals a campsite for a single camper vehicle.

C. Beginning September 15, 1982, specific areas of the Park will be designated for specific types of vehicles. The designations will be as follows:
    - Area north of the two mile post to Grande Avenue designated for and restricted to street legal vehicle use.
    - Area south of the two mile post to the fenced or posted area north of Oso Flaco Creek designated for OHV use.

D. On or before January 1983, the following will occur: OHV day use will be limited to a specified number of users established in consultation with agreement by the County of San Luis Obispo and the Executive Director of the Coastal Commission and the Department of State Parks. OHV day use fees may be collected.

E. Protective Fencing of Dunes, archeological resources, and wet environments shall be accomplished in the following manner subject to review and approval by the Executive Director of the Coastal Commission in consultation with the County of San Luis Obispo and the State Department of Fish and Game.

    (a) Fencing proposed and approved herein, plus fencing of the area shown as Area A on Exhibit D plus the perimeter fencing along the Sand Highway (or along the ridge just eastward of the Sand Highway) and the Eastern Boundary of ODSVRA shall be accomplished by November 30, 1982. All other vegetated areas indicated on Exhibit D shall be fenced by Aug 31, 1983.

    (b) One primary objective of the fencing is to prohibit vehicle access to the dune area south of Oso Flaco Creek. Accordingly, the east/west aligned fence north of Oso Flaco Creek shall continue seaward to the mean low water line so that vehicles do not pass to the south. The continuation of this line to mean low water may require different construction than normal fencing – possibly driven piles.

    (c) Except for the following, fencing alignments shall be placed a minimum of 100 feet from the vegetated areas being fenced:

        1. Along Sand Highway where the fence would encroach into the Sand Highway travel corridor.

        2. Along the seaward side of the foredunes paralleling the beach where fencing may be placed in a manner similar to that already existing along the westerly line of the State Dune Preserve except that a minimal number of breaks in the foredune fencing outside of the dune preserve may be allowed of OHV access to the backdune area. The fencing protecting the foredunes need not be a closed perimeter fence completely surrounding the foredune vegetation if it can be demonstrated to the Executive Director that such perimeter fencing is not necessary for effective preservation and stabilization of foredunes.

3. In other areas where it is demonstrated that a placement closer to vegetation will not diminish the effectiveness of the fence to stabilize the dune, protect the vegetation and provide necessary conditions for dune rehabilitation and restoration. Said demonstration shall be in the form of competent analysis of the dynamics of dune sand transport and natural condition necessary for dune stabilization. Reduction in the minimum setback under this condition shall be reviewed and approved by the Executive Director of the Coastal Commission.

(d) If fenced corridors to the Oso Flaco are constructed, they shall only be for use of state parks personnel and for the purpose of emergency, normal patrol duties, management and enforcement. Accordingly, these corridors shall have locked gates as shown on Exhibit D.

(e) Since a barrier to OHV movement south of Oso Flaco Creek is to be constructed on the north side of the creek, any construction of fencing south of Oso Flaco Creek or lakes shall be only for the purpose of preventing OHV intrusion into the State Park holdings from adjacent private lands. Such fencing shall therefore be perimeter fencing around parcels 8, 7, 3, and 4 and shall require a coastal development permit. Fencing applied for herein south of Oso Flaco which is not perimeter fencing shall not be constructed, or if constructed shall have been to an alignment approved herein by November 30, 1982.

4. Restoration

A dunes restoration program shall be undertaken by the DPR. The program shall be reviewed and approved by the Executive Director of the Coastal Commission. Restoration of vegetated dunes within the fenced-off areas shall be undertaken as expeditiously as funds and technical knowledge allows. Plantings shall begin no later than January 1983 with notification of the County and the Executive Director of the Coastal Commission. The restoration program shall be an ongoing program with the experimental or initial phase completed within three (3) years of the date of certification of the LUP and the full program in effect on that date or before.

5. Protection of Archeological Resources

Archeological resources within the PDVRA shall be protected by fencing. Accordingly, as part of the current fencing project, site No. SLO 199 shall be fenced for protection. Other sites shall be fenced as their locations become known.

6. Six months after the issuance of this permit, and annually thereafter <u>(or as needed)</u> until a permanent staging area is operational, a formal review of the effectiveness of the conditions of the permit shall take place. This review shall be undertaken jointly by designated representatives of the California Coastal Commission, the California Department of Fish and Game, the County of San Luis Obispo, the Community of Oceano, the California Department of Parks and Recreation and user groups.

~~If after each of the annual reviews, or after the three year review required in condition 1(b) above, it is found that the Off-Highway Vehicle (OHV) use within the Pismo Dunes State Vehicle Recreation Area (PDSVRA) is not occurring in a manner which protects environmentally sensitive habitats and adjacent community values consistent with the requirements of the San Luis Obispo Local Coastal Program Land Use Plan, then OHV access may be further limited pursuant to the access and habitat protection policies of the County certified Land Use Plan. If the above reviews find that OHV use within the PDSVRA is consistent with the protection of environmentally sensitive habitats and adjacent community values, and/or that additional staff and management revenues become available to the California Department of Parks and Recreation, levels of OHV use of the PDSVRA may be increased to a level not to exceed the enforcement and management capabilities available to the Pismo Beach State Parks Units.~~

<u>If, after an annual (or any other) review it is found that the ORV use within the SVRA is not occurring in a manner that protects environmentally sensitive habitats and community values consistent with the conditions of this permit and the County's Local Coastal Plan, then OHV access and the number of camp units allowed may be further limited by the Executive Director with concurrence by resolution of the Board of Supervisors of San Luis Obispo County. If the above reviews find that OHV use in the SVRA is consistent with the protection of environmentally sensitive habitats and community values, and/or that additional staff and management revenues become available to the DPR, levels of OHV access and the allowable number of camp units may be increased not to exceed the enforcement and management capabilities of the DPR by determination of the Executive Director with concurrence by resolution of the Board of Supervisors of San Luis Obispo County.</u>

CDP 4-82-300-A3, approved in 1984

1. Staging Area Location:

A. An interim OHV staging area shall be operational no later than September 15th 1982 in a designated area on or adjacent to the beach south of the two mile post (Exhibit C). This staging area shall remain operational subject to the stated conditions and standards herein until such time as a permanent staging area is constructed.

Upon implementation of the interim staging area, all OHVs, ATCs and other non-street legal vehicles shall be trailored to and from Grande and Pier Avenues. At all times such vehicles when under their own power, shall be prohibited north of the northerly terminus of Sand Highway.

B. A permanent staging area site shall be selected as expeditiously as possible but in no case later than 18 months from the effective date of the County's LUP certification consistent with the following standards. Construction of this permanent staging area shall begin no later than three (3) years form the date of the certification of the County's LUP of its LCP. If construction and operation of a permanent staging area cannot be accomplished within the above time limits, this permit shall be subject to review and modification if necessary or appropriate by the County or the Commission or either in consultation with the other. Prior to construction, the County's LUP and the State Parks General Development Plan shall be amended to include the selected site with all additional standards or conditions for its design and operation. At the present time, there are several known locations which shall be considered and evaluated for staging area use, these locations are: Callendar Road area; the stables/agricultural lands area south of Arroyo Grande Creek; Agricultural lands north of Oso Flaco Creek adjacent to the Union Oil property; on the beach as per the interim staging area described herein (see Exhibit C). Other potential sites may also be evaluated. The site selection process shall include an environmental impacts analysis adequate to enable the selection of the least environmentally damaging location for the use. Accordingly, the on and off-site impacts of each alternative shall be measured against the impacts of the others. In selecting the site and amending the County's LUP and the State Parks General Development Plan to incorporate the selected site, the following standards must be found to have been met: 1) that the site selected is the least environmentally damaging alternative; and 2) that all feasible design and operational related mitigations have been incorporated to minimize adverse environmental impacts. Additional standards for site selection are in their order of importance: locating a site which reduces to the maximum extent feasible OHV related impacts to the residential character of the community of Oceano; locating a site which facilitates the successful separation and regulation of recreational uses within the park itself; locating a site which can be constructed and operational expeditiously.

C. Oso Flaco Lakes Area: An off-highway vehicle staging area shall not be constructed at the Oso Flaco Lake site indicated on Exhibit C. As part of the fencing proposed in this project, the Oso Flaco causeway to the PSVRA shall be permanently closed to vehicular traffic. Pedestrian and equestrian access only shall be allowed over

the causeway or in the vicinity of the Oso Flaco Lakes. The state owned agricultural lands south of Oso Flaco Lakes may be utilized for the development of a campground for passive recreational use of the dune areas within the Park excluded from OHV use. The State Parks and Recreation Department shall amend its General Development Plan accordingly. Uses in this camping area shall be permitted only if consistent with the resource protection policies of the San Luis Obispo County Land Use Plan; 100 foot buffering setbacks from the lakes, creek and wetlands shall be applied at a minimum with greater setbacks required if necessary, only resource dependent uses and passive recreational activities shall be permitted.

2. Control of Access to the Park: Effective immediately upon issuance of this permit and until either a permanent staging area is operational or this permit and the County's LUP is amended to accommodate possible necessary minor adjustments in the operation of these conditions, access and egress to and from the park shall be controlled and monitored in the following manner:

   A. All vehicular access and egress shall be via Grande Avenue and Pier Avenue, an effective vehicle barriers shall be placed at the southern end of the Oso Flaco causeway to assure that no OHV access over the causeway is permitted.
   B. Manned vehicle contact stations (kiosks) shall be placed at the Pier and Grande Avenue access points.

3. Control of uses within the Park: By the July 4 week-end of 1982 and as soon as possible prior to that date, the Parks and Recreation Department shall institute a Public Information program for vehicular recreational users within the Parks units. At the Grande and Pier Avenue's kiosks, occupants of all vehicles entering the Park will be provided a pass or ticket to the park and the following information:

   A. The following rules are effective immediately with violators subject to citation and fines:
      - All non-street legal vehicles shall be prohibited from the area north of the two mile post after dusk each day.
      - Vegetated dune areas, whether they are fenced or unfenced, are strictly off-limits to all vehicles.
      - All areas posted as Private Property or Restricted Use are off-limits to vehicle activity.
      - All vehicle activity is prohibited south of the Oso Flaco Creek (or south of the fence line that is constructed).

   B. Beginning with the 4th of July weekend 1983 Beach Camping within the Park units shall be restricted to a maximum of 1,000 units* with each unit available only through a reservation obtained through the State Parks Reservation System (Ticketron). Thereafter, admittance to the Park for the purpose of overnight camping will be denied to individuals without a valid reservation unless vacant unreserved camping spaces are available.

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  - Area north of the two mile post to Grande Avenue designated for and restricted to street legal vehicle use.
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D. On or before January 1983, the following will occur: OHV day use will be limited to a specified number of users established in consultation with agreement by the County of San Luis Obispo and the Executive Director of the Coastal Commission and the Department of State Parks. OHV day use fees may be collected.

E. Protective Fencing of Dunes, archeological resources, and wet environments shall be accomplished in the following manner subject to review and approval by the Executive Director of the Coastal Commission in consultation with the County of San Luis Obispo and the State Department of Fish and Game.

   (a) Fencing proposed and approved herein, plus fencing of the area shown ~~as Area A~~ on Exhibit A-2 ~~D~~ plus the perimeter fencing along the Sand Highway (or along the ridge just eastward of the Sand Highway) and the Eastern Boundary of ODSVRA shall be accomplished by November 30, 1982. All other vegetated areas indicated on Exhibit A-2 ~~D~~ shall be fenced by Aug 31, 1983.

   (b) One primary objective of the fencing is to prohibit vehicle access to the dune area south of Oso Flaco Creek. Accordingly, the east/west aligned fence north of Oso Flaco Creek shall continue seaward to the mean low water line so that vehicles do not pass to the south. The continuation of this line to mean low water may require different construction than normal fencing – possibly driven piles.

   (c) Except for the following, fencing alignments shall be placed a minimum of 100 feet from the vegetated areas being fenced:

      1. Along Sand Highway where the fence would encroach into the Sand Highway travel corridor.

      2. Along the seaward side of the foredunes paralleling the beach where fencing may be placed in a manner similar to that already existing along the westerly line of the State Dune Preserve except that a minimal number of breaks in the foredune fencing outside of the dune preserve may be allowed of OHV access to the backdune area. The fencing protecting the foredunes need not be a closed perimeter fence completely surrounding the foredune vegetation if it can be demonstrated to the Executive Director that such perimeter fencing is not necessary for effective preservation and stabilization of foredunes.

3. In other areas where it is demonstrated that a placement closer to vegetation will not diminish the effectiveness of the fence to stabilize the dune, protect the vegetation and provide necessary conditions for dune rehabilitation and restoration. Said demonstration shall be in the form of competent analysis of the dynamics of dune sand transport and natural condition necessary for dune stabilization. Reduction in the minimum setback under this condition shall be reviewed and approved by the Executive Director of the Coastal Commission.

(d) If fenced corridors to the Oso Flaco are constructed, they shall only be for use of state parks personnel and for the purpose of emergency, normal patrol duties, management and enforcement. Accordingly, these corridors shall have locked gates~~ as shown on Exhibit D~~.

(e) Since a barrier to OHV movement south of Oso Flaco Creek is to be constructed on the north side of the creek, any construction of fencing south of Oso Flaco Creek or lakes shall be only for the purpose of preventing OHV intrusion into the State Park holdings from adjacent private lands. Such fencing shall therefore be perimeter fencing around parcels 8, 7, 3, and 4 and shall require a coastal development permit. Fencing applied for herein south of Oso Flaco which is not perimeter fencing shall not be constructed, or if constructed shall have been to an alignment approved herein by November 30, 1982.

4. Restoration

A dunes restoration program shall be undertaken by the DPR. The program shall be reviewed and approved by the Executive Director of the Coastal Commission. Restoration of vegetated dunes within the fenced-off areas shall be undertaken as expeditiously as funds and technical knowledge allows. Plantings shall begin no later than January 1983 with notification of the County and the Executive Director of the Coastal Commission. The restoration program shall be an ongoing program with the experimental or initial phase completed within three (3) years of the date of certification of the LUP and the full program in effect on that date or before.

5. Protection of Archeological Resources

Archeological resources within the PDVRA shall be protected by fencing. Accordingly, as part of the current fencing project, site No. SLO 199 shall be fenced for protection. Other sites shall be fenced as their locations become known.

6. Six months after the issuance of this permit, and annually thereafter (or as needed) until a permanent staging area is operational, a formal review of the effectiveness of the conditions of the permit shall take place. This review shall be undertaken jointly by designated representatives of the California Coastal Commission, the California Department of Fish and Game, the County of San Luis Obispo, the Community of Oceano, the California Department of Parks and Recreation and user groups.

If, after an annual (or any other) review it is found that the ORV use within the SVRA is not occurring in a manner that protects environmentally sensitive habitats and community values consistent with the conditions of this permit and the County's Local Coastal Plan, then OHV access and the number of camp units allowed may be further limited by the Executive Director with concurrence by resolution of the Board of Supervisors of San Luis Obispo County. If the above reviews find that OHV use in the SVRA is consistent with the protection of environmentally sensitive habitats and community values, and/or that additional staff and management revenues become available to the DPR, levels of OHV access and the allowable number of camp units may be increased not to exceed the enforcement and management capabilities of the DPR by determination of the Executive Director with concurrence by resolution of the Board of Supervisors of San Luis Obispo County.

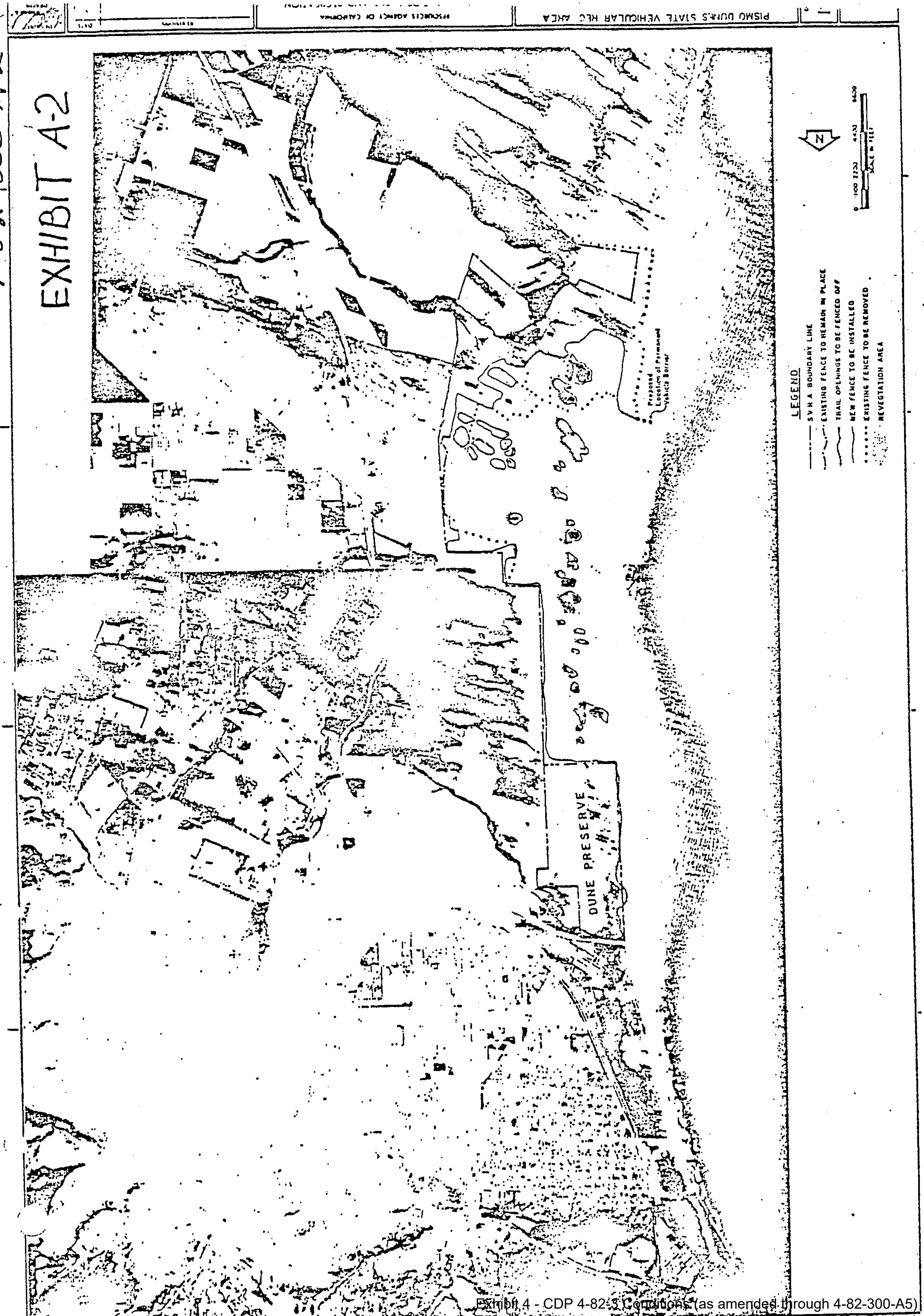
EXHIBIT A-2
PISMO DUNES STATE VEHICULAR REC AREA
RESOURCES AGENCY OF CALIFORNIA
DUNE PRESERVE
Proposed Location of Permanent Vehicle Barrier
N
LEGEND
SVRA BOUNDARY LINE
EXISTING FENCE TO REMAIN IN PLACE
TRAIL OPENINGS TO BE FENCED OFF
NEW FENCE TO BE INSTALLED
EXISTING FENCE TO BE REMOVED
REVEGETATION AREA

CDP 4-82-300-A4, approved in 1991

1. Staging Area Location:

A. An interim OHV staging area shall be operational no later than September 15th 1982 in a designated area on or adjacent to the beach south of the two mile post (Exhibit C). This staging area shall remain operational subject to the stated conditions and standards herein until such time as a permanent staging area is constructed.

Upon implementation of the interim staging area, all OHVs, ATCs and other non-street legal vehicles shall be trailored to and from Grande and Pier Avenues. At all times such vehicles when under their own power, shall be prohibited north of the northerly terminus of Sand Highway.

B. A permanent staging area site shall be selected as expeditiously as possible but in no case later than 18 months from the effective date of the County's LUP certification consistent with the following standards. Construction of this permanent staging area shall begin no later than three (3) years form the date of the certification of the County's LUP of its LCP. If construction and operation of a permanent staging area cannot be accomplished within the above time limits, this permit shall be subject to review and modification if necessary or appropriate by the County or the Commission or either in consultation with the other. Prior to construction, the County's LUP and the State Parks General Development Plan shall be amended to include the selected site with all additional standards or conditions for its design and operation. At the present time, there are several known locations which shall be considered and evaluated for staging area use, these locations are: Callendar Road area; the stables/agricultural lands area south of Arroyo Grande Creek; Agricultural lands north of Oso Flaco Creek adjacent to the Union Oil property; on the beach as per the interim staging area described herein (see Exhibit C). Other potential sites may also be evaluated. The site selection process shall include an environmental impacts analysis adequate to enable the selection of the least environmentally damaging location for the use. Accordingly, the on and off-site impacts of each alternative shall be measured against the impacts of the others. In selecting the site and amending the County's LUP and the State Parks General Development Plan to incorporate the selected site, the following standards must be found to have been met: 1) that the site selected is the least environmentally damaging alternative; and 2) that all feasible design and operational related mitigations have been incorporated to minimize adverse environmental impacts. Additional standards for site selection are in their order of importance: locating a site which reduces to the maximum extent feasible OHV related impacts to the residential character of the community of Oceano; locating a site which facilitates the successful separation and regulation of recreational uses within the park itself; locating a site which can be constructed and operational expeditiously.

C. Oso Flaco Lakes Area: An off-highway vehicle staging area shall not be constructed at the Oso Flaco Lake site indicated on Exhibit C. As part of the fencing proposed in this project, the Oso Flaco causeway to the PSVRA shall be permanently closed to vehicular traffic. Pedestrian and equestrian access only shall be allowed over

the causeway or in the vicinity of the Oso Flaco Lakes effective no later than March 1, 1992.

By acceptance of this permit the applicant agrees to not close equestrian access at Oso Flaco Lake until March 1, 1992 or sooner if an alternative equestrian access solution is identified. The intent of this condition is to allow additional time for all parties involved in the attempt to locate alternative access routes to the beach to identify a site which would be suitable and acceptable to the Commission. The Commission will review and make a decision on the appropriateness of that site at a subsequent date. If an alternative equestrian access route is identified prior to March 1, 1992, the applicant will submit the proposed route to the Commission for its review and approval at a subsequent date. In the event an alternative equestrian access route is not identified, equestrian access through Oso Flaco Lake Natural Area can be closed on March 1, 1992.

The state owned agricultural lands south of Oso Flaco Lakes may be utilized for the development of a campground for passive recreational use of the dune areas within the Park excluded from OHV use. The State Parks and Recreation Department shall amend its General Development Plan accordingly. Uses in this camping area shall be permitted only if consistent with the resource protection policies of the San Luis Obispo County Land Use Plan; 100 foot buffering setbacks from the lakes, creek and wetlands shall be applied at a minimum with greater setbacks required if necessary, only resource dependent uses and passive recreational activities shall be permitted.

2. Control of Access to the Park: Effective immediately upon issuance of this permit and until either a permanent staging area is operational or this permit and the County's LUP is amended to accommodate possible necessary minor adjustments in the operation of these conditions, access and egress to and from the park shall be controlled and monitored in the following manner:

   A. All vehicular access and egress shall be via Grande Avenue and Pier Avenue, an effective vehicle barriers shall be placed at the southern end of the Oso Flaco causeway to assure that no OHV access over the causeway is permitted.
   B. Manned vehicle contact stations (kiosks) shall be placed at the Pier and Grande Avenue access points.
   C. Equestrian Gate: The applicant within sixty (60) days of approval (by November 10, 1991) shall reconstruct a portion of the existing fence along the southern Pismo Dunes State Vehicle Recreation Area (SVRA) boundary to allow equestrians and pedestrians to pass along the beach, while preventing passage by off-highway vehicles.

3. Control of uses within the Park: By the July 4 week-end of 1982 and as soon as possible prior to that date, the Parks and Recreation Department shall institute a Public Information program for vehicular recreational users within the Parks units. At the Grande and Pier Avenue's kiosks, occupants of all vehicles entering the Park will be provided a pass or ticket to the park and the following information:

A. The following rules are effective immediately with violators subject to citation and fines:
    - All non-street legal vehicles shall be prohibited from the area north of the two mile post after dusk each day.
    - Vegetated dune areas, whether they are fenced or unfenced, are strictly off-limits to all vehicles.
    - All areas posted as Private Property or Restricted Use are off-limits to vehicle activity.
    - All vehicle activity is prohibited south of the Oso Flaco Creek (or south of the fence line that is constructed).

B. Beginning with the 4th of July weekend 1983 Beach Camping within the Park units shall be restricted to a maximum of 1,000 units* with each unit available only through a reservation obtained through the State Parks Reservation System (Ticketron). Thereafter, admittance to the Park for the purpose of overnight camping will be denied to individuals without a valid reservation unless vacant unreserved camping spaces are available.

*One unit equals a campsite for a single camper vehicle.

C. Beginning September 15, 1982, specific areas of the Park will be designated for specific types of vehicles. The designations will be as follows:
    - Area north of the two mile post to Grande Avenue designated for and restricted to street legal vehicle use.
    - Area south of the two mile post to the fenced or posted area north of Oso Flaco Creek designated for OHV use.

D. On or before January 1983, the following will occur: OHV day use will be limited to a specified number of users established in consultation with agreement by the County of San Luis Obispo and the Executive Director of the Coastal Commission and the Department of State Parks. OHV day use fees may be collected.

E. Protective Fencing of Dunes, archeological resources, and wet environments shall be accomplished in the following manner subject to review and approval by the Executive Director of the Coastal Commission in consultation with the County of San Luis Obispo and the State Department of Fish and Game.

    (a) Fencing proposed and approved herein, plus fencing of the area shown on Exhibit A-2 plus the perimeter fencing along the Sand Highway (or along the ridge just eastward of the Sand Highway) and the Eastern Boundary of ODSVRA shall be accomplished by November 30, 1982. All other vegetated areas indicated on Exhibit A-2 shall be fenced by Aug 31, 1983.

    (b) One primary objective of the fencing is to prohibit vehicle access to the dune area south of Oso Flaco Creek. Accordingly, the east/west aligned fence north of Oso Flaco Creek shall continue seaward to the mean low water line so that vehicles do not pass to the south. The continuation of this line to mean low water may require different construction than normal fencing – possibly driven piles.

(c) Except for the following, fencing alignments shall be placed a minimum of 100 feet from the vegetated areas being fenced:

1. Along Sand Highway where the fence would encroach into the Sand Highway travel corridor.

2. Along the seaward side of the foredunes paralleling the beach where fencing may be placed in a manner similar to that already existing along the westerly line of the State Dune Preserve except that a minimal number of breaks in the foredune fencing outside of the dune preserve may be allowed of OHV access to the backdune area. The fencing protecting the foredunes need not be a closed perimeter fence completely surrounding the foredune vegetation if it can be demonstrated to the Executive Director that such perimeter fencing is not necessary for effective preservation and stabilization of foredunes.

3. In other areas where it is demonstrated that a placement closer to vegetation will not diminish the effectiveness of the fence to stabilize the dune, protect the vegetation and provide necessary conditions for dune rehabilitation and restoration. Said demonstration shall be in the form of competent analysis of the dynamics of dune sand transport and natural condition necessary for dune stabilization. Reduction in the minimum setback under this condition shall be reviewed and approved by the Executive Director of the Coastal Commission.

(d) If fenced corridors to the Oso Flaco are constructed, they shall only be for use of state parks personnel and for the purpose of emergency, normal patrol duties, management and enforcement. Accordingly, these corridors shall have locked gates.

(e) Since a barrier to OHV movement south of Oso Flaco Creek is to be constructed on the north side of the creek, any construction of fencing south of Oso Flaco Creek or lakes shall be only for the purpose of preventing OHV intrusion into the State Park holdings from adjacent private lands. Such fencing shall therefore be perimeter fencing around parcels 8, 7, 3, and 4 and shall require a coastal development permit. Fencing applied for herein south of Oso Flaco which is not perimeter fencing shall not be constructed, or if constructed shall have been to an alignment approved herein by November 30, 1982.

4. Restoration

A dunes restoration program shall be undertaken by the DPR. The program shall be reviewed and approved by the Executive Director of the Coastal Commission. Restoration of vegetated dunes within the fenced-off areas shall be undertaken as expeditiously as funds and technical knowledge allows. Plantings shall begin no later than January 1983 with notification of the County and the Executive Director of the Coastal Commission. The restoration program shall be an ongoing program with the experimental or initial phase completed within three (3) years of the date of certification of the LUP and the full program in effect on that date or before.

5. Protection of Archeological Resources

   Archeological resources within the PDVRA shall be protected by fencing. Accordingly, as part of the current fencing project, site No. SLO 199 shall be fenced for protection. Other sites shall be fenced as their locations become known.

6. Six months after the issuance of this permit, and annually thereafter (or as needed) until a permanent staging area is operational, a formal review of the effectiveness of the conditions of the permit shall take place. This review shall be undertaken jointly by designated representatives of the California Coastal Commission, the California Department of Fish and Game, the County of San Luis Obispo, the Community of Oceano, the California Department of Parks and Recreation and user groups.

   If, after an annual (or any other) review it is found that the ORV use within the SVRA is not occurring in a manner that protects environmentally sensitive habitats and community values consistent with the conditions of this permit and the County's Local Coastal Plan, then OHV access and the number of camp units allowed may be further limited by the Executive Director with concurrence by resolution of the Board of Supervisors of San Luis Obispo County. If the above reviews find that OHV use in the SVRA is consistent with the protection of environmentally sensitive habitats and community values, and/or that additional staff and management revenues become available to the DPR, levels of OHV access and the allowable number of camp units may be increased not to exceed the enforcement and management capabilities of the DPR by determination of the Executive Director with concurrence by resolution of the Board of Supervisors of San Luis Obispo County.

CDP 4-82-300-A5, approved in 2001

1. Staging Area Location:

A. An interim OHV staging area shall be operational no later than September 15th 1982 in a designated area on or adjacent to the beach south of the two mile post (Exhibit C). This staging area shall remain operational subject to the stated conditions and standards herein until such time as a permanent staging area is constructed.

Upon implementation of the interim staging area, all OHVs, ATCs and other non-street legal vehicles shall be trailored to and from Grande and Pier Avenues. At all times such vehicles when under their own power, shall be prohibited north of the northerly terminus of Sand Highway.

B. A permanent staging area site shall be selected as expeditiously as possible but in no case later than 18 months from the effective date of the County's LUP certification consistent with the following standards. Construction of this permanent staging area shall begin no later than three (3) years form the date of the certification of the County's LUP of its LCP. If construction and operation of a permanent staging area cannot be accomplished within the above time limits, this permit shall be subject to review and modification if necessary or appropriate by the County or the Commission or either in consultation with the other. Prior to construction, the County's LUP and the State Parks General Development Plan shall be amended to include the selected site with all additional standards or conditions for its design and operation. At the present time, there are several known locations which shall be considered and evaluated for staging area use, these locations are: Callendar Road area; the stables/agricultural lands area south of Arroyo Grande Creek; Agricultural lands north of Oso Flaco Creek adjacent to the Union Oil property; on the beach as per the interim staging area described herein (see Exhibit C). Other potential sites may also be evaluated. The site selection process shall include an environmental impacts analysis adequate to enable the selection of the least environmentally damaging location for the use. Accordingly, the on and off-site impacts of each alternative shall be measured against the impacts of the others. In selecting the site and amending the County's LUP and the State Parks General Development Plan to incorporate the selected site, the following standards must be found to have been met: 1) that the site selected is the least environmentally damaging alternative; and 2) that all feasible design and operational related mitigations have been incorporated to minimize adverse environmental impacts. Additional standards for site selection are in their order of importance: locating a site which reduces to the maximum extent feasible OHV related impacts to the residential character of the community of Oceano; locating a site which facilitates the successful separation and regulation of recreational uses within the park itself; locating a site which can be constructed and operational expeditiously.

C. Oso Flaco Lakes Area: An off-highway vehicle staging area shall not be constructed at the Oso Flaco Lake site indicated on Exhibit C. As part of the fencing proposed in this project, the Oso Flaco causeway to the PSVRA shall be permanently closed to vehicular traffic. Pedestrian and equestrian access only shall be allowed over

the causeway or in the vicinity of the Oso Flaco Lakes effective no later than March 1, 1992.

By acceptance of this permit the applicant agrees to not close equestrian access at Oso Flaco Lake until March 1, 1992 or sooner if an alternative equestrian access solution is identified. The intent of this condition is to allow additional time for all parties involved in the attempt to locate alternative access routes to the beach to identify a site which would be suitable and acceptable to the Commission. The Commission will review and make a decision on the appropriateness of that site at a subsequent date. If an alternative equestrian access route is identified prior to March 1, 1992, the applicant will submit the proposed route to the Commission for its review and approval at a subsequent date. In the event an alternative equestrian access route is not identified, equestrian access through Oso Flaco Lake Natural Area can be closed on March 1, 1992.

The state owned agricultural lands south of Oso Flaco Lakes may be utilized for the development of a campground for passive recreational use of the dune areas within the Park excluded from OHV use. The State Parks and Recreation Department shall amend its General Development Plan accordingly. Uses in this camping area shall be permitted only if consistent with the resource protection policies of the San Luis Obispo County Land Use Plan; 100 foot buffering setbacks from the lakes, creek and wetlands shall be applied at a minimum with greater setbacks required if necessary, only resource dependent uses and passive recreational activities shall be permitted.

2. Control of Access to the Park: Effective immediately upon issuance of this permit and until either a permanent staging area is operational or this permit and the County's LUP is amended to accommodate possible necessary minor adjustments in the operation of these conditions, access and egress to and from the park shall be controlled and monitored in the following manner:

   A. All vehicular access and egress shall be via Grande Avenue and Pier Avenue, an effective vehicle barriers shall be placed at the southern end of the Oso Flaco causeway to assure that no OHV access over the causeway is permitted.
   B. Manned vehicle contact stations (kiosks) shall be placed at the Pier and Grande Avenue access points.
   C. Equestrian Gate: The applicant within sixty (60) days of approval (by November 10, 1991) shall reconstruct a portion of the existing fence along the southern Pismo Dunes State Vehicle Recreation Area (SVRA) boundary to allow equestrians and pedestrians to pass along the beach, while preventing passage by off-highway vehicles.

3. Control of uses within the Park: By the July 4 week-end of 1982 and as soon as possible prior to that date, the Parks and Recreation Department shall institute a Public Information program for vehicular recreational users within the Parks units. At the Grande and Pier Avenue's kiosks, occupants of all vehicles entering the Park will be provided a pass or ticket to the park and the following information:

A. The following rules are effective immediately with violators subject to citation and fines:
   - All non-street legal vehicles shall be prohibited from the area north of the two mile post after dusk each day.
   - Vegetated dune areas, whether they are fenced or unfenced, are strictly off-limits to all vehicles.
   - All areas posted as Private Property or Restricted Use are off-limits to vehicle activity.
   - All vehicle activity is prohibited south of the Oso Flaco Creek (or south of the fence line that is constructed).

~~B. Beginning with the 4th of July weekend 1983 Beach Camping within the Park units shall be restricted to a maximum of 1,000 units* with each unit available only through a reservation obtained through the State Parks Reservation System (Ticketron). Thereafter, admittance to the Park for the purpose of overnight camping will be denied to individuals without a valid reservation unless vacant unreserved camping spaces are available.~~

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Archeological resources within the PDVRA shall be protected by fencing. Accordingly, as part of the current fencing project, site No. SLO 199 shall be fenced for protection. Other sites shall be fenced as their locations become known.

~~6.~~ ~~Six months after the issuance of this permit, and annually thereafter (or as needed) until a permanent staging area is operational, a formal review of the effectiveness of the conditions of the permit shall take place. This review shall be undertaken jointly by designated representatives of the California Coastal Commission, the California Department of Fish and Game, the County of San Luis Obispo, the Community of Oceano, the California Department of Parks and Recreation and user groups.~~

~~If, after an annual (or any other) review it is found that the ORV use within the SVRA is not occurring in a manner that protects environmentally sensitive habitats and community values consistent with the conditions of this permit and the County's Local Coastal Plan, then OHV access and the number of camp units allowed may be further limited by the Executive Director with concurrence by resolution of the Board of Supervisors of San Luis Obispo County. If the above reviews find that OHV use in the SVRA is consistent with the protection of environmentally sensitive habitats and community values, and/or that additional staff and management revenues become available to the DPR, levels of OHV access and the allowable number of camp units may be increased not to exceed the enforcement and management capabilities of the DPR by determination of the Executive Director with concurrence by resolution of the Board of Supervisors of San Luis Obispo County.~~

SPECIAL CONDITIONS OF APPROVAL

1. Scope of Permit. This permit amendment replaces Special Conditions 3B, 3D, and 6 of CDP 4-82-300. This permit amendment also authorizes the institution of interim vehicle (street-legal, off-highway vehicle, and camping) limits at the ODSVRA, and the establishment of an ODSVRA Technical Review Team, for an initial one-year period form the date of approval of the revised conditions and findings.

2. Renewal of Permit. Annually, the Commission shall review the overall effectiveness of the Technical Review Team in managing vehicle impacts at the ODSVRA. If the Commission is satisfied with the review, the amendment will remain in effect for another year. Otherwise, an alternative approach to resource management, or set of management measures, may be instituted through this review process.

3. Interim Vehicle Limits

a. Interim *Day-Use Vehicle Limits.* Except as qualified by 3d-, interim limits on motor vehicle use on the beaches and dunes of Oceano Dunes SVRA shall be no more than 2,580 street-legal vehicles per day. This limit does not include off-highway vehicles, or street-legal vehicles attributable to allowed overnight camper use within the ODSVRA.

b. Interim Camping Limits. Except as qualified by 3d, interim limits on overnight motor vehicle use on the beaches and dunes of Ocean Dunes SVRA shall be no more than 1,000 camping units (i.e. 1,000 street-legal vehicles) per night. This limit does not include off-highway vehicles or street-legal vehicles attributable to allowed day-use within the ODSVRA.

c. Interim Off-Highway Vehicle Limits. Except as qualified by 3d, interim limits on off-highway vehicle use on the beaches and dunes of Oceano Dunes SVRA shall be no more than 1,720 off-highway vehicles at any given time. This limit does not include the street-legal vehicles used to tow or trailer the OHVs into the ODSVRA.

d. Holiday Periods[1]. Interim street-legal and off-highway vehicle limits may be exceeded only during the four major holiday periods of Memorial Day (Saturday through Monday), July 4th (one day and any adjacent weekend days), Labor Day (Saturday through Monday), and Thanksgiving (Thursday through Sunday).

4. Technical Review Team. The Technical Review Team (TRT), advisory to the Superintendent of the Oceano Dunes State Vehicular Recreation Area, shall be established within three months, and shall meet within six months, from approval of the revised conditions and findings of this coastal development permit amendment (4-82-300-A5). A Charter for the TRT, establishing members, roles and procedures for the Team, shall be submitted to the Executive Director for review within one year of approval of the revised conditions and findings of this coastal development permit amendment.

a. The Charter shall establish a specific structure and process in order for the TRT to do at least the following:
   i. Assist in building community support through problem solving, consensus building, new constituency development, and increasing understanding about the ODSVRA; and
   ii. Develop recommendations to the Superintendent of the ODSVRA regarding additional monitoring studies, adjustments to day and overnight use limits, and management strategies.

b. The Charter shall also include at least the following:
   i. A provision to create a scientific subcommittee to identify, develop and evaluate the scientific information needed by decision-makers to ensure that the ODSVRA's natural resources are adequately managed and protected. The subcommittee shall be composed of resource experts representing the five government agencies (CCC, SLO County, USFWS, DFG, DPR) and at least two independent scientists with expertise in

[1] These exceedance periods are no longer allowed under terms of settlement agreement entered into by Parks.

Western snowy plover, California least tern, steelhead trout or other species of concern, as well as ecological processes to analyze technical data and provide scientific recommendations to the TRT; and

ii. A provision to submit a list of proposed members of the scientific subcommittee to the Executive Director for review and approval.

c. The Charter shall establish a specific structure and process in order for the scientific subcommittee to do at least the following:

i. Recommend to the TRT the scientific studies and investigations that may be necessary to develop information needed by resource managers;

ii. Advise the TRT regarding the protection of the SVRA's natural resources by helping identify and review needed research measures and restoration efforts to rebuild or protect the ODSVRA natural resources;

iii. Evaluate monitoring results and reevaluate monitoring protocols contained in Oceano Dunes SVRA annual reports for the Habitat Monitoring System, reports on the breeding, nesting and fledgling success of the western snowy plover and California least tern populations in the SVRA, and other reports related to the environmental impacts of recreational activities;

iv. Provide comments on the adequacy of various scientific research studies and make management recommendations to the TRT; and

v. Submit the full recommendations of the scientific subcommittee to the Commission and make them available to the public, as part of the annual review process required in Special Condition 2.

5. Annual Report. The TRT and the ODSVRA Superintendent shall prepare annual reports (for the period of October to September) summarizing annual recreational use and habitat trends at the Park; and highlighting the TRT's major accomplishments (including progress made towards meeting the objectives of the TRT), projects, correspondence, and recommendations as well as a summary of subcommittees, working groups, and task force activities. The first annual report shall include (1) a draft or final Charter for the TRT, and (2) a description of the process by which the TRT will rank research and management questions and priorities. The second annual report shall include (1) the final Charter for the TRT (if not submitted with the first annual report), (2) the TRT's ranking of research and management questions and priorities, and (3) a scope of work for those projects identified as highest priority. Subsequent reports will include a status report on the progress of those projects as well as updates to research and management priorities and the corresponding scopes of work for addressing those new priorities. One component of the Commission's annual review will be to evaluate the progress of the TRT's work as measured against the submitted work plans.

In identifying and selecting the priority research and management questions and projects, the TRT shall consider information developed by the USFWS and shall include the following:

a. Appropriate management techniques for the western snowy plover, California least tern, and steelhead trout including an evaluation of:

i. How the geographic location of nests, proximity of nests to foraging areas, and nest closure techniques affect the hatching and fledgling success of the species,

ii. What studies may be necessary to determine appropriate management techniques, or what known management techniques could be put in place, for protecting each species of concern, and

iii. The potential environmental, recreational and economic costs and benefits of alternative beach/dune habitat protection strategies.

b. Appropriate management techniques for protecting water quality and dune habitats from potential pollutants that might result from motor vehicle fluids or other contaminants that might enter the ODSVRA and ocean through polluted runoff or direct discharges; and

c. The success of past revegetation efforts within the ODSVRA and the potential need for continuing or expanding those efforts, including expansion of vegetation exclosures.

d. Conduct a comprehensive, long-term monitoring and comparative analysis of the resources impacts associated with varying levels of use, including the highest (peak-use) attendance periods.

If alternative research and management questions and projects are identified as a higher priority that those listed in a through d above, the annual reports shall discuss the basis for such a determination. Annual reports shall be submitted to San Luis Obispo County and California Coastal Commission for informational purposes no later than January 1st of the following year. The first annual report (or portion thereof) shall be completed and submitted to the Commission no later than January 1, 2002.

CDP 4-82-300 Conditions (through 4-82-300-A5)

1. Staging Area Location:

A. An interim OHV staging area shall be operational no later than September 15th 1982 in a designated area on or adjacent to the beach south of the two mile post (Exhibit C). This staging area shall remain operational subject to the stated conditions and standards herein until such time as a permanent staging area is constructed.

Upon implementation of the interim staging area, all OHVs, ATCs and other non-street legal vehicles shall be trailored to and from Grande and Pier Avenues. At all times such vehicles when under their own power, shall be prohibited north of the northerly terminus of Sand Highway.

B. A permanent staging area site shall be selected as expeditiously as possible but in no case later than 18 months from the effective date of the County's LUP certification consistent with the following standards. Construction of this permanent staging area shall begin no later than three (3) years form the date of the certification of the County's LUP of its LCP. If construction and operation of a permanent staging area cannot be accomplished within the above time limits, this permit shall be subject to review and modification if necessary or appropriate by the County or the Commission or either in consultation with the other. Prior to construction, the County's LUP and the State Parks General Development Plan shall be amended to include the selected site with all additional standards or conditions for its design and operation. At the present time, there are several known locations which shall be considered and evaluated for staging area use, these locations are: Callendar Road area; the stables/agricultural lands area south of Arroyo Grande Creek; Agricultural lands north of Oso Flaco Creek adjacent to the Union Oil property; on the beach as per the interim staging area described herein (see Exhibit C). Other potential sites may also be evaluated. The site selection process shall include an environmental impacts analysis adequate to enable the selection of the least environmentally damaging location for the use. Accordingly, the on and off-site impacts of each alternative shall be measured against the impacts of the others. In selecting the site and amending the County's LUP and the State Parks General Development Plan to incorporate the selected site, the following standards must be found to have been met: 1) that the site selected is the least environmentally damaging alternative; and 2) that all feasible design and operational related mitigations have been incorporated to minimize adverse environmental impacts. Additional standards for site selection are in their order of importance: locating a site which reduces to the maximum extent feasible OHV related impacts to the residential character of the community of Oceano; locating a site which facilitates the successful separation and regulation of recreational uses within the park itself; locating a site which can be constructed and operational expeditiously.

C. Oso Flaco Lakes Area: An off-highway vehicle staging area shall not be constructed at the Oso Flaco Lake site indicated on Exhibit C. As part of the fencing proposed in this project, the Oso Flaco causeway to the PSVRA shall be permanently closed to vehicular traffic. Pedestrian and equestrian access only shall be allowed over

the causeway or in the vicinity of the Oso Flaco Lakes effective no later than March 1, 1992.

By acceptance of this permit the applicant agrees to not close equestrian access at Oso Flaco Lake until March 1, 1992 or sooner if an alternative equestrian access solution is identified. The intent of this condition is to allow additional time for all parties involved in the attempt to locate alternative access routes to the beach to identify a site which would be suitable and acceptable to the Commission. The Commission will review and make a decision on the appropriateness of that site at a subsequent date. If an alternative equestrian access route is identified prior to March 1, 1992, the applicant will submit the proposed route to the Commission for its review and approval at a subsequent date. In the event an alternative equestrian access route is not identified, equestrian access through Oso Flaco Lake Natural Area can be closed on March 1, 1992.

The state owned agricultural lands south of Oso Flaco Lakes may be utilized for the development of a campground for passive recreational use of the dune areas within the Park excluded from OHV use. The State Parks and Recreation Department shall amend its General Development Plan accordingly. Uses in this camping area shall be permitted only if consistent with the resource protection policies of the San Luis Obispo County Land Use Plan; 100 foot buffering setbacks from the lakes, creek and wetlands shall be applied at a minimum with greater setbacks required if necessary, only resource dependent uses and passive recreational activities shall be permitted.

2. Control of Access to the Park: Effective immediately upon issuance of this permit and until either a permanent staging area is operational or this permit and the County's LUP is amended to accommodate possible necessary minor adjustments in the operation of these conditions, access and egress to and from the park shall be controlled and monitored in the following manner:

   A. All vehicular access and egress shall be via Grande Avenue and Pier Avenue, an effective vehicle barriers shall be placed at the southern end of the Oso Flaco causeway to assure that no OHV access over the causeway is permitted.
   B. Manned vehicle contact stations (kiosks) shall be placed at the Pier and Grande Avenue access points.
   C. Equestrian Gate: The applicant within sixty (60) days of approval (by November 10, 1991) shall reconstruct a portion of the existing fence along the southern Pismo Dunes State Vehicle Recreation Area (SVRA) boundary to allow equestrians and pedestrians to pass along the beach, while preventing passage by off-highway vehicles.

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A. The following rules are effective immediately with violators subject to citation and fines:
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    (b) One primary objective of the fencing is to prohibit vehicle access to the dune area south of Oso Flaco Creek. Accordingly, the east/west aligned fence north of Oso Flaco Creek shall continue seaward to the mean low water line so that vehicles do not pass to the south. The continuation of this line to mean low water may require different construction than normal fencing – possibly driven piles.

    (c) Except for the following, fencing alignments shall be placed a minimum of 100 feet from the vegetated areas being fenced:

        1. Along Sand Highway where the fence would encroach into the Sand Highway travel corridor.

        2. Along the seaward side of the foredunes paralleling the beach where fencing may be placed in a manner similar to that already existing along the westerly line of the State Dune Preserve except that a minimal number of breaks in the foredune fencing outside of the dune preserve may be allowed of OHV access to the backdune area. The fencing protecting the foredunes need not be a

closed perimeter fence completely surrounding the foredune vegetation if it can be demonstrated to the Executive Director that such perimeter fencing is not necessary for effective preservation and stabilization of foredunes.

3. In other areas where it is demonstrated that a placement closer to vegetation will not diminish the effectiveness of the fence to stabilize the dune, protect the vegetation and provide necessary conditions for dune rehabilitation and restoration. Said demonstration shall be in the form of competent analysis of the dynamics of dune sand transport and natural condition necessary for dune stabilization. Reduction in the minimum setback under this condition shall be reviewed and approved by the Executive Director of the Coastal Commission.

(d) If fenced corridors to the Oso Flaco are constructed, they shall only be for use of state parks personnel and for the purpose of emergency, normal patrol duties, management and enforcement. Accordingly, these corridors shall have locked gates.

(e) Since a barrier to OHV movement south of Oso Flaco Creek is to be constructed on the north side of the creek, any construction of fencing south of Oso Flaco Creek or lakes shall be only for the purpose of preventing OHV intrusion into the State Park holdings from adjacent private lands. Such fencing shall therefore be perimeter fencing around parcels 8, 7, 3, and 4 and shall require a coastal development permit. Fencing applied for herein south of Oso Flaco which is not perimeter fencing shall not be constructed, or if constructed shall have been to an alignment approved herein by November 30, 1982.

4. Restoration

A dunes restoration program shall be undertaken by the DPR. The program shall be reviewed and approved by the Executive Director of the Coastal Commission. Restoration of vegetated dunes within the fenced-off areas shall be undertaken as expeditiously as funds and technical knowledge allows. Plantings shall begin no later than January 1983 with notification of the County and the Executive Director of the Coastal Commission. The restoration program shall be an ongoing program with the experimental or initial phase completed within three (3) years of the date of certification of the LUP and the full program in effect on that date or before.

5. Protection of Archeological Resources

Archeological resources within the PDVRA shall be protected by fencing. Accordingly, as part of the current fencing project, site No. SLO 199 shall be fenced for protection. Other sites shall be fenced as their locations become known.

SPECIAL CONDITIONS OF APPROVAL

1. Scope of Permit. This permit amendment replaces Special Conditions 3B, 3D, and 6 of CDP 4-82-300. This permit amendment also authorizes the institution of interim vehicle (street-legal, off-highway vehicle, and camping) limits at the ODSVRA, and the establishment of an ODSVRA Technical Review Team, for an initial one-year period form the date of approval of the revised conditions and findings.

2. Renewal of Permit. Annually, the Commission shall review the overall effectiveness of the Technical Review Team in managing vehicle impacts at the ODSVRA. If the Commission is satisfied with the review, the amendment will remain in effect for another year. Otherwise, an alternative approach to resource management, or set of management measures, may be instituted through this review process.

3. Interim Vehicle Limits
    a. Interim *Day-Use Vehicle Limits.* Except as qualified by 3d , interim limits on motor vehicle use on the beaches and dunes of Oceano Dunes SVRA shall be no more than 2,580 street-legal vehicles per day. This limit does not include off-highway vehicles, or street-legal vehicles attributable to allowed overnight camper use within the ODSVRA.
    b. Interim Camping Limits. Except as qualified by 3d, interim limits on overnight motor vehicle use on the beaches and dunes of Ocean Dunes SVRA shall be no more than 1,000 camping units (i.e. 1,000 street-legal vehicles) per night. This limit does not include off-highway vehicles or street-legal vehicles attributable to allowed day-use within the ODSVRA.
    c. Interim Off-Highway Vehicle Limits. Except as qualified by 3d, interim limits on off-highway vehicle use on the beaches and dunes of Oceano Dunes SVRA shall be no more than 1,720 off-highway vehicles at any given time. This limit does not include the street-legal vehicles used to tow or trailer the OHVs into the ODSVRA.
    d. Holiday Periods[1]. Interim street-legal and off-highway vehicle limits may be exceeded only during the four major holiday periods of Memorial Day (Saturday through Monday), July 4th (one day and any adjacent weekend days), Labor Day (Saturday through Monday), and Thanksgiving (Thursday through Sunday).

4. Technical Review Team. The Technical Review Team (TRT), advisory to the Superintendent of the Oceano Dunes State Vehicular Recreation Area, shall be established within three months, and shall meet within six months, from approval of the revised conditions and findings of this coastal development permit amendment (4-82-300-A5). A Charter for the TRT, establishing members, roles and procedures for the Team, shall be submitted to the Executive Director for review within one year of approval of the revised conditions and findings of this coastal development permit amendment.

    a. The Charter shall establish a specific structure and process in order for the TRT to do at least the following:

[1] These exceedance periods are no longer allowed under terms of settlement agreement entered into by Parks.

i. Assist in building community support through problem solving, consensus building, new constituency development, and increasing understanding about the ODSVRA; and

ii. Develop recommendations to the Superintendent of the ODSVRA regarding additional monitoring studies, adjustments to day and overnight use limits, and management strategies.

b. The Charter shall also include at least the following:

i. A provision to create a scientific subcommittee to identify, develop and evaluate the scientific information needed by decision-makers to ensure that the ODSVRA's natural resources are adequately managed and protected. The subcommittee shall be composed of resource experts representing the five government agencies (CCC, SLO County, USFWS, DFG, DPR) and at least two independent scientists with expertise in Western snowy plover, California least tern, steelhead trout or other species of concern, as well as ecological processes to analyze technical data and provide scientific recommendations to the TRT; and

ii. A provision to submit a list of proposed members of the scientific subcommittee to the Executive Director for review and approval.

c. The Charter shall establish a specific structure and process in order for the scientific subcommittee to do at least the following:

i. Recommend to the TRT the scientific studies and investigations that may be necessary to develop information needed by resource managers;

ii. Advise the TRT regarding the protection of the SVRA's natural resources by helping identify and review needed research measures and restoration efforts to rebuild or protect the ODSVRA natural resources;

iii. Evaluate monitoring results and reevaluate monitoring protocols contained in Oceano Dunes SVRA annual reports for the Habitat Monitoring System, reports on the breeding, nesting and fledgling success of the western snowy plover and California least tern populations in the SVRA, and other reports related to the environmental impacts of recreational activities;

iv. Provide comments on the adequacy of various scientific research studies and make management recommendations to the TRT; and

v. Submit the full recommendations of the scientific subcommittee to the Commission and make them available to the public, as part of the annual review process required in Special Condition 2.

5. Annual Report. The TRT and the ODSVRA Superintendent shall prepare annual reports (for the period of October to September) summarizing annual recreational use and habitat trends at the Park; and highlighting the TRT's major accomplishments (including progress made towards meeting the objectives of the TRT), projects, correspondence, and recommendations as well as a summary of subcommittees, working groups, and task force activities. The first annual report shall include (1) a draft or final Charter for the TRT, and (2) a description of the process by which the TRT will rank research and management questions and priorities. The second annual report shall include (1) the final Charter for the TRT (if not submitted with the first annual report), (2) the TRT's ranking

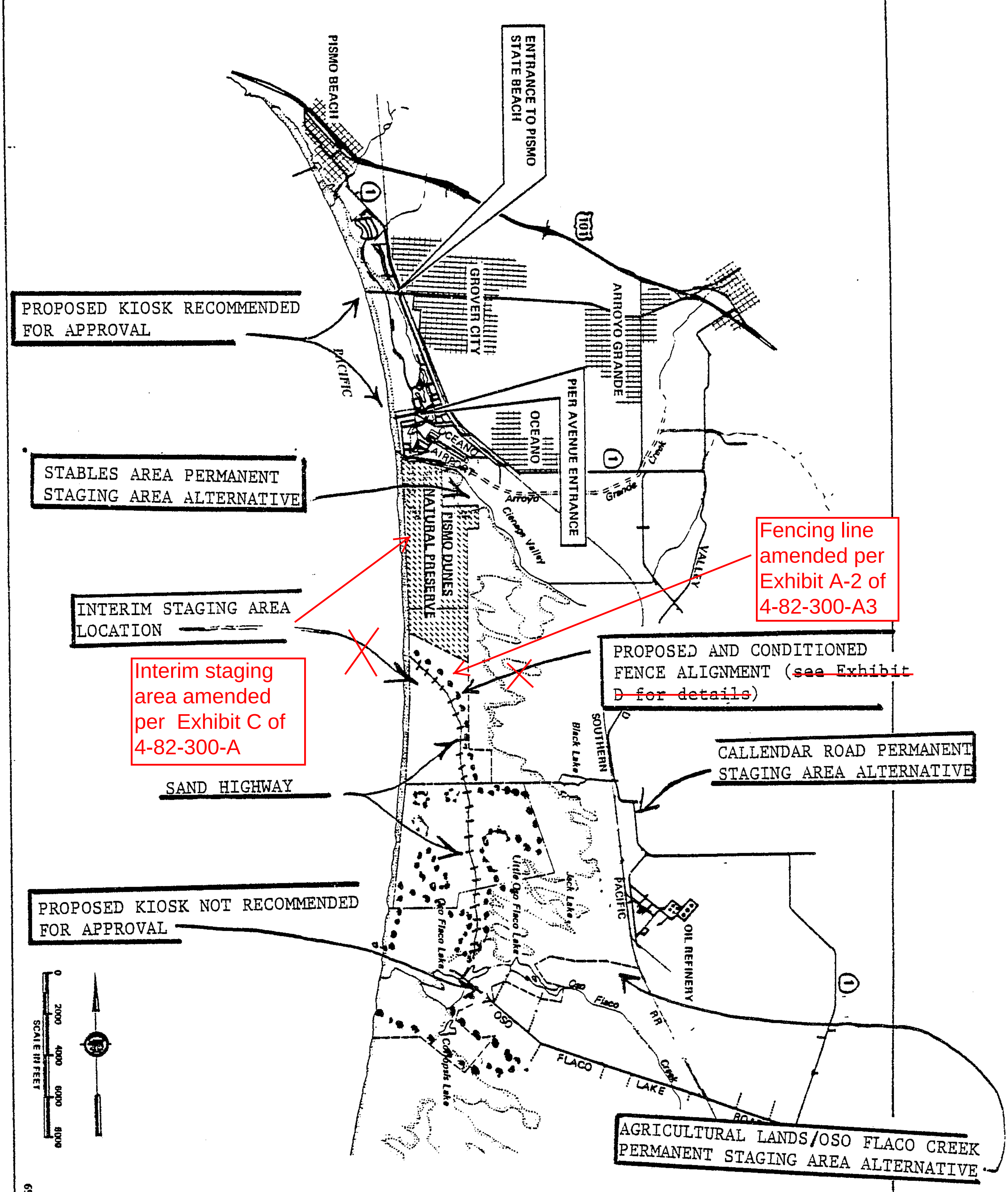
of research and management questions and priorities, and (3) a scope of work for those projects identified as highest priority. Subsequent reports will include a status report on the progress of those projects as well as updates to research and management priorities and the corresponding scopes of work for addressing those new priorities. One component of the Commission's annual review will be to evaluate the progress of the TRT's work as measured against the submitted work plans.

In identifying and selecting the priority research and management questions and projects, the TRT shall consider information developed by the USFWS and shall include the following:

a. Appropriate management techniques for the western snowy plover, California least tern, and steelhead trout including an evaluation of:
    i. How the geographic location of nests, proximity of nests to foraging areas, and nest closure techniques affect the hatching and fledgling success of the species,
    ii. What studies may be necessary to determine appropriate management techniques, or what known management techniques could be put in place, for protecting each species of concern, and
    iii. The potential environmental, recreational and economic costs and benefits of alternative beach/dune habitat protection strategies.
b. Appropriate management techniques for protecting water quality and dune habitats from potential pollutants that might result from motor vehicle fluids or other contaminants that might enter the ODSVRA and ocean through polluted runoff or direct discharges; and
c. The success of past revegetation efforts within the ODSVRA and the potential need for continuing or expanding those efforts, including expansion of vegetation exclosures.
d. Conduct a comprehensive, long-term monitoring and comparative analysis of the resources impacts associated with varying levels of use, including the highest (peak-use) attendance periods.

If alternative research and management questions and projects are identified as a higher priority that those listed in a through d above, the annual reports shall discuss the basis for such a determination. Annual reports shall be submitted to San Luis Obispo County and California Coastal Commission for informational purposes no later than January 1st of the following year. The first annual report (or portion thereof) shall be completed and submitted to the Commission no later than January 1, 2002.

EXHIBIT C



69

PISMO STATE BEACH AND PISMO DUNES STATE VEHICULAR RECREATION AREA
FIGURE 12
RECREATION ELEMENTS

DEPARTMENT OF PARKS AND RECREATION

14365

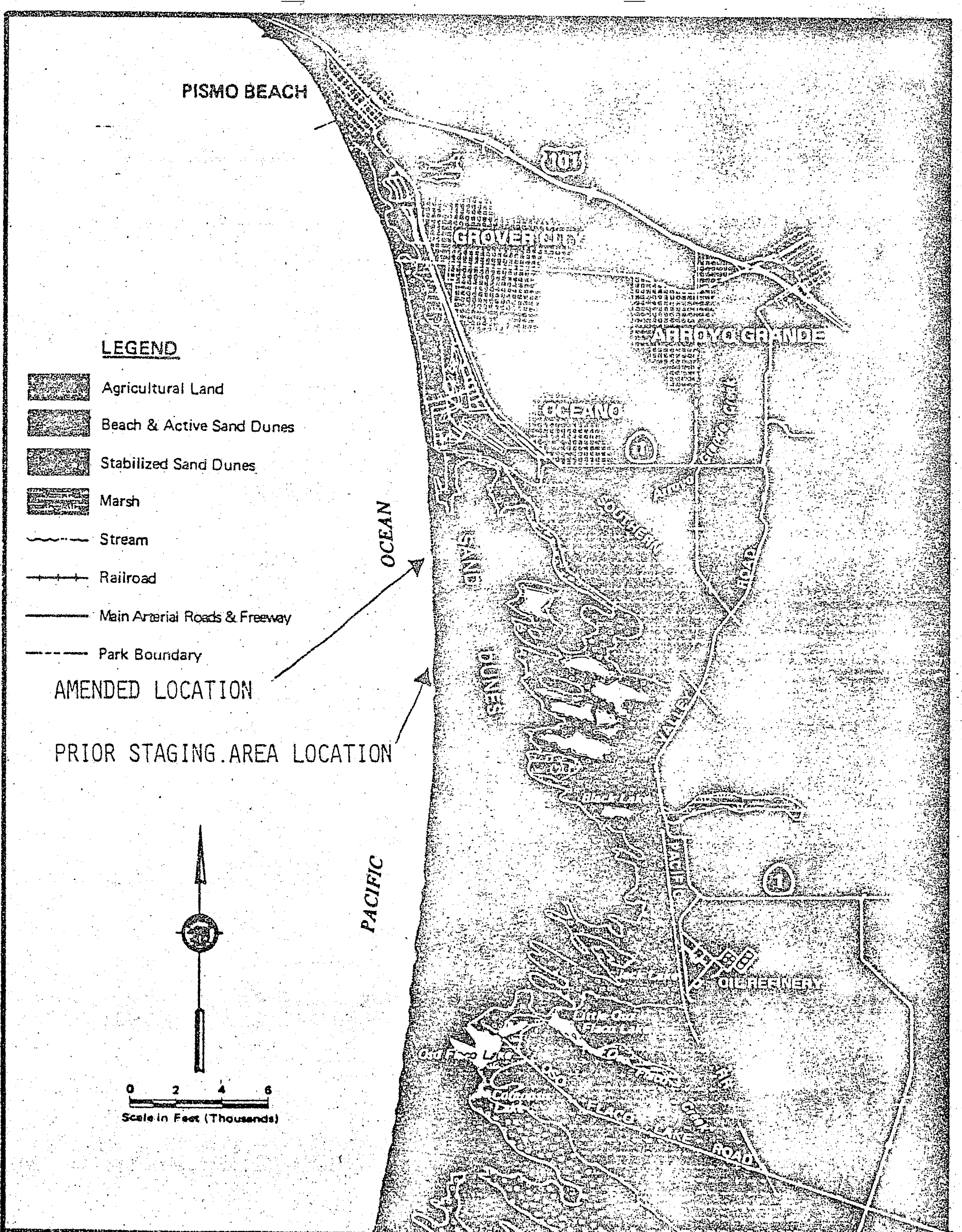


FIGURE 3

EXHIBIT C

PHYSICAL CHARACTERISTICS

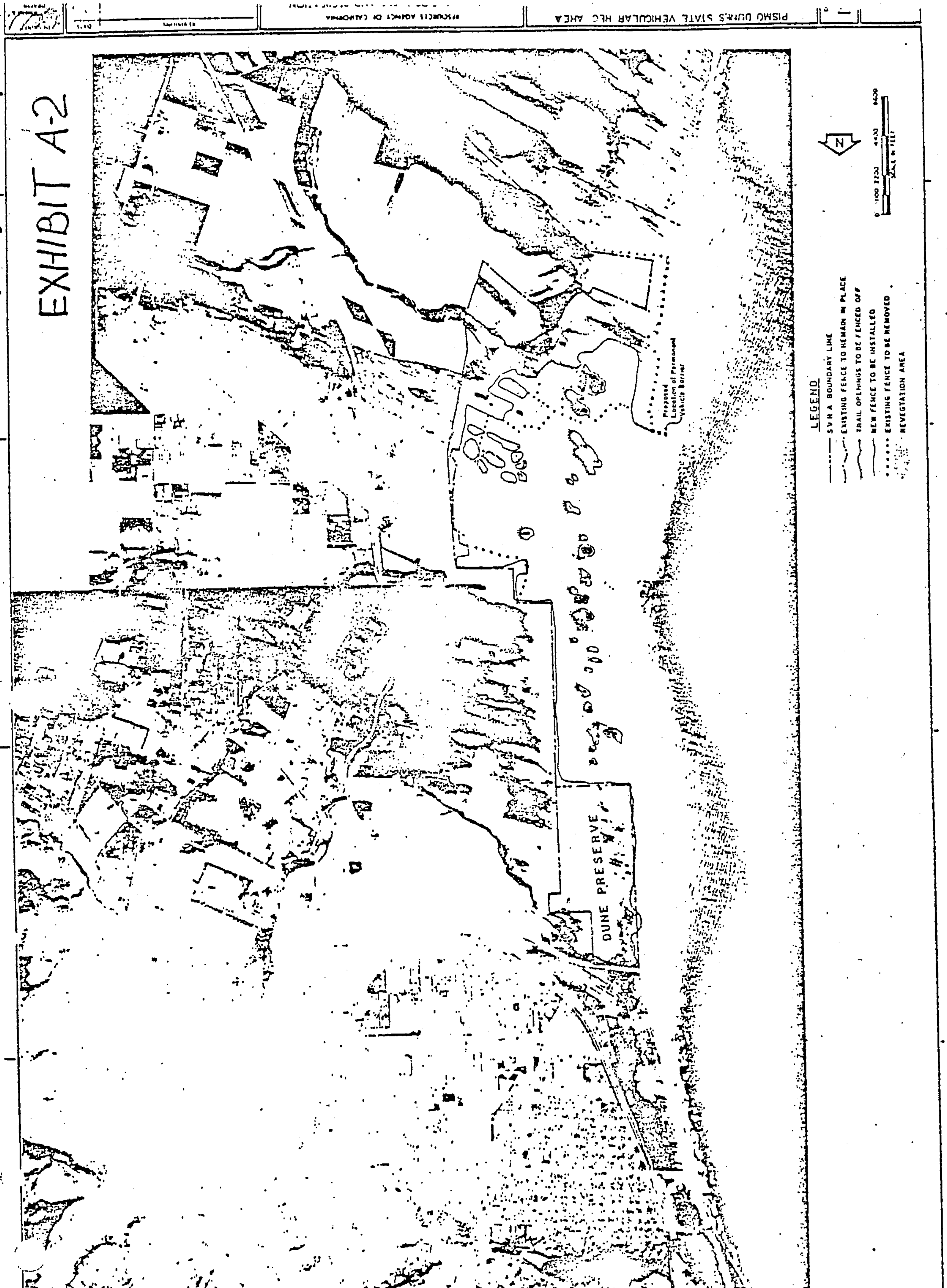


EXHIBIT A-2
PISMO DUNES STATE VEHICULAR REC AREA
RESOURCES AGENCY OF CALIFORNIA
DUNE PRESERVE
Proposed Location of Permanent Vehicle Barrier
LEGEND
SVRA BOUNDARY LINE
EXISTING FENCE TO REMAIN IN PLACE
TRAIL OPENINGS TO BE FENCED OFF
NEW FENCE TO BE INSTALLED
EXISTING FENCE TO BE REMOVED
REVEGETATION AREA
N

Exhibit 5

CDP 4-82-300 Conditions (as modified through the January 12, 2017 hearing)

In cross-through and underline format

1. Staging Area Location:

A. An interim OHV staging area shall be operational no later than September 15th 1982 in a designated area on or adjacent to the beach south of the two mile post (Exhibit C). This staging area shall remain operational subject to the stated conditions and standards herein until such time as a permanent staging area is constructed. Upon implementation of the interim staging area, all OHVs, ATCs and other non-street legal vehicles shall be trailored to and from Grande and Pier Avenues. At all times such vehicles when under their own power, shall be prohibited north of the northerly terminus of Sand Highway.

B. P~~A p~~ermanent access and staging areas ~~site~~ shall be selected as expeditiously as possible but in no case later than as established in subsection C below ~~18 months from the effective date of the County's LUP certification~~ consistent with the following standards. Construction of this permanent access and staging areas shall begin as established in subsection C below~~no later than three (3) years form the date of the certification of the County's LUP of its LCP~~. ~~If construction and operation of a permanent staging area cannot be accomplished within the above time limits, this permit shall be subject to review and modification if necessary or appropriate by the County or the Commission or either in consultation with the other.~~ Prior to construction, the County's LUP and the State Parks General Development Plan shall be amended to include the selected sites with all additional standards or conditions for ~~its~~ their design and operation. At the present time, there are several known locations ~~which shall~~to be considered and evaluated for staging area use, these locations are: Callendar Road area; the stables/agricultural lands area south of Arroyo Grande Creek; Agricultural lands north of Oso Flaco Creek adjacent to the ~~Union Oil~~Phillips 66 property; on the beach as per the interim staging area described herein (see Exhibit C). Other potential sites may also be evaluated. At the present time, there are several known locations to be considered and evaluated for access into the Park, these locations are: West Grand Avenue; Pier Avenue; Ocean Street; Creek Road; Silver Spur Place; Phillips 66; Little Oso Flaco Lake; and Oso Flaco Lake. The site selection process shall include an environmental impacts analysis adequate to enable the selection of the least environmentally damaging location for ~~the~~ access and staging uses. Accordingly, the on and off-site impacts of each alternative shall be measured against the impacts of the others. In selecting the sites and amending the County's LUP and the State Parks General Development Plan to incorporate the selected sites, the following standards must be found to have been met: 1) that the site selected is the least environmentally damaging alternative; and 2) that all feasible design and operational related mitigations have been incorporated to minimize adverse environmental impacts. Additional standards for site selection are in their order of importance: locating a site which reduces to the maximum extent feasible OHV related impacts to the residential character of the community of Oceano; locating a site which facilitates the successful separation and regulation of recreational uses within the park itself; locating a site which can be constructed and operational expeditiously.

C. **ODSVRA Access and Staging.** Within six months of the January 12, 2017 CDP re-review (i.e., by July 12, 2017), DPR shall submit an Access Study for Executive Director review and approval. The Access Study may be based upon DPR's past access analyses (i.e., including the 2006 Alternative Access Study Oceano Dunes State Vehicular Recreation Area. Produced by Condor Environmental Planning Services, Inc.), but shall be updated as necessary to reflect any pertinent new information (including with respect to habitat protections for sensitive species) that may affect its evaluations and/or conclusions. The purpose of the Access Study is to identify the environmentally-preferred final vehicle access and staging system for the Park, including through analysis of the environmental impacts and benefits (including with respect to dunes, habitats, creeks, beaches, neighborhoods, and community character) and feasibility associated with alternative access and staging locations, including evaluating the two existing access points as well as potential alternatives across the same set of analysis factors and levels of detail.

Following Executive Director approval of the Access Study, the Executive Director shall provide a recommendation to the Commission in an agendized public hearing for Commission action to approve the appropriate final access and staging system for the Park. Following Commission approval, the CDP shall be amended to reflect the Commission-approved access and staging system, and, if changes to the interim access and staging system are necessary to implement the approved access and staging system, DPR shall be required to submit materials to implement the Commission-approved access system plan as soon as possible, but no later than within one year of the Commission's approval of the final access and staging system, unless the Commission identifies a different time frame for implementation.

~~C~~**D**.Oso Flaco Lakes Area: An off-highway vehicle staging area shall not be constructed at the Oso Flaco Lake site indicated on Exhibit C. As part of the fencing proposed in this project, the Oso Flaco causeway to the PSVRA shall be permanently closed to vehicular traffic. Pedestrian and equestrian access only shall be allowed over the causeway or in the vicinity of the Oso Flaco Lakes effective no later than March 1, 1992.

By acceptance of this permit the applicant agrees to not close equestrian access at Oso Flaco Lake until March 1, 1992 or sooner if an alternative equestrian access solution is identified. The intent of this condition is to allow additional time for all parties involved in the attempt to locate alternative access routes to the beach to identify a site which would be suitable and acceptable to the Commission. The Commission will review and make a decision on the appropriateness of that site at a subsequent date. If an alternative equestrian access route is identified prior to March 1, 1992, the applicant will submit the proposed route to the Commission for its review and approval at a subsequent date. In the event an alternative equestrian access route is not identified, equestrian access through Oso Flaco Lake Natural Area can be closed on March 1, 1992.

The state owned agricultural lands south of Oso Flaco Lakes may be utilized for the development of a campground for passive recreational use of the dune areas within the Park excluded from OHV use. The State Parks and Recreation Department shall amend its General Development Plan accordingly. Uses in this camping area shall be permitted only if consistent with the resource protection policies of the San Luis Obispo County Land Use Plan; 100 foot buffering setbacks from the lakes, creek and wetlands shall be applied at a minimum with greater setbacks required if necessary, only resource dependent uses and passive recreational activities shall be permitted.

2. **Control of Access to the Park:** Effective immediately upon issuance of this permit and until either a permanent staging area is operational or this permit and the County's LUP is amended to accommodate possible necessary minor adjustments in the operation of these conditions, access and egress to and from the park shall be controlled and monitored in the following manner:

   A. All vehicular access and egress shall be via Grande Avenue and Pier Avenue, an effective vehicle barriers shall be placed at the southern end of the Oso Flaco causeway to assure that no OHV access over the causeway is permitted.

   B. Manned vehicle contact stations (kiosks) shall be placed at the Pier and Grande Avenue access points.

   C. **Equestrian Gate:** The applicant within sixty (60) days of approval (by November 10, 1991) shall reconstruct a portion of the existing fence along the southern Pismo Dunes State Vehicle Recreation Area (SVRA) boundary to allow equestrians and pedestrians to pass along the beach, while preventing passage by off-highway vehicles.

3. **Control of uses within the Park:** By the July 4 week-end of 1982 and as soon as possible prior to that date, the Parks and Recreation Department shall institute a Public Information program for vehicular recreational users within the Parks units. At the Grande and Pier Avenue's kiosks, occupants of all vehicles entering the Park will be provided a pass or ticket to the park and the following information:

   A. The following rules are effective immediately with violators subject to citation and fines:

   - All non-street legal vehicles shall be prohibited from the area north of the two mile post after dusk each day.
   - Vegetated dune areas, whether they are fenced or unfenced, are strictly off-limits to all vehicles.
   - All areas posted as Private Property or Restricted Use are off-limits to vehicle activity.
   - All vehicle activity is prohibited south of the Oso Flaco Creek (or south of the fence line that is constructed).

B. Beginning September 15, 1982, specific areas of the Park will be designated for specific types of vehicles. The designations will be as follows:

- Area north of the two mile post to Grande Avenue designated for and restricted to street legal vehicle use.

- Area south of the two mile post to the fenced or posted area north of Oso Flaco Creek designated for OHV use.

C. Protective Fencing of Dunes, archeological resources, and wet environments shall be accomplished in the following manner subject to review and approval by the Executive Director of the Coastal Commission in consultation with the County of San Luis Obispo and the State Department of Fish and Game.

(a) Fencing proposed and approved herein, plus fencing of the area shown on Exhibit A-2 plus the perimeter fencing along the Sand Highway (or along the ridge just eastward of the Sand Highway) and the Eastern Boundary of ODSVRA shall be accomplished by November 30, 1982. All other vegetated areas indicated on Exhibit A-2 shall be fenced by Aug 31, 1983.

(b) One primary objective of the fencing is to prohibit vehicle access to the dune area south of Oso Flaco Creek. Accordingly, the east/west aligned fence north of Oso Flaco Creek shall continue seaward to the mean low water line so that vehicles do not pass to the south. The continuation of this line to mean low water may require different construction than normal fencing – possibly driven piles.

(c) Except for the following, fencing alignments shall be placed a minimum of 100 feet from the vegetated areas being fenced:

1. Along Sand Highway where the fence would encroach into the Sand Highway travel corridor.

2. Along the seaward side of the foredunes paralleling the beach where fencing may be placed in a manner similar to that already existing along the westerly line of the State Dune Preserve except that a minimal number of breaks in the foredune fencing outside of the dune preserve may be allowed of OHV access to the backdune area. The fencing protecting the foredunes need not be a closed perimeter fence completely surrounding the foredune vegetation if it can be demonstrated to the Executive Director that such perimeter fencing is not necessary for effective preservation and stabilization of foredunes.

3. In other areas where it is demonstrated that a placement closer to vegetation will not diminish the effectiveness of the fence to stabilize the dune, protect the vegetation and provide necessary conditions for dune rehabilitation and restoration. Said demonstration shall be in the form of competent analysis of the dynamics of dune sand transport and natural condition necessary for dune stabilization. Reduction in the minimum setback under this condition shall be reviewed and approved by the Executive Director of the Coastal Commission.

(d) **Dune Management and Fencing.** Fencing at the perimeter of the riding area shall be maintained in a manner designed to best protect dune and other resources in the non-riding area. Significant vegetated areas within the riding area shall be similarly fenced, and riding and other disallowed activities prohibited within these vegetated "island" areas. Such vegetated island fencing shall be adjusted on a regular basis to respond to shifting vegetation, including as necessary to fence off new areas of significant vegetation, with an emphasis and preference on adaptation designed to ensure larger and more contiguous vegetated dune and dune habitat areas, as opposed to smaller and more isolated vegetated dune fragments. In all cases, DPR shall ensure to the maximum feasible extent that the acreage of such vegetated islands in the riding area is not reduced from January 2017 levels (allowing for "islands" that become connected to the perimeter non-riding area through adaptation to be counted toward vegetated island acreage).

~~(d)~~(e) If fenced corridors to the Oso Flaco are constructed, they shall only be for use of state parks personnel and for the purpose of emergency, normal patrol duties, management and enforcement. Accordingly, these corridors shall have locked gates.

~~(e)~~(f) Since a barrier to OHV movement south of Oso Flaco Creek is to be constructed on the north side of the creek, any construction of fencing south of Oso Flaco Creek or lakes shall be only for the purpose of preventing OHV intrusion into the State Park holdings from adjacent private lands. Such fencing shall therefore be perimeter fencing around parcels 8, 7, 3, and 4 and shall require a coastal development permit. Fencing applied for herein south of Oso Flaco which is not perimeter fencing shall not be constructed, or if constructed shall have been to an alignment approved herein by November 30, 1982.

4. **Restoration.** A dunes restoration program shall be undertaken by the DPR. The program shall be reviewed and approved by the Executive Director of the Coastal Commission. Restoration of vegetated dunes within the fenced-off areas shall be undertaken as expeditiously as funds and technical knowledge allows. Plantings shall begin no later than January 1983 with notification of the County and the Executive Director of the Coastal Commission. The restoration program shall be an ongoing program with the experimental or initial phase completed within three (3) years of the date of certification of the LUP and the full program in effect on that date or before.

5. **Protection of Archeological Resources.** Archeological resources within the PDVRA shall be protected by fencing. Accordingly, as part of the current fencing project, site No. SLO 199 shall be fenced for protection. Other sites shall be fenced as their locations become known.

6. **Managing Day-to-Day Operations.** Effective immediately (i.e., as of January 12, 2017), the existing interim vehicle use limits specified in CDP special conditions 3 and 8 (i.e., special condition 3 of CDP amendment 4-82-300-A5) shall be eliminated. The intent of this change is to allow DPR to manage the Park as it manages other Parks (consistent with providing ecologically balanced recreation, and through best resource and recreation management practices and adaptation on a daily basis) to protect the Park and its resources, as well as the surrounding area, from the effects of potential overuse. Such management will include

limiting motorized recreation to defined areas, prohibiting activities as needed to protect natural resources (including sensitive species and habitats), protecting cultural and archaeological resources, and restoring lands. CDP requirements (e.g., limiting riding to defined areas, prohibiting disallowed activities in non-riding dune areas, protecting archaeological resources, requiring ongoing monitoring and reporting, etc.) will continue to apply, both informing and providing a complementary framework for DPR's day-to-day management decisions. The primary objective of DPR's day-to-day Park management efforts under the CDP shall be to ensure that vehicular operations, including those related to special events, occur in a way that does not overburden the Park and surrounding areas, that does not lead to significant adverse impacts on coastal resources, including dunes, sensitive species and their habitats, and public recreational access opportunities of all kinds (e.g., beach-going, camping, swimming, hiking, etc.), and that provides for maximum public safety, appropriate levels of use, and strong resource conservation.

7. **Annual Monitoring.** DPR shall prepare an annual monitoring report to be submitted for Executive Director review and written approval by December 31st of each year (with the first such report due by December 31, 2018). At a minimum, the report shall document the effectiveness of the previous year's Park management activities in achieving an appropriate balance between providing vehicular recreation and protecting dune and other coastal resources; it shall provide an evaluation of vehicular recreation and coastal resource trends, impacts, and issues facing Park operations; and it shall provide recommendations for changes to Park management to better address identified impacts.

   Within six months of the January 12, 2017 CDP re-review (i.e., by July 12, 2017), DPR shall provide for Executive Director review and approval a monitoring report framework. At a minimum, the framework shall describe the structure, content, and methods for ongoing monitoring of vehicular recreation and coastal resources at a sufficient level of detail to facilitate both comprehensive understanding of issues and development of appropriate adaptation measures through the annual monitoring report process.

   DPR shall prepare the annual monitoring report in accordance with the Executive Director-approved framework. Through approval of the annual monitoring report, the Executive Director may require changes to Park management that do not arise to the level of requiring a CDP amendment. The Executive Director-approved annual monitoring report shall be presented to the Commission as deemed appropriate by the Executive Director (including if any Executive Director-required changes require a CDP amendment) and/or if DPR and the Executive Director cannot resolve disputes over any Executive Director-required changes.

~~6. **Scope of Permit.** This permit amendment replaces Special Conditions 3B, 3D, and 6 of CDP 4-82-300. This permit amendment also authorizes the institution of interim vehicle (street-legal, off-highway vehicle, and camping) limits at the ODSVRA, and the establishment of an ODSVRA Technical Review Team, for an initial one-year period form the date of approval of the revised conditions and findings.~~

~~7. **Renewal of Permit.** Annually, the Commission shall review the overall effectiveness of the Technical Review Team in managing vehicle impacts at the ODSVRA. If the Commission is satisfied with the review, the amendment will remain in effect for another year. Otherwise,~~

~~an alternative approach to resource management, or set of management measures, may be instituted through this review process.~~

~~**8. Interim Vehicle Limits**~~

~~**A. Interim Day-Use Vehicle Limits.** Except as qualified by [subsection 8]d [below], interim limits on motor vehicle use on the beaches and dunes of Oceano Dunes SVRA shall be no more than 2,580 street-legal vehicles per day. This limit does not include off-highway vehicles, or street-legal vehicles attributable to allowed overnight camper use within the ODSVRA.~~

~~**B. Interim Camping Limits.** Except as qualified by [subsection 8]d [below], interim limits on overnight motor vehicle use on the beaches and dunes of Ocean Dunes SVRA shall be no more than 1,000 camping units (i.e. 1,000 street-legal vehicles) per night. This limit does not include off-highway vehicles or street-legal vehicles attributable to allowed day-use within the ODSVRA.~~

~~**C. Interim Off-Highway Vehicle Limits.** Except as qualified by [subsection 8]d [below], interim limits on off-highway vehicle use on the beaches and dunes of Oceano Dunes SVRA shall be no more than 1,720 off-highway vehicles at any given time. This limit does not include the street-legal vehicles used to tow or trailer the OHVs into the ODSVRA.~~

~~**D. Holiday Periods.** Interim street-legal and off-highway vehicle limits may be exceeded only during the four major holiday periods of Memorial Day (Saturday through Monday), July 4th (one day and any adjacent weekend days), Labor Day (Saturday through Monday), and Thanksgiving (Thursday through Sunday).~~

~~**9. Technical Review Team.** The Technical Review Team (TRT), advisory to the Superintendent of the Oceano Dunes State Vehicular Recreation Area, shall be established within three months, and shall meet within six months, from approval of the revised conditions and findings of this coastal development permit amendment (4-82-300-A5). A Charter for the TRT, establishing members, roles and procedures for the Team, shall be submitted to the Executive Director for review within one year of approval of the revised conditions and findings of this coastal development permit amendment.~~

~~**A.** The Charter shall establish a specific structure and process in order for the TRT to do at least the following:~~

~~i. Assist in building community support through problem solving, consensus building, new constituency development, and increasing understanding about the ODSVRA; and~~

~~ii. Develop recommendations to the Superintendent of the ODSVRA regarding additional monitoring studies, adjustments to day and overnight use limits, and management strategies.~~

~~**B.** The Charter shall also include at least the following:~~

~~i. A provision to create a scientific subcommittee to identify, develop and evaluate the scientific information needed by decision-makers to ensure that the ODSVRA's natural resources are adequately managed and protected. The subcommittee shall be composed of resource experts representing the five government agencies (CCC, SLO County, USFWS, DFG, DPR) and at least two independent scientists with expertise in Western snowy plover, California least tern, steelhead trout or other species of concern, as well as ecological processes to analyze technical data and provide scientific recommendations to the TRT; and~~

~~ii. A provision to submit a list of proposed members of the scientific subcommittee to the Executive Director for review and approval.~~

~~**C.** The Charter shall establish a specific structure and process in order for the scientific subcommittee to do at least the following:~~

~~i. Recommend to the TRT the scientific studies and investigations that may be necessary to develop information needed by resource managers;~~

~~ii. Advise the TRT regarding the protection of the SVRA's natural resources by helping identify and review needed research measures and restoration efforts to rebuild or protect the ODSVRA natural resources;~~

~~iii. Evaluate monitoring results and reevaluate monitoring protocols contained in Oceano Dunes SVRA annual reports for the Habitat Monitoring System, reports on the breeding, nesting and fledgling success of the western snowy plover and California least tern populations in the SVRA, and other reports related to the environmental impacts of recreational activities;~~

~~iv. Provide comments on the adequacy of various scientific research studies and make management recommendations to the TRT; and~~

~~v. Submit the full recommendations of the scientific subcommittee to the Commission and make them available to the public, as part of the annual review process required in Special Condition 2.~~

~~**10. Annual Report.** The TRT and the ODSVRA Superintendent shall prepare annual reports (for the period of October to September) summarizing annual recreational use and habitat trends at the Park; and highlighting the TRT's major accomplishments (including progress made towards meeting the objectives of the TRT), projects, correspondence, and recommendations as well as a summary of subcommittees, working groups, and task force activities. The first annual report shall include (1) a draft or final Charter for the TRT, and (2) a description of the process by which the TRT will rank research and management questions and priorities. The second annual report shall include (1) the final Charter for the TRT (if not submitted with the first annual report), (2) the TRT's ranking of research and management questions and priorities, and (3) a scope of work for those projects identified as highest priority. Subsequent reports will include a status report on the progress of those projects as well as updates to research and management priorities and the corresponding scopes of work~~

~~for addressing those new priorities. One component of the Commission's annual review will be to evaluate the progress of the TRT's work as measured against the submitted work plans.~~

~~In identifying and selecting the priority research and management questions and projects, the TRT shall consider information developed by the USFWS and shall include the following:~~

~~**A.** Appropriate management techniques for the western snowy plover, California least tern, and steelhead trout including an evaluation of:~~

~~i. How the geographic location of nests, proximity of nests to foraging areas, and nest closure techniques affect the hatching and fledgling success of the species,~~

~~ii. What studies may be necessary to determine appropriate management techniques, or what known management techniques could be put in place, for protecting each species of concern, and~~

~~iii. The potential environmental, recreational and economic costs and benefits of alternative beach/dune habitat protection strategies.~~

~~**B.** Appropriate management techniques for protecting water quality and dune habitats from potential pollutants that might result from motor vehicle fluids or other contaminants that might enter the ODSVRA and ocean through polluted runoff or direct discharges; and~~

~~**C.** The success of past revegetation efforts within the ODSVRA and the potential need for continuing or expanding those efforts, including expansion of vegetation exclosures.~~

~~**D.** Conduct a comprehensive, long-term monitoring and comparative analysis of the resources impacts associated with varying levels of use, including the highest (peak-use) attendance periods.~~

~~If alternative research and management questions and projects are identified as a higher priority that those listed in a through d above, the annual reports shall discuss the basis for such a determination. Annual reports shall be submitted to San Luis Obispo County and California Coastal Commission for informational purposes no later than January 1st of the following year. The first annual report (or portion thereof) shall be completed and submitted to the Commission no later than January 1, 2002.~~

1. **Staging Area Location:**

   A. An interim OHV staging area shall be operational no later than September 15th 1982 in a designated area on or adjacent to the beach south of the two mile post (Exhibit C). This staging area shall remain operational subject to the stated conditions and standards herein until such time as a permanent staging area is constructed. Upon implementation of the interim staging area, all OHVs, ATCs and other non-street legal vehicles shall be trailored to and from Grande and Pier Avenues. At all times such vehicles when under their own power, shall be prohibited north of the northerly terminus of Sand Highway.

   B. Permanent access and staging areas shall be selected as expeditiously as possible but in no case later than as established in subsection C below consistent with the following standards. Construction of this permanent access and staging areas shall begin as established in subsection C below. Prior to construction, the County's LUP and the State Parks General Development Plan shall be amended to include the selected sites with all additional standards or conditions for their design and operation. At the present time, there are several known locations to be considered and evaluated for staging area use, these locations are: Callendar Road area; the stables/agricultural lands area south of Arroyo Grande Creek; Agricultural lands north of Oso Flaco Creek adjacent to the Phillips 66 property; on the beach as per the interim staging area described herein (see Exhibit C). Other potential sites may also be evaluated. At the present time, there are several known locations to be considered and evaluated for access into the Park, these locations are: West Grand Avenue; Pier Avenue; Ocean Street; Creek Road; Silver Spur Place; Phillips 66; Little Oso Flaco Lake; and Oso Flaco Lake. The site selection process shall include an environmental impacts analysis adequate to enable the selection of the least environmentally damaging location for access and staging uses. Accordingly, the on and off-site impacts of each alternative shall be measured against the impacts of the others. In selecting the sites and amending the County's LUP and the State Parks General Development Plan to incorporate the selected sites, the following standards must be found to have been met: 1) that the site selected is the least environmentally damaging alternative; and 2) that all feasible design and operational related mitigations have been incorporated to minimize adverse environmental impacts. Additional standards for site selection are in their order of importance: locating a site which reduces to the maximum extent feasible OHV related impacts to the residential character of the community of Oceano; locating a site which facilitates the successful separation and regulation of recreational uses within the park itself; locating a site which can be constructed and operational expeditiously.

   C. ODSVRA Access and Staging. Within six months of the January 12, 2017 CDP re-review (i.e., by July 12, 2017), DPR shall submit an Access Study for Executive Director review and approval. The Access Study may be based upon DPR's past access analyses (i.e., including the 2006 Alternative Access Study Oceano Dunes State Vehicular Recreation Area. Produced by Condor Environmental Planning Services, Inc.), but shall be updated as necessary to reflect any pertinent new information (including with respect to habitat protections for sensitive species) that may affect its evaluations and/or conclusions. The purpose of the Access Study is to identify the environmentally-preferred final vehicle access and staging system for the Park, including through analysis of the environmental impacts and benefits (including with respect to dunes, habitats, creeks, beaches, neighborhoods, and community character) and feasibility associated with alternative access and staging locations, including evaluating the two existing access points as well as potential alternatives across the same set of analysis factors and levels of detail.

Following Executive Director approval of the Access Study, the Executive Director shall provide a recommendation to the Commission in an agendized public hearing for Commission action to approve the appropriate final access and staging system for the Park. Following Commission approval, the CDP shall be amended to reflect the Commission-approved access and staging system, and, if changes to the interim access and staging system are necessary to implement the approved access and staging system, DPR shall be required to submit materials to implement the Commission-approved access system plan as soon as possible, but no later than within one year of the Commission's approval of the final access and staging system, unless the Commission identifies a different time frame for implementation.

D. Oso Flaco Lakes Area: An off-highway vehicle staging area shall not be constructed at the Oso Flaco Lake site indicated on Exhibit C. As part of the fencing proposed in this project, the Oso Flaco causeway to the PSVRA shall be permanently closed to vehicular traffic. Pedestrian and equestrian access only shall be allowed over the causeway or in the vicinity of the Oso Flaco Lakes effective no later than March 1, 1992.

By acceptance of this permit the applicant agrees to not close equestrian access at Oso Flaco Lake until March 1, 1992 or sooner if an alternative equestrian access solution is identified. The intent of this condition is to allow additional time for all parties involved in the attempt to locate alternative access routes to the beach to identify a site which would be suitable and acceptable to the Commission. The Commission will review and make a decision on the appropriateness of that site at a subsequent date. If an alternative equestrian access route is identified prior to March 1, 1992, the applicant will submit the proposed route to the Commission for its review and approval at a subsequent date. In the event an alternative equestrian access route is not identified, equestrian access through Oso Flaco Lake Natural Area can be closed on March 1, 1992.

The state owned agricultural lands south of Oso Flaco Lakes may be utilized for the development of a campground for passive recreational use of the dune areas within the Park excluded from OHV use. The State Parks and Recreation Department shall amend its General Development Plan accordingly. Uses in this camping area shall be permitted only if consistent with the resource protection policies of the San Luis Obispo County Land Use Plan; 100 foot buffering setbacks from the lakes, creek and wetlands shall be applied at a minimum with greater setbacks required if necessary, only resource dependent uses and passive recreational activities shall be permitted.

2. **Control of Access to the Park:** Effective immediately upon issuance of this permit and until either a permanent staging area is operational or this permit and the County's LUP is amended to accommodate possible necessary minor adjustments in the operation of these conditions, access and egress to and from the park shall be controlled and monitored in the following manner:

   A. All vehicular access and egress shall be via Grande Avenue and Pier Avenue, an effective vehicle barriers shall be placed at the southern end of the Oso Flaco causeway to assure that no OHV access over the causeway is permitted.

   B. Manned vehicle contact stations (kiosks) shall be placed at the Pier and Grande Avenue access points.

   C. **Equestrian Gate:** The applicant within sixty (60) days of approval (by November 10, 1991) shall reconstruct a portion of the existing fence along the southern Pismo Dunes State Vehicle Recreation Area (SVRA) boundary to allow equestrians and pedestrians to pass along the beach, while preventing passage by off-highway vehicles.

3. **Control of uses within the Park:** By the July 4 week-end of 1982 and as soon as possible prior to that date, the Parks and Recreation Department shall institute a Public Information program for vehicular recreational users within the Parks units. At the Grande and Pier Avenue's kiosks, occupants of all vehicles entering the Park will be provided a pass or ticket to the park and the following information:

   A. The following rules are effective immediately with violators subject to citation and fines:

   - All non-street legal vehicles shall be prohibited from the area north of the two mile post after dusk each day.
   - Vegetated dune areas, whether they are fenced or unfenced, are strictly off-limits to all vehicles.
   - All areas posted as Private Property or Restricted Use are off-limits to vehicle activity.
   - All vehicle activity is prohibited south of the Oso Flaco Creek (or south of the fence line that is constructed).

   B. Beginning September 15, 1982, specific areas of the Park will be designated for specific types of vehicles. The designations will be as follows:

   - Area north of the two mile post to Grande Avenue designated for and restricted to street legal vehicle use.
   - Area south of the two mile post to the fenced or posted area north of Oso Flaco Creek designated for OHV use.

C. Protective Fencing of Dunes, archeological resources, and wet environments shall be accomplished in the following manner subject to review and approval by the Executive Director of the Coastal Commission in consultation with the County of San Luis Obispo and the State Department of Fish and Game.

(a) Fencing proposed and approved herein, plus fencing of the area shown on Exhibit A-2 plus the perimeter fencing along the Sand Highway (or along the ridge just eastward of the Sand Highway) and the Eastern Boundary of ODSVRA shall be accomplished by November 30, 1982. All other vegetated areas indicated on Exhibit A-2 shall be fenced by Aug 31, 1983.

(b) One primary objective of the fencing is to prohibit vehicle access to the dune area south of Oso Flaco Creek. Accordingly, the east/west aligned fence north of Oso Flaco Creek shall continue seaward to the mean low water line so that vehicles do not pass to the south. The continuation of this line to mean low water may require different construction than normal fencing – possibly driven piles.

(c) Except for the following, fencing alignments shall be placed a minimum of 100 feet from the vegetated areas being fenced:

1. Along Sand Highway where the fence would encroach into the Sand Highway travel corridor.

2. Along the seaward side of the foredunes paralleling the beach where fencing may be placed in a manner similar to that already existing along the westerly line of the State Dune Preserve except that a minimal number of breaks in the foredune fencing outside of the dune preserve may be allowed of OHV access to the backdune area. The fencing protecting the foredunes need not be a closed perimeter fence completely surrounding the foredune vegetation if it can be demonstrated to the Executive Director that such perimeter fencing is not necessary for effective preservation and stabilization of foredunes.

3. In other areas where it is demonstrated that a placement closer to vegetation will not diminish the effectiveness of the fence to stabilize the dune, protect the vegetation and provide necessary conditions for dune rehabilitation and restoration. Said demonstration shall be in the form of competent analysis of the dynamics of dune sand transport and natural condition necessary for dune stabilization. Reduction in the minimum setback under this condition shall be reviewed and approved by the Executive Director of the Coastal Commission.

(d) Dune Management and Fencing. Fencing at the perimeter of the riding area shall be maintained in a manner designed to best protect dune and other resources in the non-riding area. Significant vegetated areas within the riding area shall be similarly fenced, and riding and other disallowed activities prohibited within these vegetated "island" areas. Such vegetated island fencing shall be adjusted on a regular basis to respond to shifting vegetation, including as necessary to fence off new areas of significant vegetation, with an emphasis and preference on adaptation designed to ensure larger and more contiguous vegetated dune and dune habitat areas, as opposed to smaller and more isolated vegetated dune fragments. In all cases, DPR shall ensure to the maximum feasible extent that the acreage of such vegetated islands in the riding area is not reduced from January 2017 levels (allowing for "islands" that become connected to the perimeter non-riding area through adaptation to be counted toward vegetated island acreage).

(e) If fenced corridors to the Oso Flaco are constructed, they shall only be for use of state parks personnel and for the purpose of emergency, normal patrol duties, management and enforcement. Accordingly, these corridors shall have locked gates.

(f) Since a barrier to OHV movement south of Oso Flaco Creek is to be constructed on the north side of the creek, any construction of fencing south of Oso Flaco Creek or lakes shall be only for the purpose of preventing OHV intrusion into the State Park holdings from adjacent private lands. Such fencing shall therefore be perimeter fencing around parcels 8, 7, 3, and 4 and shall require a coastal development permit. Fencing applied for herein south of Oso Flaco which is not perimeter fencing shall not be constructed, or if constructed shall have been to an alignment approved herein by November 30, 1982.

4. **Restoration.** A dunes restoration program shall be undertaken by the DPR. The program shall be reviewed and approved by the Executive Director of the Coastal Commission. Restoration of vegetated dunes within the fenced-off areas shall be undertaken as expeditiously as funds and technical knowledge allows. Plantings shall begin no later than January 1983 with notification of the County and the Executive Director of the Coastal Commission. The restoration program shall be an ongoing program with the experimental or initial phase completed within three (3) years of the date of certification of the LUP and the full program in effect on that date or before.

5. **Protection of Archeological Resources.** Archeological resources within the PDVRA shall be protected by fencing. Accordingly, as part of the current fencing project, site No. SLO 199 shall be fenced for protection. Other sites shall be fenced as their locations become known.

6. **Managing Day-to-Day Operations.** Effective immediately (i.e., as of January 12, 2017), the existing interim vehicle use limits specified in CDP special conditions 3 and 8 (i.e., special condition 3 of CDP amendment 4-82-300-A5) shall be eliminated. The intent of this change is to allow DPR to manage the Park as it manages other Parks (consistent with providing ecologically balanced recreation, and through best resource and recreation management practices and adaptation on a daily basis) to protect the Park and its resources, as well as the surrounding area, from the effects of potential overuse. Such management will include limiting motorized recreation to defined areas, prohibiting activities as needed to protect natural resources (including sensitive species and habitats), protecting cultural and archaeological resources, and restoring lands. CDP requirements (e.g., limiting riding to defined areas, prohibiting disallowed activities in non-riding dune areas, protecting archaeological resources, requiring ongoing monitoring and reporting, etc.) will continue to apply, both informing and providing a complementary framework for DPR's day-to-day management decisions. The primary objective of DPR's day-to-day Park management efforts

under the CDP shall be to ensure that vehicular operations, including those related to special events, occur in a way that does not overburden the Park and surrounding areas, that does not lead to significant adverse impacts on coastal resources, including dunes, sensitive species and their habitats, and public recreational access opportunities of all kinds (e.g., beach-going, camping, swimming, hiking, etc.), and that provides for maximum public safety, appropriate levels of use, and strong resource conservation.

7. **Annual Monitoring.** DPR shall prepare an annual monitoring report to be submitted for Executive Director review and written approval by December 31st of each year (with the first such report due by December 31, 2018). At a minimum, the report shall document the effectiveness of the previous year's Park management activities in achieving an appropriate balance between providing vehicular recreation and protecting dune and other coastal resources; it shall provide an evaluation of vehicular recreation and coastal resource trends, impacts, and issues facing Park operations; and it shall provide recommendations for changes to Park management to better address identified impacts.

   Within six months of the January 12, 2017 CDP re-review (i.e., by July 12, 2017), DPR shall provide for Executive Director review and approval a monitoring report framework. At a minimum, the framework shall describe the structure, content, and methods for ongoing monitoring of vehicular recreation and coastal resources at a sufficient level of detail to facilitate both comprehensive understanding of issues and development of appropriate adaptation measures through the annual monitoring report process.

   DPR shall prepare the annual monitoring report in accordance with the Executive Director-approved framework. Through approval of the annual monitoring report, the Executive Director may require changes to Park management that do not arise to the level of requiring a CDP amendment. The Executive Director-approved annual monitoring report shall be presented to the Commission as deemed appropriate by the Executive Director (including if any Executive Director-required changes require a CDP amendment) and/or if DPR and the Executive Director cannot resolve disputes over any Executive Director-required changes.

STATE OF CALIFORNIA – THE RESOURCES AGENCY

ARNOLD SCHWARZENEGGER, *Governor*

CALIFORNIA COASTAL COMMISSION

CENTRAL COAST DISTRICT OFFICE
725 FRONT STREET, SUITE 300
SANTA CRUZ, CA 95060
(831) 427-4863

April 17, 2007

Mr. Matt Janssen
Coastal Supervising Planner
San Luis Obispo County Department of Planning and Building
County Government Center
San Luis Obispo, CA 93408

Subject: Coastal Commission Staff Response to Your Letter of March 9, 2007, Regarding the County's Proposed Sale of 585 Acres of Oceano Dunes Property to State Parks

Dear Mr. Janssen:

Thank you for contacting me regarding your department's review of the proposal by the San Luis Obispo County Department of General Services to sell approximately 585 acres of property within Oceano Dunes to the State of California. Your letter of March 9, 2007 requests the Commission staff's opinion regarding the relevance of the Figure 4 of the South County Area Plan and Coastal Plan Policies to the General Plan Conformity Report process. In addition, your letter requests our input on how Figure 4 played into the 1982 coastal development permit for the park (CDP 4-82-300) and subsequent amendments. This letter attempts to respond to these requests, as well as to the County staff's stated presumption that Figure 4 is "background information and advisory, but not regulatory or a critical component of the LCP".

1. Figure 4 Background

Use of the Oceano dunes for off-highway vehicle (OHV) recreation, and the need to protect sensitive habitats and adjacent properties from adverse impacts attributable to OHV use, has been a long-standing controversial issue for both the Coastal Commission and San Luis Obispo County, and was discussed in detail during the County's development of its Local Coastal Program (LCP). Based on a review of the LCP and permit history regarding this issue, it is clear that both San Luis Obispo County and the Coastal Commission have had significant concerns regarding the appropriate location for a permanent access route and staging area to serve the OHV riding area. We have also been concerned about managing OHV use, and other forms of recreation, in a manner that is consistent with the resource protection requirements of the Coastal Act.

These concerns were particularly evident during the development and certification of the LCP's Land Use Plan (LUP), which, as originally adopted by the County in October 1981, proposed to close the dunes to vehicle use and camping until a management plan was submitted by State Parks and approved by the County. In response to the issues raised by this proposal, staff from the County, the Coastal Commission, and State Parks worked together with interested parties to evaluate and develop alternative policies that would allow for continued OHV and camping uses, while providing appropriate levels of resource protection. The results of this effort are reflected by the terms of the Commission's approval of Coastal Development Permit 4-82-300 (which occurred prior to the Commissions adoption of the LUP in 1983) as well as in the certified LUP.

In particular, both CDP 4-82-300 and the LUP consider the existing access route to the OHV riding area (via Grand and Pier Avenues) to be temporary in nature; recognize that OHV and other recreational uses have adverse impacts on the sensitive habitat areas supported by the park; and require further evaluation of alternative access routes and management measures to avoid and minimize these impacts. Specifically, condition 1b of CDP 4-82-300 requires the selection of a permanent staging area within 18 months of LUP certification, and construction of the permanent staging area within 3 years of LUP certification. In the event that the construction and operation of a permanent staging area is not completed within these timeframes (as is currently the case), condition 1b states that the permit shall be subject to review and modification by the County or the Commission. This condition also states that prior to construction, the County LUP and the State Parks General Development Plan shall be amended to include the selected permanent staging area site and additional standards or conditions for its design and operation. Such an amendment has never been proposed.

In light of the above history, it is the Coastal Commission staff's opinion that Figure 4 was intentionally included within the certified LUP to reflect the long-term objectives shared by the County and the Commission for this sensitive dune habitat area, which included phasing out of the northern access route for OHV use and restricting OHV use on County owned land. At the time that CDP 4-82-300 was approved and the LUP was certified it was recognized that further evaluation of the most appropriate location for the permanent staging area would be needed to implement this objective. The inclusion of Figure 4 within the LUP, along with policies that cross-reference the requirements of CDP 4-82-300, reflect the interim nature of current OHV use patterns and require further consideration of these long-term management options as necessary to carry out the resource protection requirements of the Coastal Act and the certified LCP. Contrary to the County staff's presumption that Figure 4 should be viewed as background information only, it is the Commission staff's opinion that both Figure 4 and the associated LCP policies establish important standards that are applicable to the use and development of the County owned lands at issue.

2. Relationship of Figure 4 to CDP 4-82-300 and Associated Permit Amendments

As described above, the Commission's decision to approve CDP 4-82-300 predates the certification of the LUP and associated figures. The Commission's action on this permit recognizes, in the adopted findings, that "The proposed projects recommended for approval herein are central to the resolution of a major Substantial Issue within the submitted San Luis Obispo County Land Use Plan of its Local Coastal Program. They are proposed by State Parks as an initial step in the resolution of that issue."

Following the Commission's action on CDP 4-82-300, the County submitted an LUP that included the figure currently referenced as Figure 4 by the LCP, as well as policies that continued to propose a temporary moratorium on vehicle use and camping. The Commission suggested modification to these policies that were later accepted by the County, which provided a cross reference to the interim provisions of CDP 4-82-300, and maintained the County's stated desire to establish a natural buffer from the impacts of OHV use on County owned land (e.g., as reflected by Figure 4 and South County Area Plan Policy 9). Thus, the relevant LCP policies and Figures reflect the interim status of the OHV and camping use patterns in effect at the time of certification, and the County and the Commission's long term desire to provide increased protection of sensitive dune habitats, among other ways by relocating the OHV staging area to the south, and establishing a buffer area on all County owned lands.

Implementation of these LCP and permit conditions has taken place in conjunction with State Parks, using various techniques. Condition Compliance reviews initiated by the Commission in 1994, partly in response to concerns expressed by the County regarding the intensity of recreational use, resulted in a renewed effort to understand the "carrying capacity" of the park unit, and regulate the types and levels of public use accordingly. After failing to reach consensus on how to effectively accomplish this objective, State Parks proposed an amendment to establish a Technical Review Team (TRT), which was approved by the Coastal Commission in 2001 (CDP 4-82-300-A5), and currently functions as the method by which these long-term management issues continue to be discussed.

Although Figure 4 and other LCP policies calling for the establishment of a buffer on County land have not, to the knowledge of Commission staff, been raised in prior amendments and permit reviews, the issues associated with these provisions and described above, continue to be discussed. In fact, at its February 2007 hearing, the Coastal Commission decided to send a letter to the park superintendent that identifies the need to resolve the interim status of the existing riding entrance and staging area, and states that State parks should submit a permit amendment application that, among other things, proposes a permanent location for recreational vehicle access and staging. The provisions of the certified LCP will be applicable to this application, and currently apply to any new development proposed within the area.

3. General Plan Conformity Report and Potential Sale

The County's decision whether to sell the land it owns, as well as its implementation of Government Code Section 65402 (requiring a General Plan conformity report prior to such a sale), are not "development" decisions that are regulated by the Coastal Commission. This decision may, however, affect both the County's and the Coastal Commission's ability to carry out the terms of the certified LCP and CDP 4-82-300 discussed above, and the Commission staff therefore appreciates the opportunity to comment on the proposed sale, and we support the conclusions of the County Planning staff that the sale would result in the continuation of a use that is inconsistent with the land use designations established by the certified LCP.

With respect to the proposed sale, the Commission staff is concerned that a transfer of ownership to State Parks, for the stated purpose of continued OHV use, may affect implementation of the long term planning and resource management requirements established by CDP 4-82-300 and the certified LCP. In the past, the OHV enabling legislation has been cited by State Parks as preempting the Commission's ability to regulate the type and level of recreational use within the park unit. As a result, retaining County ownership over these lands will help ensure that LCP and Coastal Act policies can be applied to future park management decisions that affect these areas.

For these reasons, the Commission staff encourages the County to consider entering into a short-term lease agreement with State Parks rather than selling the land. This will enhance our ability to work with County and State Parks staff on the outstanding long-term park management issues discussed above. Thank your for your consideration of these comments.

Sincerely,

Steve Monowitz

Steve Monowitz
District Manager

RECREATION: The following standards apply only to lands within the Recreation land use category in the rural portions of the planning area.

NOTE: PORTIONS OF THE TEXT ADDRESSING AREAS OUTSIDE THE COASTAL ZONE HAVE BEEN DELETED. (LCP)

Guadalupe Dunes. The following standards apply to the sand dune areas south of Oso Flaco Road (see Figure 2). (LCP)

1. **Access.** Access to the recreation area is not to be across lands designated in the Agriculture land use category. (LCP)

2. **Dune Stabilization**. Development of recreational uses is to include a program for dune stabilization to prevent sand migration into the adjacent farmland of the Oso Flaco Valley. (LCP)

3. **Limitation On Use.** Allowable uses identified in Coastal Table O, Part I of the Land Use Element are limited to the following: fisheries and game preserves; pipelines and power transmission; crop production and grazing; coastal accessways; and water wells and impoundments. No off-road vehicular use is permitted other than for management of the natural areas or to service allowable uses. (LCP)

Pismo State Beach and State Vehicular Recreation Area. Standards 4 through 13 apply to the development of the Pismo State Beach and State Vehicular Recreation Areas. (LCP)

4. **General Development Plan Revisions.** The General Development Plan (GDP) shall be revised in accordance with the Local Coastal Plan. The plan should identify a variety of recreational opportunities with use areas separated where possible to minimize conflicts. Passive recreational uses and nature study uses should be provided for in the sensitive vegetated areas restricted from OHV use. (LCP)

   Approval of the GDP for inclusion into the County's LCP, or approval of a coastal development permit for a development within either Pismo Beach State Park or the Pismo Dunes State Vehicular Recreation Area, shall be subject to a finding that the State Department of Parks and Recreation is making a commitment for sufficient manpower to ensure resource protection, ordinance enforcement and access control in conformance with the conditions of Coastal Development Permit No. 4-82-30A. Should the terms and conditions of the coastal permit not be enforced or accomplished or should they not be sufficient to regulate the use in a manner consistent with the protection of resources, public health and safety and community values, then under the county's police powers, the imposition of an interim moratorium on ORV use may be necessary to protect resources while long-range planning, development of facilities and requisition of equipment and manpower is completed. (LCP)

5. **Access Control.** All access points to the park facility will be controlled. Primary access for off-road vehicles into the dunes will be as indicated in Coastal Development Permit No. 4-82-30A. (LCP)

6. **Noise Control.** Noise control measures shall be required for ORV use in proximity to natural preserve areas. (LCP)

7. **Alternative Camping Areas.** Alternative camping areas subject to the numerical limitations of Coastal Development Permit No. 4-82-30A may be appropriate in the dunes area and beach. These are dependent upon assurance that scattered sites will still allow for adequate environmental protection throughout the dunes. (LCP)

Back dunes camping areas shall be identified at locations outside of the buffers. Adequate sanitary facilities shall be provided. These back dunes camping areas shall be for tent camping or camping from four-wheel drive vehicles that can gain access to them. With provision of adequate improved facilities, heavier units (which would have a greater environmental impact when accessing the dunes) should make use of the designated staging area. For major events such as hill climbs and competitions, state parks may authorize special access from the Oso Flaco causeway where it can ensure that adequate habitat protection exists. (LCP)

Beach camping in conformance with the numerical limitations of Coastal Development Permit No. 4-82-30A shall be permitted where it can be established that: a) administration of the entire park unit would not be adversely affected, b) control of total users can be maintained within acceptable carrying enforcement/ capacity. The General Development Plan must identify area(s) for beach camping which would minimize conflicts with other users of the sandy beach. (It is estimated each campsite can accommodate from five to eight persons). Consistent with the provisions of Coastal Development Permit No. 4-82-30A, this limit can be adjusted either upward or downward based on monitoring of the impacts of this use. (LCP)

In addition, to the camping facilities for ORV users, the GDP must identify overnight and day use areas for non-ORV users, including hikers, horseback riding, etc. (LCP)

Peak OHV use on the six major weekends must be closely monitored to evaluate the impacts. Monitoring data shall be reviewed jointly by State Department of Parks and Recreation, the county, Department of Fish and Game and the Coastal Commission on an annual basis. Long-term reduction of the peak use may be necessary to ensure adequate resource protection. (LCP)

8. **Habitat Protection.** Natural buffer areas for sensitive habitat areas shall be identified and fenced, consistent with the provisions of Coastal Development Permit No. 4-82-30A and the stabilized dune areas. Habitat enhancement programs shall be undertaken for the following areas including programs such as stabilization of the dunes with appropriate native vegetation to protect encroachment on wetlands and surrounding agricultural land. (LCP)

a. Dune Lakes
b. Coreopsis Hill
c. Oso Flaco Lake
d. Little Oso Flaco Lake

Fences or other appropriate techniques shall be maintained where needed to preclude vehicular access in such areas as the Dune Lakes, Oso Flaco Lake and natural areas in the eastern portion of the park and lease area. (LCP)

9. **ORV Use Area.** ORV use shall be permitted only in identified unfenced vehicular use area. These areas are identified in Figure 4. No recreational ORV use will be allowed in the designated natural areas. These buffer areas reflect areas required for habitat protection and generally recognize the established lease agreement with Union Oil for the areas adjacent to the eastern portion of the park. ORV is prohibited in all vegetated areas. (LCP)

   ORV use of the county held portion (generally lying between the sandy beach and Dune Lakes) shall be limited to the Sand Highway west to the sandy beach. This will minimize conflicts with the Dune Lake Properties to the east and the State Department of Parks and Recreation Dune Preserve to the north. The map of ORV use areas indicates a buffer area along these critical interface areas. (LCP)

10. **Administration of County Holdings.** The county-owned land south of the dune preserve shall be administered through a memorandum of understanding between the county and the State Department of Parks and Recreation. Management of the facility has been assigned to the State. This shall be reexamined periodically to establish the most appropriate management capability. (LCP)

11. **Cooperative Education Programs with ORV User Groups**. The De- partment of Parks and Recreation shall continue and where needed expand the dune users education program. This may include distribution of maps at major access points, identifying user areas and natural buffer areas. Involvement by local and state ORV groups are essential supplements to ensuring proper dune use. (LCP)

12. **Archaeological Resource Preservation.** To ensure archaeological resource protection, the State Department of Parks and Recreation should provide the fullest protection by fencing all known sites. (LCP)

13. **Other Recreation Users**. Non-ORV-dependent uses such as camping, hiking trails, and passive use areas shall be identified and developed. Equestrian centers shall be identified. Parking areas for this day use shall be incorporated. (LCP)

FIGURE 4

OFF-ROAD VEHICLE USE AREAS

LEGEND

OHV USE AREA

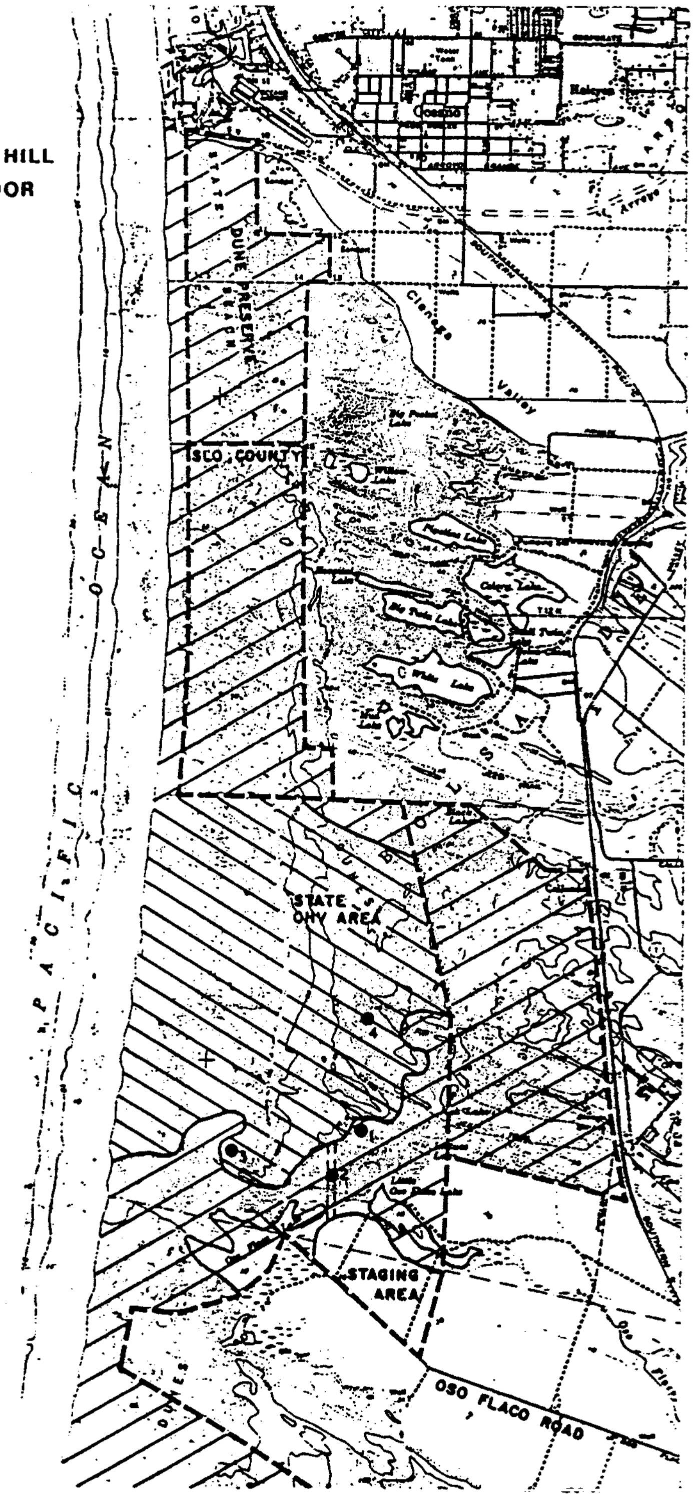
BUFFER AREA

1 LITTLE COREOPSIS HILL

2 OHV ACCESS CORRIDOR (Schematic)

3 MAIDENFORM FLATS

4 BOY SCOUT CAMP



REGULATION X

FUGITIVE DUST EMISSION STANDARDS, LIMITATIONS AND PROHIBITIONS

RULE 1001 Coastal Dunes Dust Control Requirements *(Adopted 11/16/2011)*

A. APPLICABILITY. The provisions of this Rule shall apply to any operator of a coastal dune vehicle activity area, as defined by this Regulation, which is greater than 100 acres in size.

B. DEFINITIONS. For the purpose of this Rule, the following definitions shall apply:

1. "APCD": The San Luis Obispo County Air Pollution Control District.

2. "APCO": The San Luis Obispo County Air Pollution Control Officer.

3. "Coastal Dune": means sand and/or gravel deposits within a marine beach system, including, but not limited to, beach berms, fore dunes, dune ridges, back dunes and other sand and/or gravel areas deposited by wave or wind action. Coastal sand dune systems may extend into coastal wetlands.

4. "Coastal Dune Vehicle Activity Area (CDVAA)": Any area within 1.5 miles of the mean high tide line where public access to coastal dunes is allowed for vehicle activity.

5. "CDVAA Monitor": An APCO-approved monitoring site or sites designed to measure the maximum 24-hour average PM_{10} concentrations directly downwind from the vehicle riding areas at the CDVAA. At a minimum, the monitoring site shall be equipped with an APCO-approved Federal Equivalent Method (FEM) PM_{10} monitor capable of measuring hourly PM_{10} concentrations continuously on a daily basis, and an APCO-approved wind speed and wind direction monitoring system.

6. "CDVAA Operator": Any individual, public or private corporation, partnership, association, firm, trust, estate, municipality, or any other legal entity whatsoever which is recognized by law as the subject of rights and duties, who is responsible for the daily management of a CDVAA.

7. "Control Site Monitor": An APCO-approved monitoring site or sites designed to measure the maximum 24-hour average PM_{10} concentrations directly downwind from a coastal dune area comparable to the CDVAA but where vehicle activity has been prohibited. At a minimum, the monitoring site shall be equipped with an APCO-approved Federal Equivalent Method (FEM) PM_{10} monitor capable of measuring hourly PM_{10} concentrations continuously on a daily basis, and an APCO-approved wind speed and wind direction monitoring system.

8. "Designated Representative": The agent for a person, corporation or agency. The designated representative shall be responsible for and have the full authority to implement control measures on behalf of the person, corporation or agency.

9. "Monitoring Site Selection Plan": A document providing a detailed description of the scientific approach, technical methods, criteria and timeline proposed to identify, evaluate and select appropriate locations for siting the temporary and long-term CDVAA and control site monitors.

10. "Paved Roads": An improved street, highway, alley or public way that is covered by concrete, asphaltic concrete, or asphalt.

11. "PM_{10}": Particulate matter with an aerodynamic diameter smaller than or equal to a nominal 10 microns as measured by the applicable State and Federal reference test methods.

12. "PMRP": Particulate Matter Reduction Plan.

13. "PMRP Monitoring Program": The APCO approved monitoring program contained in the PMRP that includes a detailed description of the monitoring locations; sampling methods and equipment; operational and maintenance policies and procedures; data handling, storage and retrieval methods; quality control and quality assurance procedures; and related information needed to define how the CDVAA and Control Site Monitors will be sited, operated and maintained to determine compliance with section C.3.

14. "Temporary Baseline Monitoring Program": A temporary monitoring program designed to determine baseline PM10 concentrations at the APCO-approved CDVAA and Control Site Monitor locations prior to implementation of the PMRP emission reduction strategies and monitoring program. The program shall include a detailed description of the monitoring locations; sampling methods and equipment; operational and maintenance policies and procedures; data handling, storage and retrieval methods; quality control and quality assurance procedures; and related information needed to define how the temporary monitors will be sited, operated and maintained to provide the required baseline data. The temporary monitors shall meet the specifications of the CDVAA and Control Site Monitors unless otherwise specified by the APCO.

15. "Track-Out": Sand or soil that adhere to and/or agglomerate on the exterior surfaces of motor vehicles and/or equipment (including tires) that may then fall onto any highway or street as described in California Vehicle Code Section 23113 and California Water Code 13304.

16. "Track-Out Prevention Device": A gravel pad, grizzly, rumble strip, wheel wash system, or a paved area, located at the point of intersection of an unpaved area and a paved road that is designed to prevent or control track-out.

17. "Vehicle": Any self-propelled conveyance, including, but not limited to, off-road or all-terrain equipment, trucks, cars, motorcycles, motorbikes, or motor buggies.

18. "24-Hour Average PM_{10} Concentration": The value obtained by adding the hourly PM_{10} concentrations measured during a calendar 24-hour period from midnight to midnight, and dividing by 24.

C. GENERAL REQUIREMENTS

1. The CDVAA operator shall develop and implement an APCO-approved Temporary Baseline Monitoring Program to determine existing PM10 concentrations at the APCO-approved CDVAA and Control Site Monitor locations prior to implementation of the PMRP emission reduction strategies and monitoring program.

2. The operator of a CDVAA shall prepare and implement an APCO-approved Particulate Matter Reduction Plan (PMRP) to minimize PM_{10} emissions for the area under the control of a CDVAA operator. The PMRP shall contain measures that meet the performance requirements in C.3 and include:

   a. An APCO-approved PM_{10} monitoring network containing at least one CDVAA Monitor and at least one Control Site Monitor.
   b. A description of all PM_{10} control measures that will be implemented to reduce PM_{10} emissions to comply with this rule, including the expected emission reduction effectiveness and implementation timeline for each measure.
   c. A Track-Out Prevention Program that does not allow track-out of sand to extend 25 feet or more in length onto paved public roads and that requires track-out to be removed from pavement according to an APCO-approved method and schedule.

3. The CDVAA operator shall ensure that if the 24-hr average PM_{10} concentration at the CDVAA Monitor is more than 20% above the 24-hr average PM_{10} concentration at the Control Site Monitor, the 24-hr average PM_{10} concentration at the CDVAA Monitor shall not exceed 55 ug/m3.

4. The CDVAA operator shall ensure they obtain all required permits from the appropriate land-use agencies and other affected governmental agencies, and that the requirements of the California Environmental Quality Act (CEQA) and the National Environmental Quality Act (NEPA) are satisfied to the extent any proposed measures identified in the PMRP or Temporary Baseline Monitoring Program require environmental review.

Civil Case No. CV120013 Consent Decree found invalid requirement C5 only.

5. All facilities subject to this rule shall obtain a Permit to Operate from the Air Pollution Control District by the time specified in the Compliance Schedule.

D. Exemptions

1. Section C.3 shall not apply during days that have been declared an exceptional event by the APCO and where the United States Environmental Protection Agency has not denied the exceptional event.

E. RECORDKEEPING REQUIREMENTS: The CDVAA operator subject to the requirements of this Rule shall compile and retain records as required in the APCO approved PMRP. Records shall be maintained and be readily accessible for two years after the date of each entry and shall be provided to the APCD upon request.

F. COMPLIANCE SCHEDULE:

1. The CDVAA operator shall comply with the following compliance schedule:

    a. By February 28, 2012, submit a draft Monitoring Site Selection Plan for APCO approval.
    b. By May 31, 2012, submit a draft PMRP for APCO review.
    c. By November 30, 2012, submit complete applications to the appropriate agencies for all PMRP projects that require regulatory approval.
    d. By February 28, 2013, obtain APCO approval for a Temporary CDVAA and Control Site Baseline Monitoring Program and begin baseline monitoring.
    e. By May 31, 2013, complete all environmental review requirements and obtain land use agency approval of all proposed PMRP projects.
    f. By July 31, 2013, obtain APCO approval of the PMRP, begin implementation of the PMRP Monitoring Program, and apply for a Permit to Operate.
    g. By May 31, 2015, the requirements of Section C.3 shall apply.

2. With the exception of section F.1.g, the CDVAA operator will not be subject to civil penalties for failure to meet any timeframe set forth in section F.1 caused solely by delays from regulatory or other oversight agencies required to consider and approve the operator's PMRP or any part thereof.

State of California • Natural Resources Agency
DEPARTMENT OF PARKS AND RECREATION

Edmund G. Brown Jr., *Governor*
Lisa Ann L. Mangat, *Director*

Off-Highway Motor Vehicle Recreation Division
1725 23rd Street, Suite 200
Sacramento, California 95816

March 3, 2016

FINAL

Executive Director
California Coastal Commission
45 Fremont Street
San Francisco, CA 94105

RE: Oceano Dunes State Vehicular Recreation Area Technical Review Team Fifteenth Annual Report

Dear Executive Director:

On June 17, 1982, prior to certification of San Luis Obispo County's Local Coastal Program, the California Coastal Commission conditionally approved coastal development permit (CDP) 4-82-300 to allow the California State Parks to construct entrance kiosks, bathrooms and fencing at Oceano Dunes SVRA. Since then, five amendments have been added to the permit. Permit Amendment No. 4-82-300-A5 requires California State Parks to submit this report to the Oceano Dunes District Superintendent and the Executive Director of the California Coastal Commission (CCC). This report describes the progress of the Oceano Dunes State Vehicular Recreation Area (Oceano Dunes SVRA) Technical Review Team (TRT) over the 2015 calendar year in meeting its responsibilities as outlined within the permit. The TRT met once in person during the year, on December 11, 2015 and again on January 19, 2016 to finalize this report.

In December 2015, the TRT received and reviewed the following reports:

California Department of Fish and Wildlife. *Avian Gross Necropsy Report for Least Tern and Snowy Plover.* Santa Cruz: California Department of Fish and Wildlife, 2015.

California State Parks, Off-Highway Motor Vehicle Recreation Division. *Nesting of the California Least Tern and Western Snowy Plover at Oceano Dunes SVRA, San Luis Obispo County, 2015 Season.* California State Parks, November 2015.

Glick, Ronnie. *2015 Scientific Subcommittee Report, Oceano Dunes SVRA.* California State Parks, 2015.

Jostes, John C. "Tranisition Assessment." Assessment, Santa Barbara, 2015.

Lowry, Barry, and Eric Covington. *Oceano Dunes State Vehicular Recreation Area 2015*

Predator Management Report. USDA Wildlife Services, 2015.

Rischbieter, Douglas. *Aquatic Survey, Arroyo Grande Creek and Lagoon, Oceano Dunes SVRA and Pismo State Beach Dune Preserve.* California State Parks, 2015.

Young, Paul. *Avian Predator Management Project: Trapping and Relocation of Problem Avian Predators at Oceano Dunes State Vehicular Area in 2015.* Salinas: Ventana Wildlife Society, 2015.

These reports and other information along with TRT discussion are summarized below. The full reports are attached to this document for reference.

Summary of the 2015 Nesting Season at Oceano Dunes SVRA

The California least tern (least tern) had a very successful year in 2015. There were up to 49 breeding pairs, similar to 2014 numbers and above the 10-year average from 2005-2014. Oceano Dunes SVRA staff noted 54 known nesting attempts within the large seasonally fenced enclosure in the southern portion of the vehicle riding area. The nest-hatching rate was 88.9 percent. Eighty-four chicks hatched and 69 were color-banded to individual. Sixty-nine of the 84 chicks are known to have fledged, which is a success rate of 82.1% and an estimated 1.41-1.57 chicks fledged per pair. For the 10-year period of 2006-2015, the average productivity was 1.21-1.28 chicks fledged per pair. Mortality was documented for two juveniles in the seasonal exclosure.

The Western snowy plover (plover) had 205 breeding birds (113 males and 92 females) in 2015, which is slightly lower than 226 breeding plovers in 2014. There were 112-banded birds documented as breeding and 105 individuals had a known banding history. Of the known-origin birds, 87.6% were banded as chicks that fledged from Oceano Dunes SVRA. There were 217 known nesting attempts. There were 202 nests from known locations, 182 (90.1%) of which were located in the southern riding area seasonal exclosure and 20 (9.9%) were in Oso Flaco. Plovers from the 195 nests with known location and fate, 167 hatched (an 85% hatch rate). The fledge rate was 277 fledged chicks (56.1%), which is the most chicks fledged since monitoring at the site with an estimated 2.45 juveniles fledged per male. The 14-year average (2002-2015) is 1.47 juveniles per breeding male.

TRT Key Discussion Points

During the December 2015 meeting, the TRT discussed several ongoing topics related to its role as defined by Coastal Development Permit (CDP) 4-82-300-A5. These topics included:

- Completing the Habitat Conservation Plan (HCP) and submitting to the USFWS and the public for review;
- Issuance of an incidental take permit by the USFWS;
- The effectiveness, costs and adaptive nature of management and monitoring activities within and adjacent to the SVRA;
- Dust control activities, mitigation efforts and their off-site implications, as well as their

impacts on the overall size of the riding area within the park;

- Positive and negative on and off-site impacts of Huckfest, a special event held at the park in October 2014; and,
- A desire to continue the efforts of the TRT until the HCP is complete.

Research and Management Priorities

Under Special Condition 5 of the CDP, the permit indicates that when selecting the priority research and management questions and projects, the TRT should consider:

- information provided by the USFWS and National Oceanographic and Atmospheric Administration/National Marine Fisheries Service (NOAA/NMFS) and include appropriate management techniques for the Western snowy plover, California least tern, and steelhead trout;
- appropriate management techniques for protecting water quality and dune habitats from potential pollutants;
- the success of past revegetation efforts and potential need for continuing or expanding these efforts, including expansion of vegetation exclosures; and
- comprehensive long-term monitoring and comparative analysis of resource affect (CDP A-5 pp. 8-9).

The completion of a public review draft of the HCP continues to be highest priority_with regard to research and management initiatives. Once the HCP administrative draft is complete, public agencies will review the document and make final revisions prior to releasing a public review draft. The HCP process was delayed most recently due in part to staff turnover at the California Department of Fish and Wildlife (CDFW) and administrative needs at Oceano Dunes SVRA. Despite these challenges, Oceano Dunes SVRA staff is actively pursuing the HCP process.

The 2015 Scientific Subcommittee report and the 2015 Nesting Report recommendations and management efforts document the need to manage resources through a balance of resource protections and user activities within the park. This approach has had positive results for plover and least tern populations and other sensitive species within the park boundaries, while providing recreational opportunities for off-highway vehicle (OHV) enthusiasts. The Scientific Subcommittee (SSC) no longer calls out a number of recommendations within their report because they have become standard operating procedures at Oceano Dunes SVRA.

Arroyo Grande Creek and Lagoon

Oceano Dunes SVRA carries out fisheries monitoring of the Arroyo Grande Creek mouth and lagoon through expertise provided by state fisheries biologist Doug Rischbieter. The following is the summary from the *Arroyo Grande Lagoon and Adjacent Waters Fishery and Aquatic Resources Summary 2015 Monitoring Report.* See the full report for more information.

California State Parks has been investigating and monitoring the fishery and habitat of the lowest half-mile of Arroyo Grande Creek since 2003. These waters are within and adjacent to Oceano Dunes State Vehicular Recreation Area (SVRA) and Pismo Dunes Natural Preserve (San Luis Obispo County, California). Fish-collection surveys were made on six dates in 2015, and Park staff made cursory hydrologic observations on some additional dates. Sampling of the fishery in this area was conducted for several purposes: to gather information about various species' use of the habitats within this California State Park unit; to evaluate whether any Park activities may be affecting the fishery or aquatic habitat; and to document the impacts of habitat disturbance caused by a persistent drought and upstream water management activities.

Seven species of California native fish were collected between February and December 2015, though their numbers fluctuated and most became absent from the catch as the year advanced. Tidewater Goby *Eucyclogobius newberryi* (federally listed as Endangered) and Striped Mullet *Mugil cephalus* were persistent through much of the year. Threespine Stickleback *Gasterosteus aculeatus* were moderately abundant early in the year, but inexplicably disappeared from the catch for the first time ever. Staghorn Sculpin *Leptocottus armatus*, Prickly Sculpin *Cottus asper*, and Sacramento Sucker *Catostomus occidentalis*, were present at times in low numbers, but apparently did not persist throughout the year. Topsmelt *Antherinops affinis* arrived on a high tide that breached the lagoon just before the middle of December. Mosquitofish *Gambusia affinis*, a non-native species, was also collected in numbers that dramatically increased throughout the second half of the year until being decimated by the aforementioned December lagoon breach.

The current closure zone erected by park staff protects the aquatic resources well. From 2011 through most of 2014, we observed no evidence of vehicle encroachment beyond the closure. When some posts washed out in late 2014, they were replaced; we observed no incursion by vehicles (or tire tracks) in the closure zone on any 2015 survey date. Conversely, the absence of surface flows, plus 2015 wind and weather patterns, has resulted in significant changes to the configuration of the Arroyo Grande Creek channel, lagoon, and mouth. This reconfiguration and aggradation may have implications for water and flood management in local upstream areas whenever substantial and persistent surface flows resume in Arroyo Grande Creek. Park managers should remain engaged in the review of proposed projects that seek to manipulate the depth of the Arroyo Grande Creek channel and the height of the lagoon's sandbar and beach area as the valuable lagoon habitat allowed tidewater goby to persist through the unprecedented 2013-2015 drought period.

TRT Commentary: There was a discussion on the amount of groundwater that was being used and if there was a relationship between groundwater use and fine particulate matter.

Oceano Dunes SVRA Soil and Water Quality Program

California State Parks initiated a contract in May 2009 with the state Department of Water Resources Division of Environmental Services, Environmental Compliance Branch. Between 2009 and 2013, sand and water were sampled and analyzed to determine existing chemical, physical and biological constituents including California Code of Regulations Title 22 metals (CAM-17), bacteria/fecal coliform, pH, and total petroleum hydrocarbons. Given ongoing drought conditions and a desire to sample both soil and water quality during times of higher flows through the lagoon, these efforts were not undertaken this year. In the past, soil sampling has not found anything noteworthy with regard to water or soil affects from vehicles.

Vegetation Islands Management

In previous years, vegetation islands management has focused primarily on stabilizing the western edges of existing vegetation islands within Oceano Dunes SVRA to minimize fragmentation. This approach is continuing, but at levels less than those attempted during the initial years of the management effort.

Cultural Resource Preservation Efforts

Previous understanding of cultural resource sites in the North Oso Flaco area of the Park indicated that there were three separate sites present in the area. Recent sand movement has revealed that these three sites are actually part of a larger single archaeological site. As a result, the Department closed off approximately 7.5 acres (6 acres in 2014 and 1.5 in 2015) of riding area to protect these sensitive resources consistent with the state and federal regulations. Consultation with tribal representatives has been a part of this process.

Air Quality Studies and Monitoring

Oceano Dunes SVRA staff reported that Oceano Dunes SVRA implemented several seasonal mitigation strategies to control dust and monitor particulates. These strategies include installing 40 acres of wind fencing within the riding area and operation of dust monitoring equipment. In 2014, Oceano Dunes SVRA staff installed 30 acres of straw bales east of the OHV riding area between the SVRA and the California Department of Forestry and Fire Protection (Cal Fire) monitoring station. In the winter of 2014, staff restored six acres to native vegetation. In the winter of 2015 restored an additional five acres to native vegetation. Oceano Dunes SVRA also installed a dust monitoring station south of Oso Flaco Lake in June 2015 through an emergency permit from the CCC.

These efforts are part of a long-range 5-year mitigation program being evaluated in a Program Environmental Impact Report (EIR), which regulatory agencies are currently reviewing. The Program EIR will be available for public review and comment in early 2016. Oceano Dunes SVRA is also considering options for a temporary project during the 2016 windy season within the SVRA.

TRT commentary: The TRT discussed possible impacts to nesting snowy plover and least tern. The group also discussed maintaining a "no-net-loss" approach to projects to maintain available riding opportunity while accommodating temporary closure of areas to OHV recreation. There was also discussion of the scope of projects and alternatives that would be considered in the pending EIR.

Oceano Dunes SVRA Operational Measures

Oceano Dunes SVRA continues to implement recommendations and measures from previous priority studies identified by the TRT along with operational measures resulting from ongoing fieldwork by Oceano Dunes SVRA staff that serve to minimize impacts on shorebirds. Oceano Dunes SVRA staff continues to meet and/or exceed key management and monitoring issues that have been identified in the TRT report. These measures are similar to those of 2014 and include:

- As shown in the attached Vehicle Use Number charts, the vehicle numbers exceeded the limits on the following dates:
    - Oct. 17-18 and November 28 – Total OHVs. These dates preceded the determination discussed at the December 2014 TRT meeting that camping OHVs are included in the permit limits. No OHV exceedances occurred after November 2014.
    - Sept. 6 – Day Use Vehicles. Due to the holiday and large family reunions, numerous visitors with Annual Day Use Passes came in and out. Each of these repeat visits counted as a "new" entry, thus inflating the total number of day use visitors. Based on this occurrence, a new protocol has been established to avoid double-counting Annual Pass holders.
- Enforcement of camping was consistent with the CDP. Oceano Dunes SVRA implements on-going, focused enforcement to eliminate illegal camping vehicles.
- Restricting non-street legal OHV use and camping to approximately three miles of beach (non-nesting season only). In addition, this includes restricting non-street legal OHV use and camping to approximately two miles of beach during the nesting season.
- Enforcement of 15 MPH beach speed limit. Oceano Dunes SVRA continues to add speed limit signage on the beach. The addition of portable signage was first implemented in 2005. This method has proven to be effective in reducing speed related violations. Law enforcement staff continued to implement focused speed enforcement in the mid-ramps area between the Grand Avenue and Pier Avenue beach areas, including the placement of portable speed limit signs to protect Western snowy plover that congregate in the area during the fall months following the nesting season. Oceano Dunes SVRA staff conducts additional monitoring of tide conditions during this period. Action is taken to restrict vehicle access to the beach via Grand Avenue if tide conditions warrant.
- Oceano Dunes SVRA continues its public outreach and education efforts through a variety of methods including:
    - park brochure and informational flyers;
    - an informational FM radio station;
    - Off Road Police Athletic League (PALS) activities directed at youth rider safety and orientation;
    - ATV Safety Institute (ASI) certification program to provide all-terrain vehicle (ATV) safety orientation and training;
    - establishment of a registered ATV safety certificate training site within Oceano Dunes SVRA;

  - organized clean up events and volunteer sound testing;
  - ATV and sand rail rental concessionaires and employees provided safety and orientation training;
  - concessionaire employees attended ATV safety certificate training to become certified ASI safety trainers; and,
  - concession employees also attended resource management and protection training.

- All Oceano Dunes District staff and concessionaire staff attend annual Western snowy plover and California least tern training and general resource management orientation.
- Implementation of Volunteer Dune Patrol, which is made up of volunteers from the riding community, assists Oceano Dunes SVRA staff with public outreach and education regarding Oceano Dunes SVRA's resource management and public safety programs. Enforcement of dog leash laws.
- Maintenance of an off-beach vehicle corridor, parallel to the beach to allow north/south vehicle traffic flow, to assist in relieving the volume of vehicle traffic directly on the beach during high tides.
- Maintenance of vehicle corridors perpendicular to the beach and at intervals along the beach to assist vehicles to enter the dunes from the beach.
- Maintenance and enforcement of areas restricted to OHV recreation (1.5 miles of beach at Oso Flaco and Arroyo Grande Creek). These areas are closed entirely to motor vehicles.
- Maintenance and enforcement of areas restricted to non-street legal vehicles 1.5 miles of beach from Grand Avenue to beach post #2.
- The continued protection of the Arroyo Grande Creek Lagoon impounded water areas, and creek crossing recommendations from continued aquatic analysis. This includes the ongoing implementation of a "take avoidance plan" for steelhead in cooperation with the National Oceanic and Atmospheric Administration and the National Marine Fisheries Service.
- Improved regulatory signage throughout Oceano Dunes SVRA: there are five electronic billboards used throughout the park to improve regulatory advisements to the public and to provide public information.
- Improved response and care for sick and injured birds: a bird care way station is set up at the ranger station where resource staff care for sick and injured birds until they can be transferred to an animal care facility. A strict on-scene staffing protocol assures protection of sick and injured birds until help arrives.
- Improved response and care for sick and injured marine mammals: continue to emphasize strict staffing protocols to assure the protection of marine mammals until recovery help arrives.
- Limit motorized special events to back dune areas and areas away from the nesting area and typical roosting and feeding areas: motorized events are subject to California State

Parks Special Event Permit process and may be subject to environmental review.

- When park staff access Oso Flaco from the park, they will coordinate with a trained monitor who will be on-site prior to entering the area, and stay on site for the duration of the work. The interior Boneyard fence ties into the west Boneyard perimeter fence just to the north of the Oso Flaco gate. Having an access route on the east side of the interior Boneyard fence allows for efficient fence maintenance and allows maintenance of Oso Flaco road several times a season. This will also allow park staff access to the south boundary fence to maintain the waterline boundary as needed.

TRT Commentary: The group discussed any changes that may have occurred in response to a 2015 letter from CDFW to Oceano Dunes SVRA. Staff reviewed an experiment with black tubing on the exclosure fence. Staff also reviewed changes to procedures to perform necropsy on birds that are found in the SVRA. Oceano Dunes SVRA District sent a letter to CDFW responding to concerns and adopted most recommendations except increasing the buffer from the main colony to 1,000 feet. Oceano Dunes SVRA made no other ongoing management changes.

Special Events

TRT Commentary on Special Event Permits: The USFWS sent a letter to Oceano Dunes SVRA regarding concerns with protecting plovers during the 2014 Huckfest special event. Oceano Dunes SVRA provided the USFWS a notice of the plover take incident, but it was not included in the 2014 Nesting Report. Bill Standley remarked about the USFWS concerns with reporting. The USFWS indicated in their letter to Oceano Dunes SVRA that future events would need to be covered under a HCP. Oceano Dunes SVRA staff indicated that the scheduled 2015 Huckfest special event did not occur because the organizers could not meet Oceano Dunes SVRA's conditions. There was a discussion of visitor use numbers during the proposed weekend of the event and Oceano Dunes SVRA staff responded that visitation was normal for the weather and season. The group discussed risks to ongoing recreational activity in the absence of an HCP and associated Incidental Take Permit. TRT members agreed that the HCP should be completed.

SSC Recommendations and TRT Commentary on the 2015 Nesting Report

Oceano Dunes SVRA staff provided the *Nesting of the California Least Tern and Western Snowy Plover at Oceano Dunes SVRA, San Luis Obispo County, 2015 Season* (2015 Nesting Report), to SSC members on November 10, 2015 and requested e-mailed comments by November 30, 2015. Attachments to this report include:

- US Department of Agriculture Wildlife Services, *Oceano Dunes Predator Management Report, 2015 Season;*
- Ventana Wildlife Society, *Avian Predator Management Project: Trapping and Relocation of Problem Avian Predators at Oceano Dunes State Vehicular Area in 2015;* and
- *Necropsy examination report: one least tern juvenile and medical examination record: one snowy plover adult.*

TRT members received the SSC recommendations and reports on November 30, 2015, and met on December 11, 2015. In general, the 2015 SSC report recommends inclusion of all prior SSC recommendations that California State Parks has yet to implement. These recommendations are below, followed by TRT commentary. See the 2015 Nesting Report, attachments listed above, the 2015 SSC Report, and the 15th Annual TRT Meeting Notes for complete text and discussion of each item.

Overall TRT commentary: SSC recommendations have not changed substantially in the past few years.

2014 SSC Recommendation #8: Continue to study benefits of wrack addition to the Southern Exclosure shoreline and inoculation with wrack-associated invertebrates as a possible means to restore invertebrate species and biomass (these invertebrates are part of the prey base for the snowy plover chicks, juveniles, and adults).

- The SSC recommends this study be continued and reviewed in 2016.
- TRT Commentary: TRT supported this recommendation with no additional comments.

2014 SSC Recommendation #9: Continue to look for an appropriate design to cover trash dumpsters.

- The SSC continues to support the recommendation for 2016.
- TRT Commentary: TRT supported this recommendation with no additional comments.

2014 SSC Recommendation #11: Conduct study evaluating alternative plover/tern habitat treatment strategies

The SSC continues this recommendation for 2016.

The 2015 Nesting Report continues to note the compromised quality of the habitat available in the riding area at the start of the breeding season. The option as stated in the 2015 SSC Recommendations Report:

> The seven-month closure may not allow enough time for habitat to recover from OHV recreation, especially by the beginning of the breeding season. During the non-breeding season, snowy plovers continue to roost between Grand and Pier Avenues. The question remains as to whether a year-round closure in some configuration would best serve breeding plovers and terns. The park has never conducted a controlled experiment to determine whether year-round closure is beneficial.
>
> Although the park implemented year-round closures of 11 and less than 4 acres in winters 2003/2004 and 2004/2005, respectively, the closures were not implemented in a manner

that allowed biologists to draw conclusions as to whether such a closure is the optimal management approach. Available data do not allow for a scientifically based recommendation for or against a particular habitat management strategy. Although the year-round closure seemed to benefit breeding success, it is possible that enhancement measures implemented by Oceano Dunes SVRA could be just as effective. Because available data are inconclusive, the SSC recommends scientific evaluation of year-round closure. A study should be designed and implemented allowing scientific analysis of year-round closure, in comparison to habitat left open during the nonbreeding season. A formal proposal for this study should be made available for SSC and TRT.

- TRT Commentary: The TRT did not come to a consensus to support or endorse the SSC #11 recommendation.

  The TRT has reviewed this recommendation for more than 10 years and has not reached consensus on this proposal. There is some general agreement on the need to understand how the quality of habitat affects nesting success and predator activity. There is also some agreement on reducing the amount of vegetation in certain areas to improve nesting conditions. However, the proposal as provided by the SSC was not supported.

The TRT reached consensus on proposing a new recommendation in place of the 2014 SSC Recommendation #11. The new recommendation would be to:

Explore options for improving the habitat condition in the 8 exclosure.

- TRT Commentary: Jim Suty recommended that the TRT conduct a site visit to the 8 exclosure. Oceano Dunes SVRA will explore options for improving habitat in the 8 exclosure and report on the costs and steps involved to implement the recommendation.

2014 SSC Recommendation #12: Consider option to capture previously banded adult least terns to determine their origin.

The SSC continues to support the recommendation in 2016. The 2015 SSC Report states that:

> Based on the number of banded plover adults showing up, the SSC is interested in banding adult least terns. It could be valuable to know if least terns are coming in from elsewhere, which would affect how the site is managed. Ronnie is concerned it could cause nest abandonment, but others have had very low abandonment rates due to trapping. Trapping can be quick and relatively non-intrusive. Adults are caught via remote control trap after the eggs have been temporarily replaced with decoy eggs to avoid egg damage. It requires two visits but takes no more than 10-30 minutes from start to finish and takes 1-20 minutes for adults to return. Trapping is done at 7-14 days incubation so birds are invested in the site and less likely to abandon. Biologists do not trap once the majority of nests have hatched.
>
> The logistics at Oceano Dunes SVRA are very challenging since the 6 and 7 exclosures are very narrow. It is hard to get in and band due to nesting density, and there are concerns about chasing chicks into the riding and camping area. The presence of nesting plovers makes it more challenging. Ronnie Glick will need to discuss this idea with his staff. Regarding whether banded chicks will eventually return and give this data anyway,

the origins of least terns that only have USFWS bands would be unknown. This effort would specifically target only those individuals. All chicks now get a metal band, but you cannot always see whether birds are banded due to distance. For a while at the SVRA, the other leg got a plastic band that was not well retained. Monitors could also try cameras.

Ultimately, this information would help support the strong management at Oceano Dunes SVRA. Least terns from Oceano have been observed passing through San Diego, but not nesting. Oceano Dunes SVRA has no records of birds breeding at other sites, but it is likely that few sites are monitored intensely enough to detect them. Other sites should be encouraged to look. Unfortunately, a recent trend in LETE management had been to step away from banding, largely due to cost. However, CDFW has recently begun to emphasize the perceived value of banding as a tool to determine survivability.

- TRT Commentary: There were no comments on this recommendation

2015 Predator Management SSC Recommendations

The SSC suggested including the recommendations from the USFW Predator Management Report and the Ventana Wildlife Society as SSC recommendations. Oceano Dunes SVRA had previously implemented several of these recommendations as ongoing management actions. The SVRA will continue to implement the recommendations as staffing and funding permit. These recommendations are summarized below. For the full text, refer to the 2015 Scientific Subcommittee Report, Oceano Dunes SVRA, pages 4-5. The TRT commentary follows the recommendations below.

The USFWS recommends Oceano Dunes SVRA:

- Educate the public on the importance of not feeding wildlife. *Implemented.*
- Ensure all garbage containers have reinforced lids. *In progress.*
- Maintain the height and strength of the perimeter fence surrounding the exclosures. *Implemented.*
- Maintain fencing on a regular basis to prevent predators from entering the exclosure. *Implemented.*
- Reinforce leash laws for pets on the beach. *Implemented.*
- Remove dead animal carcasses from the beach to eliminate food sources for predators. *Implemented.*
- Selectively remove predators that are a known threat to the California Least Tern and Western Snowy Plover breeding populations. *Implemented.*
- Train wildlife specialists in order to add them to permits that allow entrance into areas where predators are threatening breeding birds. *Implemented.*

The Ventana Wildlife Society recommends Oceano Dunes SVRA:

- Continue the practice of depositing wood chips and other substrates into the 6, 7, and 8 exclosures early in the season. *Implemented.*
- Keep the west fence in its present location and not moved back to the west where it would functionally create a narrower shoreline with less food and cover. *Implemented.*
- Maintain the current size of the fenced tern and plover nesting exclosures. *Implemented.*

TRT Commentary: The TRT supports the SSC recommendation to include the USFWS and Ventana Wildlife Society recommendations as ongoing SSC recommendations. Members of the TRT asked some clarifying questions about these recommendations.

TRT Transition Assessment

Former TRT Facilitator, John Jostes, prepared a Transition Assessment for California State Parks, CCC and the TRT in September 2015. See the attachments for the complete report. This Transition Assessment provides an overview of the TRT accomplishments, process dynamics, and recommendations for its transition termination as an advisory body. The report provided four key actions. These key actions, along with TRT discussion are below:

- Begin formal discussions amongst USFWS, CDFW, California Oceano Dunes SVRA and the CCC focused on identifying the conditions necessary to produce a public review draft of the HCP within two years and phase-out the TRT and Scientific Subcommittee no later than December 2017.
    - TRT Commentary: As in 2014, the group consensus was to continue the annual TRT meetings until the HCP is completed. TRT members indicated that the HCP is a high priority and should be the focus of the TRT.
- For all remaining 2015 TRT meetings and future meetings, abandon the informal practice of allowing TRT members to call in to participate in meetings and insist on face-to-face meeting attendance. The TRT's Charter and Ground Rules contain no reference to remote participation so no formal TRT action is necessary.
    - The TRT supports the intent of the recommendation; however, most members agreed that phone conferencing is acceptable for those members who cannot attend in person. Members discussed the high costs of travel and time investment and suggested alternate technology to facilitate the discussions.
- Place on the TRT's December 2015 meeting agenda topics pertaining to use levels and the adjustment of the geographical extent of riding areas. With regard to boundary adjustments, the TRT should consider whether it wishes to scope and task the Scientific Subcommittee with identifying alternative scenarios which change the location of riding and non-riding areas such that: a) the existing acreage of riding area is maintained; and b), equal or greater habitat conservation and management opportunities are provided (including consideration of year-round rotating closures).
    - These topics did not make it onto the December 2015 meeting agenda. The TRT did not have comments on this action.
- Institute a sunset date by year-end, for the completion of all TRT and Scientific Subcommittee business no later than December 15, 2017. This thereby provides a two-

year lead time for Coastal Commission and DPR [Department of Parks and Recreation] staff to develop and vet a "closure or transition plan", based upon either the availability of a Public Review Draft of the HCP, or a functional equivalent resource and infrastructure plan (as noted above) which is separate and distinct from federal ESA provisions. Work closely with CCC staff and other relevant public agencies to articulate the specific focus and regulatory context for such a "non-federal" plan.

- o This item was discussed, but the TRT did not make a formal recommendation.

Other TRT Discussion:

- One participant felt that the facilitator went beyond his role and imparted his opinions into the report.
- One participant indicated that the TRT is an important method for encouraging public involvement with environmental and recreational groups before the HCP goes to broad public review.
- One participant suggested an alternative representative to the TRT. .
- Most participants see value in continuing with the group.

Concluding Remarks:

This concludes the 15th Annual Report of the Oceano Dunes SVRA TRT as prepared by the group's facilitator. Based upon review of the permit conditions related to the TRT, the group has:

- Summarized annual recreational use and habitat trends;
- ranked its research and management questions and priorities through highlighting the importance of completing a public review draft of the Habitat Conservation Plan that covers the Oceano Dunes SVRA, among other park units; and
- completed all assigned tasks and responsibilities prescribed by the Coastal Development Permit Amendment #4-82-300-A5.

Sincerely,

Katherine Metraux

Katherine Metraux,
TRT Program Facilitator for 2015
Associate Park and Recreation Specialist
OHMVR Division, California State Parks

CC:

Brent Marshall, Oceano Dunes District Superintendent
Rick LeFlore, OHMVR Division Environmental Program Manager

ATTACHMENTS:
Attachment 1: 2015 TRT Adopted Meeting Notes
Attachment 2: TRT Membership List
Attachment 3: 2015 Scientific Subcommittee Recommendations
Attachment 4: 2015 Nesting Report
Attachment 5: 2015 Predator Management Report
Attachment 6: 2015 Avian Predator Management Project Report
Attachment 7: 2015 Avian Gross Necropsy Report
Attachment 8: 2015 Arroyo Grande Lagoon and Adjacent Waters Fishery and Aquatic Resources Summary Report
Attachment 9: 2015 Oceano Dunes SVRA Vehicle Use Report
Attachment 10: TRT Transition Assessment

Bibliography

California Department of Fish and Wildlife. *Avian Gross Necropsy Report for Least Tern and Snowy Plover.* Santa Cruz: California Department of Fish and Wildlife, 2015.

California State Parks, Off-Highway Motor Vehicle Recreation Division. *Nesting of the California Least Tern and Western Snowy Plover at Oceano Dunes SVRA, San Luis Obispo County, 2015 Season.* California State Parks, November 2015.

Glick, Ronnie. *2015 Scientific Sub-Committee Report, Oceano Dunes SVRA.* California State Parks, 2015, 10.

Jostes, John C. "Tranisition Assessment." Assessment, Santa Barbara, 2015, 13.

Lowry, Barry, and Eric Covington. *OCeano Dunes State Vehicular Recreation Area 2015 Predator Management Report.* USDA Wildlife Services, 2015.

Rischbieter, Douglas. *Arroyo Grande Lagoon and Adjacent Waters Fishery and Aquatic Resources Summary 2015 Monitoring Report.* California State Parks, 2015.

Young, Paul. *Avian Predator Management Project: Trapping and Relocation of Problem Avian Predators at Oceano Dunes State Vehicular Area in 2015.* Salinas: Ventana Wildlife Society, 2015.

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Ventura Fish and Wildlife Office
2493 Portola Road, Suite B
Ventura, California 93003

IN REPLY REFER TO:
08EVEN00-2017-CPA-0023

December 22, 2016

Brent Marshall, District Superintendent
California Department of Parks and Recreation
Oceano Dunes State Vehicular Recreation Area
340 James Way, Suite 270
Pismo Beach, California 93449

Subject: Oceano Dunes State Vehicular Recreation Area, Second Notice of Additional Endangered Species Act Violations

Dear Mr. Marshall:

This letter is in response to reports made by the Oceano Dunes State Vehicular Recreation Area (SVRA), that an additional three federally threatened western snowy plovers (*Charadrius nivosus nivosus*) were found dead in vehicle tracks on two separate instances during the month of November 2016 (California Department of Fish and Wildlife 2016; R. Glick, California State Department of Parks and Recreation (State Parks) in litt. 2016a, 2016b). On March 29, 2016, we issued a similar letter expressing our concerns regarding three western snowy plovers that had been killed by vehicle collisions within a 30-day period earlier this year (U.S. Fish and Wildlife Service (Service) 2016). In the March 29 letter, we requested a site visit and made recommendations on measures the SVRA should take to avoid impacts to federally listed species.

The Service's responsibilities include administering the Endangered Species Act of 1973, as amended (Act), including sections 7, 9, and 10. Section 9 of the Act and its implementing regulations prohibit the take of listed wildlife species without special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harassment is defined by the Service as an intentional or negligent action that creates the likelihood of injury to listed species by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering. Harm is further defined by the Service to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering (50 CFR 17.3). Exemptions to the prohibitions against take may be obtained through coordination with the Service in two ways: through interagency consultations for projects with Federal involvement pursuant to section 7 of the Act or through the issuance of an incidental take permit under section lO(a)(l)(B) of the Act.

We reiterate that State Parks has had no authorization or permit to incidentally take federally-protected species at Oceano Dunes SVRA. State Parks has been working with our office to develop a habitat conservation plan (HCP) as part of an application for an incidental take permit, while implementing measures intended to avoid impacting federally-listed species; particularly, the western snowy plover and the federally endangered California least tern (*Sterna antillarum browni*). In our March 29, letter, we discussed the following items:

1. A site visit be scheduled with Ventura Fish and Wildlife Office staff and staff of the Service's Office of Law Enforcement to discuss how State Parks intends to come into compliance with the Act.
2. The need to complete the HCP process as quickly as possible.
3. Necessary review and enhancement of avoidance and minimization measures to ensure take is avoided until State Parks obtains incidental take authorization under the Act.
    a. Options include reduced speed limits, additional beach closures, and additional enforcement of existing speed limits.
4. State Parks should not schedule any special events that could increase risk of take of federally protected species.

On June 30, 2016, Ventura Fish and Wildlife Office and Office of Law Enforcement Staff met with State Parks at the Oceano Dunes SVRA to discuss the recent violations of the Act and steps to move forward. Since then, progress on the HCP has been made and regular coordination meetings are now occurring; however, as evidenced by the recent additional mortalities, the avoidance and minimization measures being implemented have not been adequate to avoid take, and thus violations of the section 9 take prohibitions of the Act continue to occur.

We request within 30 days of the date of this letter, State Parks demonstrate what avoidance and minimization measures were in place to prevent take in November 2016, and what measures it will now impose in light of the additional violations of the Act that have occurred subsequent to our March 29 letter and discussions. State Parks must demonstrate how they will ensure that any new measures identified above are implemented to avoid further violations of the Act.

The HCP has been progressing, but not quickly enough to provide State Parks with coverage for these incidences of take; thus, in your correspondence, State Parks should include the updated schedule for completion of the HCP package and application. The correspondence should further describe if the Service's prior recommendations outlined above have been adopted and/or include explanations if they have not. In addition, the correspondence should provide reports on any special events that have been held in the SVRA since the March 29 letter. In addition to the measures recommended in our March 29 letter, we recommend State Parks increase monitoring and decrease the number of recreational vehicles in the SVRA.

Please note that violations of the Act may result in civil or criminal penalties, the assessment of which could preclude the ability of State Parks to obtain an incidental take permit in the future. Should State Parks fail to respond to this letter, and take of listed species continues to occur at

Oceano Dunes SVRA, the Service may seek all appropriate legal remedies, which may include criminal or civil penalty action or civil injunctive relief. See, for example, *United States v. Town of Plymouth, Mass*., 6 F. Supp. 2d 81 (D. Mass. 1998), where the Service sought and achieved a preliminary injunction banning off road vehicles from a beach because of take of the federally threatened piping plover (*Charadrius melodus*). In addition to Federal enforcement, unauthorized take of listed species is subject to third party litigation.

We also urge you to contact the Service to discuss remediation of the take that has occurred to date. If you have any questions, please contact Lena Chang of my staff at (805) 644-1766, extension 302, or by electronic mail at lena_chang@fws.gov.

Sincerely,

Stephen P. Henry
Field Supervisor

REFERENCES CITED

California Department of Fish and Wildlife. 2016. CDFW seabird necropsy report regarding cause of death for western snowy plover collected on November 1, 2016. California Deparmtnet of Fish and Wildlife Office of Spill Prevention and Response Marine Wildlife Veterinary Care and Research Center, Santa Cruz, California. Dated November 15, 2016.

[D. Mass] United States District Court, D. Massachusetts. 1998. 6 F. Supp. 2d 81 (1998) UNITED STATES of America, Plaintiff, v. TOWN OF PLYMOUTH, MASSACHUSETTS, Defendant. Available on the internet at <No. CIV. A. 98-10566-PBS. http://law.justia.com/cases/federal/district-courts/FSupp2/6/81/2347923/>. May 15, 1998.

[Service] United States Fish and Wildlife Service. 2016. Letter to Oceano Dunes State Vehicular Recreation Area regarding Endangered Species Act violations and habitat conservation plan (2016-CPA-0086). Ventura Fish and Wildlife Office, Ventura, California. Dated March 29, 2016.

In litteris

Glick, Ronnie. 2016a. Senior Environmental Scientist, California Department of Parks and Recreation, Oceano Dunes District. Electronic mail to Roger Root, Deputy Field Supervisor, Ventura Fish and Wildlife Office, and Laura Chee, Special Agent, Office of Law Enforcement, including final necropsy report for western snowy plover found at Oceano Dunes on November 1, 2016. Dated November 15, 2016.

Glick, Ronnie. 2016b. Senior Environmental Scientist, California Department of Parks and Recreation, Oceano Dunes District. Electronic mail to Roger Root, Deputy Field Supervisor, Ventura Fish and Wildlife Office, and Laura Chee, Special Agent, Office of Law Enforcement, regarding two western snowy plovers found dead in vehicle track at Oceano Dunes on November 30, 2016. Dated November 30, 2016.

From:	Brittany Struck - NOAA Federal
To:	Glick, Ronnie@Parks
Subject:	coordination and information exchange with NOAA Fisheries
Date:	Friday, December 16, 2016 1:43:29 PM

Hi Ronnie,

I'm reaching out to you for a few reasons that I'll explain below. Perhaps, if you are in the office next week we can coordinate a time for a quick chat or follow up from my email. Quickest way to reach me is my cell: 214 505 9547.

First, in the spirit of coordination and communication, I wanted to let State Parks know that we issued a draft jeopardy/adverse modification biological opinion under the ESA Section 7(a)(2) to the Corps of Engineers for a pending permit request by the County of San Luis Obispo for sediment and vegetation removal throughout the lower 3-miles of Arroyo Grande Creek. We are currently in discussions right now with the Corps and the County to formulate a reasonable and prudent alternative to the currently proposed flood-control project. As a side note, within our draft biological opinion we anticipate sediment effects to the lagoon itself from flood-control maintenance activities.

Second, also within our draft biological opinion, we bring attention to the County's interim sandbar management plan (2013), and I was curious if the County has coordinated with State Parks on this plan (attached) given the vehicle recreation area that crosses over Arroyo Grande Creek and its lagoon system?

Lastly, we are aware that the Coastal Commission will be reviewing permits/plans in early January associated with the vehicle recreation area in and around the Arroyo Grande Creek and its lagoon. Our admin record shows we provided technical assistance to State Parks back in 2008, and I would like to revisit and discuss with you the possibility of incorporating some seasonally-specific minimization measures for vehicles crossing this area, particularly during the winter and spring, when we likely see more hydrologic connectivity between the ocean and lagoon. Also, from some recent lagoon surveys, we are seeing evidence of steelhead redds/spawning habitat which deviates from the usual life-history tactics of the species.

Let me know when we can chat and if you are open to receiving seasonally-specific protective minimization measures from us with regard to the vehicle recreation area program.

Thanks,
Brittany

--
Brittany Struck
Natural Resource Management Specialist

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"Coming together is a beginning;
keeping together is progress;
working together is success."
- Henry Ford

--
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United States Department of the Interior

FISH AND WILDLIFE SERVICE
Ventura Fish and Wildlife Office
2493 Portola Road, Suite B
Ventura, California 93003

IN REPLY REFER TO:
08EVEN00-2016-CPA-0086

March 29, 2016

Brent Marshall, District Superintendent
California Department of Parks and Recreation
Oceano Dunes State Vehicular Recreation Area
340 James Way, Suite 270
Pismo Beach, California 93449

Subject: Oceano Dunes State Vehicular Recreation Area Endangered Species Act Violations and Habitat Conservation Plan

Dear Mr. Marshall,

This letter is in response to the three federally threatened western snowy plovers (*Charadrius nivosus nivosus*) that were recently killed by vehicle collisions within a 30-day period at Oceano Dunes State Vehicular Recreation Area (SVRA). As you are aware, California State Department of Parks and Recreation (State Parks) has had no authorization or permit to incidentally take federally-protected species at Oceano Dunes SVRA since 2001 when the Army Corps of Engineers relinquished jurisdiction over the maintenance of the sand ramps within the SVRA. Since that time, State Parks has been developing a Habitat Conservation Plan (HCP) as part of an application for an Incidental Take Permit from the U.S. Fish and Wildlife Service (Service), while at the same time implementing measures intended to avoid impacting federally-listed species, particularly, the western snowy plover and the federally endangered California least tern (*Sterna antillarum browni*). However, as evidenced by the recent mortalities, as well as other mortalities of both western snowy plovers and California least terns that have occurred since 2001, the measures being implemented are not adequate to fully avoid take, and thus violations of the section 9 take prohibitions of the Federal Endangered Species Act continue to occur.

The Service's responsibilities include administering the Endangered Species Act of 1973, as amended (Act), including sections 7, 9, and 10. Section 9 of the Act and its implementing regulations prohibit the take of listed wildlife species without special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harassment is defined by the Service as an intentional or negligent action that creates the likelihood of injury to listed species by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering. Harm is further defined by the Service to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering (50 CFR 17.3). Exemptions to the prohibitions against take may be obtained through coordination with the

Service in two ways: through interagency consultations for projects with Federal involvement pursuant to section 7 of the Act or through the issuance of an incidental take permit under section 10(a)(1)(B) of the Act.

In 2013, after a period of little progress, State Parks made a renewed commitment to completing the HCP and established a schedule whereby two draft chapters (of the anticipated eight-chapter HCP) would be submitted to the Service for review every 2 months, with a complete draft anticipated by the end of 2015. However, progress stalled in 2014 after four draft chapters were submitted. We understand State Parks has been occupied by issues at the SVRA other than endangered species compliance, and that you had issues with consultant contracting, but we have to emphasize that violations cannot continue.

I request that a site visit be scheduled with my staff and staff of the Service's Office of Law Enforcement as soon as possible to discuss how State Parks intends to come into compliance with the ESA. In addition to the obvious need to complete the HCP process as quickly as possible, avoidance and minimization measures need to be reviewed and enhanced to ensure take is avoided until State Parks obtains incidental take authorization under the Act. Options include reduced speed limits, additional beach closures, and additional enforcement of existing speed limits. In addition, State Parks should not schedule any special events that could increase risk of take of federally protected species.

If you have any questions regarding this letter, please contact Bill Standley of my staff at (805) 644-1766, extension 315, or by e-mail at Bill_Standley@fws.gov.

Sincerely,

Stephen P. Henry
Field Supervisor

cc:
Laura Chee, USFWS Special Agent
Julie Vance, California Department of Fish and Wildlife

State of California – Natural Resources Agency
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March 3, 2016

Brent Marshall, District Superintendent
Oceano Dunes District
California Department of Parks and Recreation
340 James Way, Suite 270
Pismo Beach, California 93449

Subject: **2016 Nesting Plan for California Least Tern at Oceano Dunes SVRA**

Dear Mr. Marshall:

The California Department of Fish and Wildlife (CDFW) has reviewed the 2016 Nesting Plan for Least Terns (2016 Plan) at Oceano Dunes State Vehicular Recreation Area (ODSVRA). The 2016 Plan was prepared by your staff at the California Department of Parks and Recreation (DPR) to address take of California least terns (CLT) at ODSVRA. As discussed in our prior letters over the past 15 years, CLT is listed as "Fully Protected" under Fish & Game Code (FGC) §3511 and as Endangered under both the California Endangered Species Act (CESA) and Federal Endangered Species Act (FESA). The fully protected statute specifically prohibits the Department from authorizing any "take" except for authorized scientific research. "Take", is defined by FGC §86 as "hunt, pursue, catch, capture, or kill, or attempt to hunt, pursue, catch, capture, or kill".

It should be noted the Memorandum of Understanding (MOU) between CDFW and DPR allows for "take" of CLT as part of the population monitoring program. However, the "take" authorization in the MOU is very specific and only covers capturing, banding, and monitoring CLT to determine fledging and survival rates (e.g. authorized scientific research). The MOU does not and cannot authorize any take associated projects, including but not limited to Off Highway Vehicle (OHV) use, park operations, or fence construction/maintenance. In 2015, we noted that an unfledged CLT was captured by DPR staff in an open riding area and moved back into the primary CLT exclosure. Even though this "take" was much more desirable than the tern being killed by a vehicle, it was not covered under nor authorized by the MOU.

Over the past fifteen years, there have been 10 documented incidents of take of CLT which resulted in mortalities. Over this period, CDFW has worked with DPR to increase protective measures (increasing nest buffer size, determining night roost locations, fence modifications) so further take can be avoided. However, the proposed 2016 Plan reduces previous protections for CLT at ODSVRA or makes prior practices optional (see specifics below).

CDFW provided guidance letters to DPR in 2002, 2004, 2006, and 2015 regarding measures necessary to avoid take of CLT. Two specific measures were included in our prior written guidance; maintaining a minimum 300 meter buffer around the main CLT colony, which was located in the "Boneyard" area at the time, and lining the top fencing wire with plastic tubing so the fence would be more visible to flushing CLT. This latter measure was recommended and implemented specifically to minimize and avoid the CLT injuries and mortalities that occurred in 2014 which were attributed to CLT striking the fence.

The 2016 Plan proposes to modify prior agreements or previously employed minimization and avoidance procedures. First, the 2016 Plan does not address the movement of the main CLT colony to the north where the 300 meter buffer is no longer maintained. The 2016 plan contends this buffer was not supported by scientific literature. Secondly, the 2016 plan proposes to utilize another method for making the top wire visible to CLT in an undefined "experimental area".

CDFW staff have reviewed the literature and recommendations regarding flushing distances and appropriate buffers around least tern nests and colonies. The recommended buffers for nesting sites and unfledged chicks ranged from a minimum of 100 meters in North Carolina (Erwin 1989, National Park Service 2015), to 154 meters in Florida (Rogers and Smith 1995), to 400 meters around nesting colonies in the interior United States (USFWS 2016). Given that "no take" is authorized for CLT and that "take" has occurred over the past 15 years, CDFW recommends a minimum 100 meter buffer be established around all CLT nests in accordance with the minimum distances described above. This distance will need to be increased if any take occurs. It should be noted that the unfledged chick that was captured in the riding area in 2015 had moved beyond the buffer fence approximately 150 meters away from its original nest prior to its capture.

CDFW also recommends some sort of marker be installed on all fencing within 100 meters of a nesting CLT. CDFW is open to working with DPR to develop the most effective and pragmatic marking system for the fences. The deployment of several different types of markers should be investigated.

In our 2004 letter, we recommended the night roost locations for CLT be identified and protected. This item is relevant since two of the CLT mortalities in 2003 were believed to have occurred at night. We have noticed the night roosts have been included in the DPR annual nesting reports and have been routinely recorded along the northern boundary of "Exclosure 6," adjacent to the open riding area. However, the 2016 Plan (or any prior plans) does not include any protective measures to be employed in the event CLT are found night roosting in open riding areas. CDFW recommends biological monitors be present every evening to ensure CLT are not night roosting in an area where they would be subject to take. CDFW also recommends DPR develop procedures to protect night roosting CLT in the event they are roosting outside an enclosure.

Both surf thistle (*Cirsium rhothophilum*) and beach spectaclepod (*Dithyrea maritima*) are listed as threatened under CESA. We encourage DPR to conduct the proposed surveys for these species and support the protective measures described in the 2016 Plan that provide for the protection of nesting CLT and western snowy plover. However, please note that take authorization pursuant to FGC Section 2081(b) (e.g. Incidental Take Permit) would be required prior to any take of either of these listed plant species.

CDFW believes that implementation of the measures described in the 2016 Plan, coupled with the measures proposed in this letter, will result in take of CLT at ODSVRA being unlikely. We look forward to working with you on developing the measures to protect night roosting CLT and for enhancing the visibility of fences. If you have any questions regarding this letter, please contact Bob Stafford, Senior Environmental Scientist (Specialist), by phone at (805) 528-8670 or via email at bob.stafford@wildlife.ca.gov.

Sincerely,

Julie A. Vance
Regional Manager

cc: Bill Henry, Jeff Phillips, Bill Standley
USFWS
2493 Portola Road # B
Ventura, California 93003

Justin Behr, Dan Carl
California Coastal Commission
725 Front Street #300
Santa Cruz, California 95060

ec: K. Hunting, S. Morey, J. Vance, T. Palmisano, R. Thompson, B. Stafford
California Department of Fish and Wildlife

Literature Cited

Erwin, R. M.. (1989). Responses to Human Intruders by Birds Nesting in Colonies: Experimental Results and Management Guidelines. *Colonial Waterbirds*, *12*(1), 104–108. http://doi.org/10.2307/1521318

Rodgers, J. A. and Smith, H. T. (1995), Set-Back Distances to Protect Nesting Bird Colonies from Human Disturbance in Florida. Conservation Biology, 9: 89–99. doi: 10.1046/j.1523-1739.1995.09010089.x

U.S. Fish and Wildlife Service. (2016) Interior Least Tern: *Sterna antillarum athallasos retrieved from* http://www.fws.gov/southdakotafieldoffice/TERN.HTM

U.S. National Park Service (2015). Environmental Assessment: Review and Adjustment of Wildlife Protection Buffers: Cape Hatteras National Seashore, North Carolina. 140pp. Retrieved from http://parkplanning.nps.gov/document.cfm?parkID=358&projectID=56762&documentID=65752

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EDMUND G. BROWN, JR., Governor
CHARLTON H. BONHAM, Director

July 3, 2015

Brent Marshall, District Superintendent
Oceano Dunes District
California Department of Parks and Recreation
340 James Way, Suite 270
Pismo Beach, California 93449

Subject: Management of California Least Tern at Oceano Dunes SVRA

Dear Mr. Marshall:

This letter is to summarize recent discussions between California Department of Fish and Wildlife (CDFW) Central Region staff and you and your staff at California Department of Parks and Recreation (DPR) regarding mortalities of California least terns (CLT) at Oceano Dunes State Vehicular Recreation Area (ODSVRA) during 2014. It is also to advise you that ODSVRA is at risk of violating the California Endangered Species Act, as well as Fish and Game Code Section 3511 regarding Fully Protected Birds.

As you are aware, CLT is listed as Endangered under both the California Endangered Species Act (CESA) and Federal Endangered Species Act (FESA). In addition, CLT is legislatively designated as "Fully Protected" pursuant to Fish and Game Code §3511, and "take" of the species is prohibited except for authorized scientific research. "Take", is defined by Fish andGame Code §86 as "... hunt, pursue, catch, capture, or kill, or attempt to hunt, pursue, catch, capture, or kill". DPR does not currently have authority to "take" CLT at ODSVRA, except for those specific activities authorized by way of your current Scientific Collecting Permit and letter Memorandum of Understanding (MOU). The CLT's listing as Fully Protected precludes CDFW from extending incidental take authorization for that species.

Over 15 years ago, ODSVRA had federal take authority for several species including CLT pursuant to Section 7 of FESA by way of consultation between the United States Fish and Wildlife Service (USFWS) and the United States Army Corps of Engineers (ACOE). However, ACOE no longer permits activities at ODSVRA so there is currently no nexus for federal consultation, and therefore no federal incidental take authorization is in place for ODSVRA at this time.

Each year, your staff provides a "Nesting Season Management Plan to Avoid Take of the California Least Tern and Western Snowy Plover at Oceano Dunes State Vehicular Recreation Area" to CDFW and the USFWS, who has responsibility for administering the provisions of FESA regarding the two shorebird species. In the Nesting Season Management Plan each year, ODSVRA states that "...DPR believes that it can continue to operate the SVRA and

Conserving California's Wildlife Since 1870 provide protection (attempting no take) of the listed species through the implementation of various protections, monitoring, and management measures as described..." [1]

Each year, the Nesting Season Management Plan identifies a number of measures and protocols DPR will put in place in order to avoid take of both western snowy plover and CLT. Those measures and protocols are based on measures and protocols specified in a prior USFWS Biological Opinion (BO) (1-8-95-F/C-17), which is no longer in effect; a CDFW letter regarding avoidance of take of CLT, dated May 8, 2001; and additional measures added in 2002 (letter May 6, 2002), 2003 (2003 Nesting Season Conservation Management Plan, March, 2003) and 2006 (2006 Nesting Season Management Plan, October, 2006). The CDFW letters and changes made subsequently in the 2003 and 2006 plans are incorporated by reference into each year's Nesting Season Management Plan. Specific provisions of the referenced documents and letters include the following measures and protocols:

1. All measures of the federal BO 1-8-95-F/C-17 to protect terns are to be implemented (regardless of whether the BO remains in effect), except that in the event there are more protective measures described in the May 6, 2002 letter, the more protective will be implemented.
2. The main least tern colony south of post 8 shall be fenced with a 300 meter (~1,000 foot) buffer from the perimeter of the colony. In Nesting Season Management Plans, as recommended by the Scientific Subcommittee, "bumpouts" are to be constructed for nests found within 100 feet of the fence after nesting had been initiated.
3. Single nests shall be exclosed including at least a 25 meter (~75 foot) buffer. In the event that chicks are observed outside an exclosure, the exclosure will be doubled to provide a 50-meter (~150 foot) buffer. If chicks travel outside of the expanded area, then a new fence will be installed to provide a 100 meter (~300 foot) buffer. Doubling of the setback distance will continue in this fashion if chicks are observed leaving the exclosure.
4. Biological monitors shall be supplied a copy of the letter(s) for ready reference in the field.
5. If a California least tern is killed or injured, or any California least tern is found dead or injured, DPR will notify CDFW and USFWS within 30 minutes of the event. Dead or injured animals will be turned over to CDFW or USFWS. A written report detailing the date, time, location, and general circumstances under which the dead or injured animal was found will be submitted to CDFW and USFWS no later than three (3) business days following the incident.

As stated in the 2002 letter from CDFW, and incorporated by reference into each year's Nesting Season Management Plan, "DFG [CDFW] believes the implementation of the measures identified in this letter will be sufficient to avoid mortality or injury to least terns at ODSVRA", and by review and approval of the Plan each year, CDFW reaffirms our confidence in the measures to avoid take of California least tern.

[1] To date, the Department has not received the 2015 Nesting Season Plan.

According to emails and meetings with your staff, there were seven documented deaths of least tern at ODSVRA in 2014. None of these was reported to CDFW in a timely manner as required by the guidance that the SVRA has been operating under, either within the 30-minute initial response window, or within the 3-business-day written report window.

On March 19, 2015, you, Ronnie Glick and Joanna Iwanicha met with Bob Stafford, Deborah Hillyard and Julie Vance of CDFW Central Region staff to discuss the least tern mortalities, the approach to addressing CLT protections in 2015, and to ensure compliance with the measures and protocols which supported CDFW's confidence that DPR activities would not result in take of California least tern at ODSVRA. Prior to the meeting, Mr. Stafford had suggested your staff provide specific information for the meeting, including a map of the birds found dead and injured; information about the dead/injured terns; and a map of the previous years' main tern nesting colony with a 300 meter/1,000 foot buffer drawn around the colony. At the meeting, there was a discussion regarding the 2014 CLT injuries/deaths and the reliance of CDFW on the requirements of the various Nesting Season Management Plans to assure ourselves and our constituents that no take of tern would occur.

Also discussed was the need for installation of an additional portion of fencing to comply with the requirement that the main nesting colony be fenced with a 1,000 foot buffer; and that the fence would be in addition to the fence which had already been installed for western snowy plover for the 2015 plover nesting season. DPR and CDFW agreed that the additional fencing to buffer the least tern main nesting colony should be installed prior to May 1 when least terns typically return to the area and that the location of the fence could be adjusted to address public safety as required by topography or other physical features. It was also agreed that DPR staff would flag the location of the 1,000 foot buffer from the main nesting colony, and CDFW would return on April 1 to review the location of the buffer, and discuss proposed modifications based on geography and public safety issues. At that meeting, CDFW requested that appropriate staff from USFWS be invited to the April 1 field meeting.

Bob Stafford and Deborah Hillyard met on April 1, 2015, with you, Ronnie Glick, Amber Clark and Joanna Iwanicha to review the 1,000 foot buffer as flagged in the field. USFWS was not in attendance, and had apparently not been invited to the field meeting. The discussion addressed modifications to the 1,000 foot buffer based on topography and some operational needs; and CDFW approved a final location for the 2015 fence at the end of the field meeting. CDFW left the meeting with the understanding that the fencing would be installed prior to May 1 in order to have it completed prior to the arrival and initiation of nesting of CLT this season.

On May 14, 2015, (approximately two weeks after the fence was to have been installed), you emailed former Regional Manager Jeff Single to advise him that "... we are unable to implement this additional closure during the 2015 nesting season" with no explanation as to why the fence, a required measure of every Nesting Season Management Plan since 2003, was not constructed. The various measures and protocols in the annual Nesting Season Management Plans have been relied upon by both DPR and CDFW to assure no incidental take of CLT would occur. The only authorized take of CLT is associated with the banding and population assessment as authorized by way of your Scientific Collecting Permit, MOU, and federal recovery permit. CDFW still believes that implementation of the measures identified in the BO, letters and subsequent Nesting Season Management Plans are sufficient to avoid mortality or injury to least terns at ODSVRA. However, there is no Nesting Season Management Plan in place for 2015, and some key provisions of previous seasons' plans have not been implemented. DPR's failure to comply with the agreed upon measures and protocols leaves DPR vulnerable to a violation of both Fish and Game Code 3511 and CESA, which could lead to an enforcement action.

We recommend that you submit the 2015 Nesting Season Management Plan as soon as possible for review and approval by CDFW and USFWS. Additionally, we recommend you review your current practices to ensure that you have implemented the measures identified in the plan (which we assume to be the same as those from the previous 12 years' Nesting Season Management Plans unless specified and approved by CDFW and USFWS), including but not limited to items 1 through 5 above. In the interim, with no Nesting Season Management Plan submitted, approved or implemented, DPR risks a violation of both CESA and Fish and Game Code 3511. If you have any questions regarding this letter, please feel free to contact Bob Stafford , Senior Environmental Scientist (Specialist), by phone at (805) 528-8670 or via email at bob.stafford@wildlife.ca.gov.

Sincerely,

Terry Palmisano

Terry Palmisano
Acting Regional Manager
Central Region

cc: Bill Henry, Jeff Phillips, Bill Standley
United States Fish and Wildlife Service
Ventura Office
2493 Portola Road, Suite B
Ventura, California 93003

Justin Buhr, Dan Carl
California Coastal Commission
Central Coast District Office
725 Front Street #300
Santa Cruz, California 95060

ec: Hunting, Morey, Palmisano, Vance, Hillyard, Stafford

State of California – The Resources Agency ARNOLD SCHWARZENEGGER, Governor
DEPARTMENT OF FISH AND GAME
CENTRAL COAST REGION
P.O. Box 47
Yountville, CA 94599
http://www.dfg.ca.gov
(707) 944-5500

March 18, 2004

Mr. Andy Zilke, Acting District Superintendent
Oceano Dunes District
Department of Parks and Recreation
576 Camino Mercado
Arroyo Grande, CA 93420-1816

Re: Protective measures to avoid incidental take of California least terns at Oceano Dunes State Vehicle Recreation Area

Dear Mr. Zilke:

For several years, the Department of Fish and Game (DFG) and Department of Parks and Recreation (DPR) have been working together in an effort to prevent the death or injury of California least terns from off-highway vehicle use at Oceano Dunes State Vehicle Recreation Area (ODSVRA). Because the least tern is a species for which no take can be authorized, our joint efforts have been focused on identification and implementation of management measures at ODSVRA to avoid the incidental take of least terns. Toward that end, a revised set of management measures was developed in the summer of 2001 that, to the best of our knowledge, was successful in preventing vehicle-related mortality of terns during the remainder of the 2001 breeding season and the entire 2002 season.

Two fledgling least terns were found dead, however, in separate incidents last summer. Both deaths occurred sometime between late afternoon and early morning in an area immediately east of the fenced nesting area exclosures, which suggests the birds might have been using this area for their night roosts. Vehicle strikes are the most likely cause of death. These tern deaths in July and August 2003 indicate that the protective measures previously developed by our agencies and described in my May 6, 2002 letter to former Superintendent Steve Yamaichi need to be supplemented since the existing measures, while beneficial, have not completely avoided take of least terns in the area east of the existing nest exclosures.

The purpose of this letter is to present additional measures that DFG believes are needed to avoid further take of terns until a study can be completed to gather information about what areas are used by terns for night roosting. This letter does not address actions that DFG may subsequently recommend to enhance habitat values at ODSVRA for California least terns, snowy plovers and other sensitive species. In addition, DFG may need to modify its recommendations from time to time, as it has in the past, as new information becomes available.

Least terns' nest establishment and chick rearing occur on the barren sands in areas of the ODSVRA. Young terns fly three weeks after hatching, and parents and fledglings often congregate at freshwater ponds and estuaries where the fledglings learn to fish. Oso Flaco Lake and the other dunes lakes located immediately east of OSDVRA have been recognized for more than 20 years as important post-breeding foraging areas. The area between the nest enclosures and the dune lakes has been open to off-highway vehicle activity day and night.

Since 1997, the ODSVRA has undertaken monitoring activities, analysis of collected data, and completion of annual reports for the breeding and nesting season of the least tern. These activities were designed not only to meet the requirements of the U.S. Fish and Wildlife Service (USFWS) Biological Opinion 1-8-95-F/C-17, but to ensure breeding and nesting success within the ODSVRA operational boundaries. Nocturnal activities of least terns are not as well documented as nesting behavior, however. While nesting adults have a certain amount of site fidelity to the loosely defined colony, pre-breeding adults and fledglings may not exhibit the same loyalty to a specific location. Just prior to the breeding season, least tern adults are known to have night roosts that are separate from the main colony and the night roosting behavior of fledglings is largely unknown.

As noted above, circumstances suggest the two birds killed last summer were struck while using the area east of the nest exclosures for their night roosts. DFG consequently believes that to avoid further take of least terns, it is necessary to close the area immediately east of the nest exclosures to nighttime vehicle use during the 2004 tern breeding season until DPR is able to collect more specific information about night roosting locations of least terns at ODSVRA. From discussions we have had with DPR in recent months, it is our understanding that the measures outlined below are feasible in addition to continued implementation of the measures outlined in our May 6, 2002 letter, a copy of which is attached.

DFG believes the following additional measures are necessary during the 2004 breeding season (from approximately May 1 to September 15) to avoid further take of least terns during off-highway vehicle use at ODSVRA:

1. DPR should establish and enforce an effective nighttime vehicle closure of the area immediately east of the fenced nest exclosures as

follows: between Post 7 and Post 8, the night closure area should extend from the nest exclosures' east fence to a line 200 feet east of that fence; and between Post 6 and 7, the night closure area should extend from the nest exclosures' east fence to a line parallel to the beach and 200 feet east of where the nesting exclosures' east fence line at Post 7 was constructed in 2003. This closure should encompass both sites where fledgling terns were found dead during the 2003 breeding season. DPR should take whatever steps are necessary to ensure vehicles do not use this area between sunset and sunrise during the tern breeding season.

2. DPR should conduct a study during 2004 to determine where least terns are roosting at night. Work on this study should commence as soon as least terns arrive at ODSVRA and continue until the terns leave for the winter. DPR should obtain DFG's and USFWS's approval of the study design. Results of this study will be used to determine what if any measures may be needed in future years to protect roosting terns outside the nest exclosures.

The least tern monitoring and protection program that ODSVRA implemented during the 2002 and 2003 breeding seasons has been instrumental in greatly reducing the chances for take of least terns at ODSVRA and should be continued. The nighttime roosting study is not intended to redirect ODSVRA's previous commitment to monitor and protect least terns throughout the park.

DFG believes that if the measures described above and those detailed in our May 6, 2002 letter are implemented, activities can be conducted without death or injury of least terns. Our opinion that take can be avoided is based in large part on DPR's assurance that the nighttime vehicle closure described above can be enforced to effectively prevent unauthorized traffic without installation of additional fences. If a least tern is killed or injured or discovered dead or injured despite measures implemented to protect the birds, DPR will notify and then consult with DFG and USFWS according to the procedures described in our 2002 letter.

In closing, I would like to thank ODSVRA and DPR management and staff for their cooperation over the past several years in addressing measures needed to avoid take of least terns. As noted above, DPR's recent efforts to monitor and protect listed birds in this park have largely been a success, and are undoubtedly an important factor behind the increase in least tern and snowy plover numbers at ODSVRA.

If DPR encounters any difficulties implementing the measures described above, please contact the Department as soon as possible so that these issues can be resolved. If you have any questions or concerns, please contact Mr. Bob Stafford at (805) 528-8670.

Sincerely,

Robert Floerke
Regional Manager
Central Coast Region

Enclosure

cc: Mr. David Widell, Deputy Secretary
California Resources Agency

Ms. Ruth Coleman, Director
Department of Parks and Recreation

Mr. Ryan Broddrick, Director
Department of Fish and Game

Mr. Michael Valentine, General Counsel
Department of Fish and Game

Mr. Steve Henry
U.S. Fish and Wildlife Service, Ventura

CALIFORNIA COASTAL COMMISSION
CENTRAL COAST DISTRICT OFFICE
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WEB: WWW.COASTAL.CA.GOV

Th14a

Prepared January 9, 2017 for January 12, 2017 Hearing

To: Commissioners and Interested Persons

From: Susan Craig, Central Coast District Manager

**Subject: Additional hearing materials for Th14a
Condition Compliance – Ocean Dunes State Vehicular Recreation Area (ODSVRA) CDP Review**

Where checked in the boxes below, this package includes additional materials related to the above-referenced hearing item as follows:

- [ ] Staff report addendum
- [x] Additional correspondence received in the time since the staff report was distributed
- [ ] Additional ex parte disclosures received in the time since the staff report was distributed
- [ ] Other:

Chaver, Yair@Coastal

From: Tom Wallace <tomwallaceghs@gmail.com>
Sent: Wednesday, December 28, 2016 12:03 AM
To: CoastalODSVRAcomments
Subject: Fwd: ODSVRA Condition Compliance Review -- Comments

---------- Forwarded message ----------
From: **Tom Wallace** <tomwallaceghs@gmail.com>
Date: Tue, Dec 27, 2016 at 10:54 PM
Subject: ODSVRA Condition Compliance Review -- Comments
To: ODSVRA@coastal.ca.gov

Item No. Th14a
Tom & Margaret
Wallace

Against all
methods to manage vehicle

impacts to the
Oceano Dunes

The methods being used to manage vehicle impacts to the Oceano Dunes do not work. I wrote to Gov. Brown in this regard when he wanted to use 1 million dollars of our taxpayer money to put up hay bales and fences to improve our air quality here on the Nipomo Mesa, to no avail.
The ATVs not only cause unhealthy air; but destroy plant and animal habitat and cause major beach erosion. They are destroying our health and environment.
There are many injuries and deaths caused by ATV drivers.
The only cure to solving these problems is to eliminate ATVs from the dunes and to replant native plants, thus encouraging the birds and animals to return.
In the meantime, those of us who live on the mesa will continue to suffer major respiratory problems; and even heart disease.

Tom & Margaret Wallace

--
Tom & Margaret Wallace
email: tomwallaceGHS@gmail.com
Webpage: http://webpages.charter.net/tomspage/TTNSite
Youtube channel: https://www.youtube.com/user/tomstda
Facebook: https://www.facebook.com/tomwallaceghs

--

'om & Margaret Wallace
mail: tomwallaceGHS@gmail.com
Vebpage: http://webpages.charter.net/tomspage/TTNSite
'outube channel: https://www.youtube.com/user/tomstda
'acebook: https://www.facebook.com/tomwallaceghs

JAN 12 - 2017
ODSVRA
Th 14 A

JANUARY 4, 2017

CALIFORNIA COASTAL COMMISSION

GRAND AVENUE ENTRANCE TO THE BEACH

1. GROVER CITY OWNED THE PROPERTY KNOWN AS GRAND AVENUE THAT RAN THROUGH THE CENTER OF OUR COMMUNITY ALL THE WAY TO THE HIGH TIDE MARK ON THE BEACH.
2. WHEN THE STATE WANTED TO CONTROL ACCESS TO THE BEACH THEY WANTED TO BUILD A KIOSK AT THE END OF GRAND AVENUE.
3. THEY NEGOTIATE WITH THE CITY OF GROVER BEACH AND WERE GRANTED THE RIGHTS TO A SMALL PORTION AT THE FAR WESTERN END OF GRAND AVENUE SO THEY COULD BUILD THEIR KIOSK.
4. THERE WAS ALWAYS THE INTENT BY THE CITY TO CONTINUE VEHICLE ACCESS TO THE BEACH AT THE GRAND AVENUE SITE.
5. THE CITY IN THEIR NEGOTIATION ALWAYS INSISTED THAT IF THE STATE EVERY CLOSED THE GRAND AVENUE VEHICLE ACCESS TO THE BEACH THE WESTERN END OF GRAND AVENUE PROPERTY MUST REVERT TO THE CITY.
6. THE CITY WOULD NEVER HAVE ALLOWED THE STATE TO OBTAIN THE PROPERTY RIGHTS TO THE GRAND AVENUE ACCESS TO THE BEACH IF THEY INTENDED TO CLOSE THE VEHICLE ACCESS AT THAT LOCATION.
7. THE VEHICLE BEACH ACCESS MUST REMAIN OPEN OR THE STATE MUST RETURN TO THE CITY ALL OF THE PROPERTY GRANTED TO THE STATE FOR THE VEHICLE ACCESS PROJECT.

DAVID EKBOM
GROVER CITY CITY COUNCIL MEMBER 1982-1990 ,
GROVER BEACH CITY COUNCIL MEMBER 2000-2008

RECEIVED
JAN - 5 2017
CALIFORNIA
COASTAL COMMISSION
CENTRAL COAST AREA

Chaver, Yair@Coastal

From: Allen Doran <aldoran@charter.net>
Sent: Wednesday, January 04, 2017 4:33 PM
To: CoastalODSVRAcomments
Subject: Coastal Commission Staff Report

January 4, 2017

Dear Sirs:
I am a recently retired physician living in the Arroyo Grande Mesa area that is directly impacted by particulate matter from the Oceano Dunes. I moved to this area approximately four years ago and I am knowledgeable of the health effects from particulate matter. There is no doubt that I have personally experienced an increase of irritation to my eyes and nose since moving from San Luis Obispo to Arroyo Grande. I also have great concern for the known health effects of prolonged exposure to particulate matter (particularly PM-2.5 & PM-10) that can lead to bronchitis, asthma, high blood pressure, heart attack, strokes and even premature death. I have observed increased dusting of our cars during highest use of the Dunes area, commonly in the summer. Although this dusting is not PM-2.5 &10, it does suggest cause and effect from the Dunes. This is the only area of the country (and I have lived in 14 locations over numerous states) that I have seen such rapid accumulation of dust on cars.

I urge you to continue a strict control over the intensity of use in the Dunes area. This control should maintain current limits on vehicles and off road vehicles which have been shown to be directly related to particulate matter in the Mesa area. It is my understanding that vegetation and fencing can help mitigate particulate matter, therefore please do not "reset" standards to 2017 levels.

Respectfully,

Allen Doran, M.D.

January 5, 2017

Item# Th14a
Application 14-482-300
Permit# 4-82-300
Marian Salsbury
In Favor

Hello Mr. Chaver,

I recently received a letter from CCC regarding the ODSVRA Condition of Compliance Review. I am the owner of a home in the Strand area of Oceano at 310 York Ave., Oceano, CA 93445. I'd like to have my letter included for consideration by the Commission please.

ITEM NO: Th14a
Coastal Development Permit 4-82-300
ODSVRA Condition Compliance Review
Hearing Date and Location: 1/12/17, 9:00am at the SLO Couty Board of Supervisors Chambers, 1055 Monterey St., San Luis Obispo, CA 93408

To all Central Coast District Office staff, Commission staff and Mr. Chaver, Coastal Planner,

I am the owner of 310 York Ave., Oceano, CA 93445. My family has been coming to the area for years and we are really tired of dealing with the sandy dust during the summer season. It's actually not too bad during the winter months, but this said I do believe the dust and sand from vehicles being on the beach is a continued issue for residents.

When we are not using our home ourselves, I do legally rent it out, some short term (pay TOT, SLOCTBID and TMD, for less than 30 night stays) and I do long term rentals as well, more than 30 nights. I would like to do more long term rentals but most potential long term guests are turned off by the vehicles on the beach. The beach is not a real family friendly beach with vehicles traveling 15 miles per hour and some travel faster than the posted speed.

I'm not sure what the environmental impact is, surely there are others that have researched this... both, for and against vehicles on the beach. I expect there is also local businesses to consider, such as the rental companies renting ATVs in the area. I'm sure they are for keeping vehicles on the beach, regardless of environmental impact.

Personally, if vehicles are allowed on the beach I'd like to see them allowed access further south away from homes. Not only would this reduce some environmental impact, the vehicles would be closer to the dunes where the recreation takes place. The beach would then be a usable beach for the average beach goer who wants to picnic, surf, fish, and enjoy a family beach experience without worrying about getting run over. In addition, I've seen so many drunk drivers out on the beach. Now with marijuana legalized in CA, it creates another problem for the police to monitor on the beach.

Thanks for listening.

Marian Salsbury, Owner
310 York Ave.
Oceano, CA 93445
303-653-4934

:haver, Yair@Coastal

'rom: Nancy Bull <anybull@gmail.com>
ient: Friday, January 06, 2017 2:57 PM
'o: CoastalODSVRAcomments
iubject: Th14a

Certainly, staff has put a great deal of time and effort into the materials supplied for consideration on this agenda item and also they are correct in that it has caused a great deal of concern and dissatisfaction over the years as well as in their analysis that something must be done to change the current dynamic at ODSVRA.

As an historic perspective, I and my family have been visiting the Oceano Dunes area for some 50 years and I have lived in a home on Strand avenue for the last 25 years giving me an unfettered perspective on the activities there and a daily view of activities on the beach. While we did ride ATV's on the beach at one time we no longer do so as it has become too dangerous to compete with the professional riders who now occupy those spaces.
It is also impossible now to casually walk the beach to enjoy the sounds of the ocean waves and enjoy the fresh ocean air as you must dodge vehicles racing along the beach in front of my home and are subjected to the fragrance of vehicle exhaust. Historically, people could walk the beach, clam along the sand and fish without hindrance along the Oceano beachfront while few vehicles carefully passed by.....that is no longer the case. While this report states that the creek only

flows to the ocean occasionally, that is not historically the case. The creek formerly nearly always flowed fully to the ocean though with varying flow levels until the Park began adjusting its course with their earth moving equipment to form what is now a "lagoon".

Over the years we have all observed dramatic increases in numbers of vehicles careening along the beach at all times of the day and night. Now even more during the night with engines racing so loudly that they overwhelm the ocean and disturb sleep on Strand Way. To assume that there is some artificial number of vehicles being allowed onto the beach in some controlled manner is simply to ignore the actual use of the dunes and the beach. Vehicles, parties, fires and a myriad of activies take place along the beach front and in the dunes all night now with no apparent interference from the DPR.

The idea of eliminating any effort to control traffic and degradation of the beach by allowing DPR free rein to "holistically manage" the park is ludicrous. DPR has proven time and again that their sole interest in the Oceano Dunes is to generate as much income as possible with no regard for the ecology or the residents of the area. They refuse to respond to phone inquiries or written queries or to take any action in response to observed destructive efforts in the Dunes or along the beach. It is time to admit that fact before suggesting DPR will "holistically" protect any portion of the land, air, water or humans in the Dune area. The entire area is clearly already 'overburdened" and no one, including the Coastal Commission ipparently, is concerned or willing to act in its defence and stand up to DPR and the ATV lobby.

The "interim" Pier Avenue entrance continues to cause frustration and present a danger to residents of the local community. Huge vehicles often block entrance roads to Strand Way and park along Pier avenue in such a way as to completely obscure oncoming traffic or block the entire 2 lane roadway.. Trash is simply dumped along the roadways into and out of the beach area and the continual backup and traffic into and out of the beach impacts local residents with usual trips to work, doctor appointments, and other activities. The Pier avenue access is directly in a residential area and is totally inappropriate for a "truck" route which it has become. When the kiosk is not manned it becomes a raceway and a clear and present danger for anyone who may be walking to dinner along the roadway. It is totally unsuitable and there are better areas for a proper truck entrance to be created away from this residential area and beyond the damaged creek outflow. I urge your insistence that it be done.

While concerns for the health of the Nipomo mesa residents is well documented there is and has been no similar concern for the residents of the Strand way development who are similarly and more directly impacted by the sand crust being broken and sand particles airborn along the beach. Upon calling the APCD and asking why we do not have a measurement device placed in ur area a very tired and frustrated voice replied "We ried"!. Clearly another agency unable to uphold its purpose nder threat of the DPR and lobbyist for an elite user group .

he only group actually able to use the beach and Dune area is a ery small segment of the total public who can afford the multi-housand dollar investment in huge trucks, trailers and RV's to camp" in the dune area. There they can simply dig a hole in the and and empty their waste water and wait for the ocean to lean up the sewage....and that is often done! To protect this lite user group with their highly paid lobbyist has no istorical foundation and is surely not the purpose of the alifornia Coastal Commisison which we proposed to protect and ave our coastal environment for ALL the population of the tate. That is your purpose and here is an opportunity for you o act on behalf of the voters who asked you to serve that urpose. Please do so.

Jancy Bull
'O Box 216
)ceano, CA

Th/4a

COMMMENTS OF FRIENDS OF OCEANO DUNES on the

Oceano Dunes SVRA Permit Review

Submitted Jan. 6, 2017

RECEIVED

JAN - 6 2017

CALIFORNIA
COASTAL COMMISSION
CENTRAL COAST AREA

LAW OFFICES OF THOMAS D. ROTH
ONE MARKET, SPEAR TOWER, SUITE 3600
SAN FRANCISCO, CALIFORNIA 94105
(415) 293-7684
Rothlaw1@comcast.net

January 6, 2017

By Fed Ex

RECEIVED
JAN - 6 2017
CALIFORNIA
COASTAL COMMISSION
CENTRAL COAST AREA

Dan Carl
Yair Chaver
California Coastal Commission
Central Coast District Office
725 Front Street, Suite 300
Santa Cruz, CA 95060

RE: Coastal Commission Re Th14a
January 12, 2017 Meeting

Comments of Friends of Oceano Dunes Re Review of overall effectiveness of methods being used to manage vehicle impacts in relation to coastal resources at the Oceano Dunes State Vehicular Recreation Area (ODSVRA), coastal permit 4-82-300 as amended

Dear Commissioners and staff:

These comments are filed on behalf of Friends of Oceano Dunes, Inc. ("Friends"), which is a California not-for-profit corporation, representing approximately 28,000 members and users of the Oceano Dunes State Vehicle Recreation Area ("SVRA") located near Pismo Beach, California.

Friends is a public watchdog organization created in 2001 expressly to preserve and expand recreational uses at Oceano Dunes SVRA. Friends' watchdog role includes review and challenges to local, state and federal rules and activities that may impact, restrict or limit recreational uses at Oceano Dunes. Friends' members live near, use, recreate, visit and personally enjoy the aesthetic, wildlife and recreational resources of the dunes area, including off road recreation, hiking, and observing wildlife.

Staff prepared a report dated December 23, 2016 for the CCC's January 12, 2017 hearing regarding a review of the overall effectiveness of methods being used to manage vehicle impacts in relation to coastal resources at the Oceano Dunes State Vehicular Recreation Area (ODSVRA). ("Staff Report").

Friends submits these comments on its behalf and its members' behalf:

1. Friends notes that the area now designated as Oceano Dunes SVRA has been used for off road vehicle recreation for more than 100 years. Car races occurred on the beach area dating back to the early 1900s. In addition, dune buggies were invented and first used in the area in the 1950s. Because this recreational activity occurred prior to the adoption of the Coastal Act, it is grandfathered.

2. The Technical Review Team (TRT) has been an effective group that compelled all stakeholders to develop SVRA management recommendations in a cooperative fashion. Staff's recommendation to terminate the group is ill-advised and will likely result in more contentious disputes regarding the management of Oceano Dunes SVRA.

3. Staff's view that the access and staging for Oceano Dunes SVRA has never been finalized is erroneous. State Parks has issued many studies over the past three decades and in each instance settled on the present access and staging points. Requiring yet another study is a massive waste of public funds and resources. Staff does not explain why it views this as a violation as State Parks has submitted numerous studies to the Commission that demonstrates that the present access is the best alternative. Staff apparently calls the current situation a "potential" violation because it well knows there is no violation of CDP 4-82-300 as it relates to this issue.

4. Staff's recommendation that the CDP be modified to implement a different management approach is completely undefined. What does it mean to "deemphasize static use numbers" and instead "more holistically" manage the park? As described on p. 5 of the Staff Report, the proposed changes are so undefined, confused and vague, there is no way to provide meaningful comment on them. Staff simply

recites resource protection standards that already exist and that State Parks is already following.

5. Staff's recommendation that the CCC adopt an annual reporting mechanism ignores that the TRT already does that. Why terminate the TRT and have some other undefined entity write the annual report? Why will having a different entity write the report "better address" on-going issues? Staff doesn't explain why the current report is inadequate. Also, again, staff doesn't detail or explain what else needs to be monitored, but only that it would coordinate with State Parks and decide later.

6. Staff purports to want to "empower" State Parks "to make typical park management decisions." Huh? State Parks already has such authority and indeed routinely exercises such authority.

7. Staff's recommendation on p. 9 of the staff report that State Parks update its access study to identify the environmentally-preferred final vehicle access and staging system for the SVRA is a waste of time and resources. State Parks has studied this topic endless and there is no evidence that there is any other vehicle access that is "environmentally-preferred" from what exists now. State Parks submitted its last study 10 years ago and since then the CCC has never challenged or questioned the conclusions. Staff does not provide a single reason why a new updated study is necessary, nor does it have any suggestions for alternative access. The staff admits that State Parks has submitted numerous studies, but the CCC failed to take action on the access studies. Thus, if there is not some formal recognition of the access, that is the CC's fault, not State Parks. Again in footnote 4 the staff alleges a "potential" violation of the CDP. When State Parks has taken the actions required of it and the CCC failed to act, that is not a "violation." That is CCC incompetence.

8. Staff's recommendation on p. 10 of the staff report that numeric vehicle use limits be eliminated and supplanted with "Park management . . . pursuant to best resource and recreation management practices and existing CDP requirements" ignores the fact that State Parks already manages the SVRA according to best practices and existing CDP requirements. State Parks already limits motorized

recreation to defined areas, prohibits activities as needed to protect natural resources, etc. The organic act governing SVRAs already requires that and State Parks already does it.

9. Staff's recommendation on pp. 10-11 of the staff report that dune fencing protect vegetated dunes areas within the riding area in an effort to expand those areas ignores that increasing the size and acreage of vegetated areas provides cover for predators of listed species such as western snowy plovers and the California least tern. See Rob Roy Ramey report submitted with these comments. Insisting that the vegetated area never be reduced from January 2017 levels would memorialize increased predation on these endangered species and therefore such a requirement would itself be a violation of the federal Endangered Species Act. Such a requirement is likewise inconsistent with staff's recommendation on p. 10 of the report that State Parks use "best resource management" practices.

10. Staff's recommendation on p. 11 of the staff report that the TRT be replaced with an annual monitoring report doesn't make sense. Staff suggests that such a change would "better address ongoing Park issues and better foster appropriate adaptations associated with the CDP," but provides no reason why an annual report by State Parks would be any better than an annual report by the TRT. Indeed, the TRT contains a CCC representative. The TRT report reflects a balanced consensus among all stakeholders. The process proposed by staff appears to eliminate meaningful stakeholder input. It is also unclear what types of management changes the CCC could insist on without triggering an amendment to the CDP. Finally, the recommendation leaves completely open-ended the "framework" that will be required by the Executive Director. Without any information on such a "framework," it is impossible for the public to provide meaningful comment on this proposed change.

11. Staff's characterization on p. 25 of the staff report that State Parks is "out of compliance" with the designation of final access points minimizes the fact that the CCC failed to review, set an agenda item and hear this issue. State parks has prepared numerous studies which have been submitted to staff. Thus, this is the CCC's failing, not State Parks. The existence of the access points for more than 30 years

without CCC objection suggests that the CCC has waived this issue, is subject to laches and that the access points are permanent. All of the alternative access points suggest by staff have been studied at one point or another during the past 30 years, and in each case State Parks determined that the current access points were the least environmentally damaging and/or the alternative access points were not feasible. Staff fails to explain how issues related to the dust mitigation measures would or could impact access to the SVRA.

12. Friends objects to Special Condition 1 (p. 28 of the Staff Report), also known as Special Condition 1(C). State Parks already has provided detailed and extensive information and reports analyzing various access alternatives. The CCC has essentially ignored this information for decades. In addition, State Parks has had in place an extensive and objectively successful program to protect and enhance plovers and terns at the SVRA. The U.S. Fish and Wildlife Service has praised State Parks for this program. See 77 Fed. Reg. 36728, 36733 (2012) [FWS commenting that "We have determined that Oceano Dunes SVRA plays an important role in conservation of the western snowy plover," and that State Parks "intensively manages habitat for the [plover] at Oceano Dunes SVRA." "[State Parks] at Oceano Dunes SVRA [has] been implementing measures to conserve the [plover] and conditions have improved [there] . . . ."] State Parks itself has noted the success of the conservation program. See California Coastal Commission Staff Report Addendum for Oceano Dunes SVRA Review (Feb. 2015), p. 4 [State Parks stating its existing management program for western snowy plover and California least tern "is one of the most successful programs in the State Park System and on the west coast."] State Parks consistently has met or exceeded the recovery criteria for the plover and the tern. Memorandum From Ecologist John D. Dixon, Ph.D. to Justin Buhr), p. 3 ["Western snowy plover and California least tern reproductive success at ODSVRA is usually high relative to other sites in California."]; Coastal Commission Staff Report for Oceano Dunes SVRA Review (Feb. 2015)], p. 28 ["Since the last Commission annual review in 2007, the nesting reports have shown that the ODSVRA fledge rates for both WSP and CLT have generally been above USFWS's recovery goal of one fledged chick per adult male."].) CCC staff has failed to explain how any of these on-going and long-standing efforts

is deficient. Rather, staff ignores this critical truth and pretends the facts are otherwise.

13.Staff fails to explain why State Parks charging more than the typical daily fee for special events is an issue. Basic economic suggests that higher entrance fees depress daily use, thus reducing impacts of special events. Staff alleges that the special event Huckfest has grown in recent years but it provides no data supporting that allegation.

14. Staff admits that State Parks has taken management actions to successfully address alleged concerns at special events. See Staff Report at p. 30.

15. Staff asserts that it is "clear" that the TRT must be replaced, but doesn't explain why that is the case. Staff notes that the TRT has not studied use limits, but since the CCC has a representative on the TRT, that representative could spear-head any such effort. He or she didn't.

16. Staff asserts that the current use limits have never been validated as the "proper balance." That assertion ignores that various use limits have been in place since 1982, and that the environmental condition of the SVRA has not declined in the past 30 plus years. State Parks have removed large areas from OHV riding. In fact, substantially less than 50 percent of the SVRA is now open to SVRA riding. Listed species have been not only protected and conserved but their numbers have increased. Other environmental metrics monitored by State Parks all show that the SVRA is being well-maintained. Staff gives the false impression that numeric limits are the only tool presently used by State Parks to ensure the environmental viability of the SVRA. Instead, it is one of many tools being used. Again, the clear evidence exists in the actual environmental condition of the SVRA, which is far superior to that of the 1970s and 1980s. Staff pretends that this real world evidence does not exist. For this reason, there is no basis to insist on Special Condition 2.

17. Eight exceedances of federal air quality standards in 6 years is minimal. Most metropolitan areas have far more exceedances. Further, the exceedances are the result of natural wind-blown dust, not pollution from OHVs. When wind blows across sand dunes, dust and sand will be transported. This has been going on from the beginning of

history.

18. On page 35 of the Staff Report, staff in one sentence asserts that State Parks applied in 2012 for CDP for the dust control measures, but then in the next sentence asserts that the CDP application has not been filed. Which is it?

19. Staff's statement on page 35 of the Staff Report that State Parks applied for an "emergency" CDP "as a means to try to meet the federal daily PM10 standard" is a complete falsehood. Staff has presented no documentation to support this statement. No action that State Parks took pursuant to the "emergency" CDP had or could have any bearing on compliance with federal standards. State Parks did not file seek an "emergency" CDP to comply with federal standards, but rather to whitewash the fact that it had no CDP to implement any portion of the dust control program, and yet was installing measures on the ground in violation of the Coastal Act. In truth, the CCC is de facto applying a hypocritical double-standard by allowing development it likes without full compliance with the Coastal Act, while insisting on compliance to the "nth" degree on OHV activity. The CCC can't have it both ways.

20. The CCC advocates establishing more vegetated areas in the foredunes as "the most appropriate measure to reduce ODSVRA dust." However, biological analysis show that increased vegetation in the foredunes is likely to increase cover for predators and increase take of plovers and tern due to predation. Predation has long been the principal threat to plover and tern at the SVRA. See report of Rob Roy Ramey submitted with these comments.

21. Staff fails to explain in its review of the La Grande Tract that SLO County believes that the LUP, Fig. 4 was added in error; in other words, the County inadvertently added the incorrect map. This fact negates much of the staff's speculation about what was "intended" in terms of long-term use of the Tract. Staff is reading its desire into the record under the guise of "interpreting" the LUP. This is not substantive evidence and is contradicted by the County which adopted the LUP.

22. Staff proposes Condition 3 concerning dune fencing protections associated with vegetated areas. Staff is demanding that State Parks "ensure that the acreage of

vegetated islands in the riding area is not reduced from January 2017 levels (allowing for "islands" that become connected to the perimeter non-riding area through adaptation to be counted toward vegetated island acreage)." This one size fits all approach ignores biological data showing that increased vegetation islands provide expanded cover for predators of plover and tern and will likely result in greater take of those protected species.

23. Staff has mischaracterized the TRT members' position on whether the TRT should be terminated. On p. 46 of the Staff Report, staff suggests that all TRT members want it terminated. That is not true or accurate. Friends and its representative oppose terminating the TRT. In fact, p 236 of the attachments to the staff report document a vote Dec 16, 2016 where the group expressed a desire to continue meeting until a Habitat Conservation Plan is adopted. During the meeting and via subsequent emails, the following members voted to submit the 15th Annual TRT Report: a representative from the environmental community, business community, off-highway vehicle community, local government, and the Off-Highway Motor Vehicle Recreation (OHMVR) Commission. See also p. 252 of the attachments - this was the report from March 2016..."most participants see value in continuing the group."

24. Further, there is also no basis for staff's opinion that the TRT has "outgrown its effectiveness," whatever that means. The fact that certain resource agencies decline to participate is up to the specific resource agencies. It is disingenuous for the CCC staff to avoid participation in the TRT for years and then argue that the TRT must be abandoned because resource agencies like the CCC aren't participating. An equally viable approach would be for resource agencies to participate. Also, staff's argument that the TRT doesn't give the CCC or State Parks adequate flexibility doesn't make any sense. In the same breath, staff notes that the TRT is advisory, meaning that State Parks can accept or reject its recommendations. That provides State Parks maximum flexibility. There is also no basis for staff to opine that the TRT has "outlived its effectiveness."

25. The CCC may not require permit applicants to submit to unreasonable conditions. Here, the new Special Conditions are unduly vague and are therefore void. They in many cases

don't contain the specifics of the new condition but rather anticipate that the Executive Director will develop the specifics AFTER the CCC votes on whether to add the condition. This is backwards and unlawful. The CCC cannot impose conditions that won't be fleshed out until after the CCC imposes the condition. Such a condition is unreasonable on its face and void for vagueness. Due process requires fair notice of what conduct is prohibited. The permit conditions must provide a standard of conduct for a permittee in order to avoid arbitrary and discriminatory enforcement. Here, the proposed permit conditions are so vague that men of common intelligence must guess at its meaning.

26. Contrary to staff's assertion on p. 51 of the Staff Report, State Parks is not in violation of the CDP with respect to staging areas and access points. State Parks has studied these issues repeatedly and has submitted those reports and studies to the CCC. The CCC staff failed to bring this issue to the full Commission for three decades. That is staff's responsibility, not State Parks.' The CCC is barred by estoppel, waiver, statute of limitations and laches by failing to enforce this alleged violation for such a long period of time, even assuming that a violation exists. The CCC also has unclean hands since it could have set review of the access studies for public hearing at any time. If staff felt an LCP amendment was required, it could have conditioned approval on that, or it could have advised State Parks that it needed to do this. There is no evidence that the CCC raised the LCP amendment issue with State Parks prior to this staff report on December 23, 2016. In addition, in 30 years, the CCC never has issued a Notice of Violation to State Parks regarding the access and staging area issue. The CCC has acted as if these access locations were de facto permanent.

27. Here, there is a strong public policy favoring estoppel and laches against the CCC. The long-standing access points to the SVRA help ensure public access to the ocean, coast and coastal dunes, which facilities compliance with the Coastal Act's public access policies. The public, including Friends' members and users of the SVRA, and have been using these access points for more than 30 years under the CDP, and for decades prior to that issuance as well.

28. More than 30 years of non-enforcement is an unreasonable

delay. The CCC's lack of sustained interest in the access issue demonstrates acquiescence. Alternatively, there is great prejudice to State Parks and the public that uses the SVRA, and accesses it and the coast through these long-standing access points and staging areas. The public has come to rely on these specific access points and staging areas. Over the years, State Parks has invested millions of dollars in creating and maintaining these access points and staging areas. Further, moving access points and staging areas that have existed for 30 years would in itself create environmental harm and harm to coastal resources. After such a long period of time, wildlife has likely organized itself and its habitat use based on these access points, and changes would disrupt those wildlife use habits and patterns.

29. There is no evidence that access points and staging areas different from those used for the past 30 years would be environmentally superior. In fact, State Parks' studies show that the current access points and staging areas are the environmentally superior alternatives.

30. Staff admits that there are only *allegations* of violations of the vehicle limits.

31. Friends' and its members' legal right to operate OHV within the SVRA, created under a state law specifically to facilitate OHV riding on areas uniquely suited for such activity (Pub. Res. Code § 5090, et seq.), will be eliminated or unduly restricted if large portions of the park are closed to recreational vehicle activity. The California Legislature enacted legislative mandates to provide OHV riding and public recreational opportunities. The law declared a state policy of setting aside "effectively managed areas and adequate facilities for the use of off-highway vehicles . . . ." Public Resources Code ("PRC") § 5090.02(b). "State vehicular recreation areas shall be established on lands where there are quality recreational opportunities for off-highway motor vehicles and in accordance with the requirements of Section 5090.35." PRC § 5090.43(a). Instead of decreasing OHV use areas, it is the **"intent of the Legislature"** that: "(1) Existing off-highway motor vehicle recreational areas, facilities, and opportunities **should be expanded** and managed in a manner consistent with this chapter, in particular to maintain sustained long-term use. (2) New off-highway motor vehicle

recreational areas, facilities, and opportunities should be provided and managed pursuant to this chapter in a manner that will sustain long-term use." PRC §5090.02(c). The Legislature also tasked State Parks with ensuring that "**Areas shall be developed, managed, and operated for the purpose of making the fullest public use of the outdoor recreational opportunities present**. The natural and cultural elements of the environment may be managed or modified to **enhance the recreational experience** consistent with the requirements of Section 5090.35," which includes preparation of an habitat protection program that might require a temporary closure only. PRC § 5090.35(c)(2) ("If the division determines that the habitat protection program is not being met in any portion of any state vehicular recreation area, the division shall close the noncompliant portion **temporarily** until the habitat protection program is met.") The SVRA Act gave the OHV Division within State Parks broad powers to plan and administer SVRAs including the newly created Pismo Dunes. Pursuant to PRC §5090.32(a), State Parks has the duty and responsibility for "planning, acquisition, development, conservation, and restoration of lands" within SVRAs. See also, PRC § 5090.35(a). Friends contends that any further reductions in the riding area would violate state law.

32. Staff suggests that the proposed changes in the CDP conditions will enable State Parks to ensure a better "balance" between acres and protection of coastal resources. Yet, staff has failed to show how such a balance is not being achieved now. Examples it gives regarding impacts to coastal resources are small and the staff ignores great benefits that have been achieved. As stated by State Parks, the size of the OHV riding area at Oceano Dunes has been reduced from a historical 25,000 acres to 1,500 acres. That is evidence that the "balance" has swung too far to conservation at the expense of access. To reduce the park another 300 acres for plovers and terns further "unbalances" the park. Now if DPR is required to increase vegetation the park will be even further "unbalanced." The CCC needs to recognize the Coastal Act's and the organic SVRA Act's dual mandates for access.

33. The California Coastal Act does not authorize the CCC to issue CDPs that create "annual reviews" of the effectiveness of State Parks in managing SVRA resources. The CCC's

authority is limited by the Legislature. It has no independent authority. Under the California Coastal Act, the CCC has the "development review authority" to review and approve or reject CDPs for developments in the coastal zone (PRC, § 30519, 30352(a), 30600, 30601) The CCC also may review certified LCPs every 5 years to determine whether it is "being effectively implemented in conformity with the policies of this division." PRC, § 30519.5(a). Development review authority for a CDP does not include "annual review" authority that persists for 34 years after the CDP was issued in 1982. If the CCC believes the State Parks is failing to abide by the conditions of the permit, the CCC has enforcement authority. The CCC's authority is also self-limited. When the CCC issued the CDP in 1982, the CCC purported to establish "annual reviews," and subsequently expanded this "authority" in 1983. However, in 2001, the CCC "repealed" this "annual review authority" which is now limited to reviewing the Technical Review Team or TRT, not the permit. However, the CCC's staff has not recognized these changes but continue to operate as if the CCC could annually review the 1982 CDP and any subsequent issues that might arise in the SVRA. It should also be noted that in 1992, when the Legislature added a section in Article 3 of the Coastal Act certain powers and duties to include authority to establish scientific panels, it limited those panel's role to reviewing technical documents to advise the CCC on technical decisions, not general overview of permits:

"The commission shall, if it determines that it has sufficient resources, establish one or more scientific panels to **review technical documents and reports and to give advice and make recommendations to the commission prior to making decisions requiring scientific expertise and analysis not available to the commission through its staff resources. It is the intent of the Legislature that the commission base any such technical decisions on scientific expertise and advice.** The panel or panels may be composed of, but not limited to, persons with expertise and training in marine biology, fisheries, geology, coastal geomorphology, geographic information systems, water quality, hydrology, ocean and coastal engineering, economics, and social sciences." Public Resources Code, § 30335.5(a).

This establishment and use of scientific panels was designed to provide assistance to the CCC in its decisions authorized by statute, an interpretation supported by the CCC's own 2001 amendment to this CDP eliminating annual review.

The initial CDP (4-82-300) was for the development of a "staging area location" in which an "interim OHV staging area [that] shall be operation[al] no later than" Labor Day weekend in 1982 and subsequent construction of a permanent staging area. (CDP 4-82-300, Condition 1)

Historically, CDP 4-82-300 purported to provide for an annual review until a permanent staging area is operational:

"If construction and operation of a permanent staging area cannot be accomplished within the above time limits, this permit shall be subject to review and modification if necessary or appropriate by the County or the Commission or either in consultation with the other." CDP 4-82-300, Condition 1(B)

and

"Six months after the issuance of this permit, and annually thereafter until a permanent staging area is operational, a formal review of the effectiveness of the conditions of the permit shall take place. This review shall be undertaken jointly by designated representatives of the California Coastal Commission, the California Department of Fish and Game, the County of San Luis Obispo, the Community of Oceano, the California Department of Parks and Recreation and user groups." CDP 4-82-300, Condition 6.

Condition 6 provided a standard for the annual reviews based on balancing environmental and OHV interests and values:

"If after each of the annual reviews, or after the three year review required in condition 1(b) above, it is found that the Off-Highway Vehicle (OHV) use within the Pismo Dunes State Vehicle Recreation Area (PDSVRA) is not occurring in a manner which protects environmentally sensitive habitats and adjacent community values consistent with the requirements of the San Luis Obispo Local Coastal Program Land Use

Plan, then OHV access may be further limited pursuant to the access and habitat protection policies of the County certified Land Use Plan. If the above reviews find that OHV use within the PDSVRA is consistent with the protection of environmentally sensitive habitats and adjacent community values, and/or that additional staff and management revenues become available to the California Department of Parks and Recreation, levels of OHV use of the PDSVRA may be increased to a level not to exceed the enforcement and management capabilities available to the Pismo Beach State Parks Units." (CDP 4-82-300, Condition 6)

This standard in Condition 6 was deleted in a 1983 amendment and replaced with the following:

"If, after an annual **(or any other) review** it is found that the ORV use within the SVRA is not occurring in a manner that protects environmentally sensitive habitats and community values consistent with the conditions of this permit and the County's Local Coastal Plan, then OHV access and the number of camp units allowed may be further limited by the Executive Director with concurrence by resolution of the Board of Supervisors of San Luis Obispo County. If the above reviews find that OHV use in the SVRA is consistent with the protection of environmentally sensitive habitats and community values, and/or that additional staff and management revenues become available to the DPR, levels of OHV access and the allowable number of camp units may be increased not to exceed the enforcement and management capabilities of the DPR by determination of the Executive Director with concurrence by resolution of the Board of Supervisors of San Luis Obispo County." CDP 4-82-300-A2 (1983)

The 1983 CDP contains an unlawful standard – "community values consistent with the conditions of this permit." Such a standard is not authorized by the Coastal Act. Also, the phrase "community values" is vague, undefined and not authorized by the Coastal Act.

The 2001 amendment (CDP 4-82-300-A5) established and defined the TRT as "advisory to the Superintendent of the

Oceano Dunes State Vehicular Recreation Area" (Condition 4). The TRT duties included assisting in "building community support through problem solving, consensus building, new constituency development, and increasing understanding about the ODSVRA," and developing "recommendations to the Superintendent of the ODSVRA regarding additional monitoring studies, adjustments to day and overnight use limits, and management strategies." (CDP 4-82-300-A5 (2001), Condition 4) Condition 4 also required the creation of a "scientific subcommittee to identify, develop and evaluate the scientific information needed by decision-makers to ensure that the ODSVRA's natural resources are adequately managed and protected," and stated what governmental agencies would be sitting on this TRT. Condition 5 required that the TRT submit annual reports to the CCC.

The 2001 amendment also established Special Condition 2, which recognized and limited annual reviews by the CCC to the effectiveness of the TRT, not permit conditions or OHV use. In 2001, "CONDITION 6 as amended in 4-82-300-A2 replaced by CONDITION 2 of this amendment" to provide that the CCC shall conduct annual reviews of the effectiveness of the TRT.

Staff argues that "Until a permanent staging area is selected, the Commission or the County may review and modify the CDP as necessary." (Staff Report, p. 14) But as shown above, the annual review requirement was eliminated in 2001.

Further, condition 1B and 2 are internally inconsistent in terms of whether an amendment to the LCP/LUP is required or not. Condition states LUP amendment is not required so long as the permanent staging sites are operational, which they effectively have been for 30 years.

Thus, neither the Coastal Act nor the CDP authorizes an annual review of the CDP.

Sincerely,

Tom Roth

Cc: Jim Suty

<u>List of Attachments</u> to Comments of Friends of Oceano Dunes Re Review of overall effectiveness of methods being used to manage vehicle impacts in relation to coastal resources at the Oceano Dunes State Vehicular Recreation Area (ODSVRA), coastal permit 4-82-300 as amended, submitted to Coastal Commission, Santa Cruz, Jan. 5, 2016

Sept. 26, 2016 Analysis of expansion of vegetation areas at Oceano Dunes and increased predation, by Rob Roy Ramey

Cavallini, P., et al., "Home range, habitat selection and activity of the red fox . . . ."

Frey, N., et al., "Habitat Use by Meso-Predators in a Corridor Environment", 2006

Lewis, J., et al., "Introduced Red Fox in California", 1993

Lewis, J., et al., "Introduction and Range Expansion of nonnative Red Foxes"

Stenzel, L. et al., "Survival and Natal Dispersal of Juvenile Snowy Plovers . . . in Central Coast California"

White, J., et al., "Home Range, Habitat Selection and Diet of Foxes", 2006

"Nesting of the California Least Tern and Western Snowy Plover at Oceano Dunes State Vehicular Recreation Area," San Luis Obispo County, California 2015 Season

"Oceano Dunes State Vehicular Recreation Area, 2007 Predator Management Report"

"Nesting of the California Least Tern and Western Snowy Plover at Oceano Dunes State Vehicular Recreation Area," San Luis Obispo County, California 2009 Season

"Nesting of the California Least Tern and Western Snowy Plover at Oceano Dunes State Vehicular Recreation Area," San Luis Obispo County, California 2012 Season

"Oceano Dunes State Vehicular Recreation Area, 2012 Predator Management Report"

"Oceano Dunes State Vehicular Recreation Area, 2010 Predator Management Report"

September 26, 2016

Tom Roth
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Dear Tom,

You have asked that I provide comments in response to the California Department of Parks and Recreation's Draft Program Environmental Impact Report for the Oceano Dunes SVRA Dust Control Program dated August 1, 2016.

The Draft EIR proposes planting 100 acres of vegetation on dunes to mitigate fugitive PM10 dust. See, e.g., DEIR, Table 2-3. Such extensive vegetation is highly likely to have a significant negative impact on the local breeding populations of western snowy plovers and California least terns due to the likely increase in predators and predation. It also is likely to result in adverse modification of designated western snowy plover critical habitat through the facilitation of mammalian predator movements. This result is likely due to the proposed vegetation's close proximity to the existing western snowy plover critical habitat and the proximity to the plover and California least tern nesting and foraging areas. A new 100 acres of vegetation will substantially expand denning, resting, and hunting habitat for coyote, red fox, skunk, opossum, and raccoon, all of which are documented to occur in Oceano Dunes and all of which are known to prey on snowy plover or least tern nests, chicks, and/or adults. (See, annual Oceano Dunes SVRA reports; see also California Least Tern Recovery Plan at p. 16 [listing these species as common predators].)

The proposed program could turn the currently productive Oceano Dunes SVRA into a "population sink" for these birds. The western snowy plover is listed as "threatened" and California least tern is listed as "endangered" under the federal Endangered Species Act. Even the introduction of the vegetation over five years, i.e., 20 acres a year is likely to have a significant effect. Twenty acres is sufficiently large to provide cover for these predators.

The DEIR misrepresents the proximity of the proposed 100-acre vegetation islands to western snowy plover critical habitat and nesting areas for the western snowy plover and California least tern. The DEIR gives the public the false impression that the vegetation will be farther from the critical habitat and nesting areas than it will be, and that the project would not negatively impact these threatened and endangered species.

Rather than providing any detailed analysis of the impacts of the project on the western snowy plover and California least tern, the EIR provides only a one sentence acknowledgement that the project could facilitate predator movements into nesting areas and vague assurances that steps will be taken to minimize the impacts of predation facilitated by the proposed project. The EIR fails to detail any methodology to quantify the impacts to the two listed species, or potential effectiveness of unspecified predator removal techniques. The EIR provides no contingency plans should predator fencing and removals prove ineffective. And, finally, there is no estimate of costs associated with predator mitigation and removal, or how the additional effort would be funded. Simply put, the DEIR neglects to square the project design and mitigation requirements with the higher standards required by the Endangered Species Act in light of the likely impacts to ESA-listed species.

Each of these issues is discussed in greater detail below.

1) The EIR misrepresents the proximity of the proposed project to snowy plover habitat.

The DEIR states on page 7-5 that,

> "The western boundary of the Program area is setback from the Pacific Ocean by approximately 1,100 feet (in the vicinity of marker posts 4 and 5) to 1,500 feet (in the vicinity of marker post 7) to avoid western snowy plover (Charadrius nivosus nivosus) critical habitat and the seasonal exclosure."

And on page S-1, the DEIR states that,

> "All vegetation plantings, seasonal dust control measure deployment, and monitoring would occur within the 690-acre Program area, which avoids U.S. Fish and Wildlife Service (USFWS)-designated critical habitat for the western snowy plover (Charadrius nivosus nivosus; federal-listed as threatened) that is located west of the Program area."

This is highly misleading.

The plover critical habitat inland boundary is not the Pacific Ocean. Critical habitat maps issued by the FWS show that critical habitat for the western snowy plover extends inland from the mean high tide line up to 1,372 feet.

Since the Program area boundary is only 1,100 feet inland at some places, and since vegetation planting may occur up to the Program area boundary, the vegetation may well be within plover critical habitat. Under this scenario, the vegetation would impede the critical habitat by nearly 300 feet. Coyotes and red fox would have dense cover directly in the critical habitat making it easy to prey on the protected shorebirds. Also, since the DEIR refers to the "Pacific Ocean" rather than the mean high tide line, the Program area may extend even further into critical habitat.

Also, even though critical habitat has not been designated for the California least tern, the tern's habitat is likely to be similar to the plover habitat.

The Oceano Dunes State Vehicular Recreation Area Technical Review Team clearly recognized problems associated with the overgrowth and spread of vegetation islands and hummocks in plover and tern nesting habitat. At their December 11, 2015 meeting, the Oceano Dunes State Vehicular Recreation Area Technical Review Team, discussed *"removing the vegetated islands and hummocks at the 7.5 exclosure to provide more acreage for nesting"* and recommended that they *"conduct a site visit to the 8 exclosure to witness the overall change in plover and tern habitat due to the growth of vegetation and hummocks."*

Even under the best case, where the Program area is 1,500 feet from the ocean, the vegetation islands could still be placed on the Program area boundary and thus would be as close as 128 feet from plover critical habitat. For a predator like a coyote or red fox, 128 feet is not a great distance.

The DEIR misleads the public by leaving the impression that the western boundary of the proposed vegetation planting would be 1,100 or 1,500 feet from plover habitat which is completely false.

Further, the illustrations in the DEIR do not appear to reflect the above data accurately. In any case, the figures 2-5, 2-8 and 2-9 in the DEIR show that even based on incomplete and false data State Parks appears to quietly admit that critical habitat for the western snowy plover is less than 250 feet west of the Program area. Again, such a short distance is easily traversed in a very short time by any of the above mentioned predators of western snowy plovers and California least terns. As such, increased predation is a virtual certainty. With vegetation islands so close and so extensive, this project will result in take of listed species in violation of section 9 of the ESA.

2) The proposed project will increase predation on western snowy plovers and California least terns.

The EIR fails to acknowledge the extent of impacts to western snowy plovers and California least terns from the proposed project. Instead, vague assurances are provided in the EIR that *"Program activities that could facilitate predator movement into known or potential nesting areas for plover and tern shall be minimized."* However, no explanation is provided. No analysis of the likelihood that the project will result in take of listed species in violation of section 9 of the ESA. Nor is any detail provided about the *"additional resources would be secured to reduce predator presence and impacts."* This vague statement, with no criteria or standards, fails to meet the minimum requirements under CEQA or the ESA. If take is anticipated, State Parks would be required to obtain an incidental take permit from FWS prior to implementing the project. Prior to obtaining such a permit, State Parks would be required to complete a habitat conservation plan, or HCP. Prior to approval of an HCP, FWS would need to undertake and complete an environmental impact statement under the National Environmental Policy Act, or NEPA.

The DEIR states only that,

"The OHMVR Division shall plan and design Dust Control Program activities to avoid changing breeding habitat in the vicinity of known or potential snowy plover and least tern nesting areas. Program activities that could facilitate predator movement into known or potential nesting areas for plover and tern shall be minimized. If avoidance is not feasible, additional predator control resources (e.g., enhanced monitoring and/or trapping) shall be secured to reduce predator presence and impacts to plover and tern adults, juveniles, chicks, and nests."

So, the DEIR does not require "avoidance." It only requires "minimization." Minimization would allow "take."

There are no details in the DEIR of methodology to minimize predator movement beyond exclosure fencing and lethal predator removal. However, no methodology was provided for how predator movements would be prevented (or even minimized) through the proposed vegetated areas, either during or after installation. All five mammalian predators are adept at invading exclosures, as evidenced by the Oceano Dunes SVRA predation reports on western snowy plovers and California least terns.

The DEIR does not acknowledge that the highest levels of predation of snowy plovers were reported in the Boneyard and Oso Flacto units, both of which adjoin stretches of contiguous vegetation, including the Maidenform Revegetation area. Nor does the DEIR mention that all of the mammalian predator removals from 2009 and 2015 occurred in areas adjacent to vegetated dunes or in revegetated areas. By planting vegetation adjacent to the largest concentrations of nesting western snowy plovers and California least terns in the area, the proposed project would adversely affect the quality of that habitat, including critical habitat for western snowy plovers, because it would *"facilitate predator movement into known or potential nesting areas for plover and tern."*

It is readily apparent from Figure C.l. from the 2015 plover and tern nesting report that that these species avoid nesting near vegetated areas. And, figures C2 to to C10 show that, virtually all depredated nests are in or adjacent to vegetated areas.

Coyotes

Of particular concern are the hundreds of coyote sightings and sign *inside* of nesting exclosures, especially those adjacent to vegetated areas in the southern part of Oceano Dunes SVRA. This indicates that coyotes are adept at getting inside of the exclosures and maintenance is inadequate to keep them out. With this being the case, it is difficult to understand how the DEIR could make credible assurances about the ability to minimize predator movements or make effective use of, *"resources to reduce predator presence and impacts"* during implementation of proposed plantings as part of its dust mitigation program.

The excerpt below, from the 2012 predator report, indicates that coyote activity, like that of other mammalian predators, is largely nocturnal, while human observer activity is largely diurnal. This contributes to a problem of detecting and underestimating predator incursions in plover and tern nesting areas at Oceano Dunes SVRA.

"Live sightings of coyotes have rarely been documented inside the exclosure or along the shoreline during daytime hours. The lack of diurnal sightings, as well as timing of observed fresh tracks relative to windblown sand and tides, indicate that coyote activity is primarily nocturnal in these areas."

It is also clear from the following 2012 predator report excerpt that monitoring data on predators is not collected systematically, precluding comparisons between years and management strategies. This raises questions as to whether the Oceano Dunes SVRA will be able to evaluate the effectiveness of proposed mitigation associated with its vegetation plantings:

"As it is difficult to monitor the shoreline on foot due to potential disturbance to plover broods, predator tracks are documented opportunistically and counts are representative of a minimum level of activity that was likely much greater this season. In addition, shoreline accessibility may vary between years making direct comparison difficult."

Moreover, it is apparent that

"In 2012, there were 78 occurrences of coyote documented inside the predator fencing of the Southern Exclosure (Table 17). This compares to 15, 19, 5, and 10 occurrences in 2008-11, respectively. Number of days coyotes were detected inside the Southern Exclosure and Oso Flaco was 119 in 2012 compared to 20, 24, 99, 114, and 126 in 2011-07, respectively (Figure 15). Coyotes can enter the predator fenced portion of the exclosure by digging under, climbing, or jumping over the fence, as well as entering through areas in disrepair.

In 2012, heavy equipment was not available to work on the fence from mid-June through the remainder of the nesting season, resulting in a less secure Boneyard exclosure interior fence. Coyote intrusion inside the Southern Exclosure at this location was high during this time. Tracks indicated that most coyote activity inside the predator fence was in Boneyard and 8 exclosures and not in 6 and 7 exclosures where the majority of nesting occurs. One plover nest was depredated by a coyote in Boneyard exclosure in 2012. In 2012, there were 100 and 47 occurrences of coyote on the Southern Exclosure and North Oso Flaco shorelines, respectively, which compares to 17 and 20 occurrences in 2011, 24 and 23 occurrences in 2010, and 99 and 94 occurrences in 2009 (Table 17)."

The following section from the 2012 predator report indicates that monitoring of predators may also be inadequate:

"In 2012, there were less documentations of coyote presence on South Oso Flaco shoreline due to decreased monitor presence in this area."

Even with inconsistent and potentially minimal levels of monitoring, coyote predation on plovers and terns is clearly occurring. This would not include plover and tern eggs, chicks, and unbanded adults (again, the following excerpt is from the 2012 predator report):

> "Coyote tracks found on the Southern Exclosure shoreline were noted as having rapidly changing gaits, from walking to running, and changing direction, suggesting hunting behavior. As part of coyote monitoring at ODSVRA, coyote scat encountered by monitoring staff and contractors was checked in the field for plastic or aluminum bands used for banding least terns and snowy plovers. Eleven plastic bands used to band plovers and one bicolor aluminum band used to band terns were retrieved from four coyote scats found throughout the season in 2012, representing a minimum of one plover chick, two unknown-aged plovers, and one unknown-aged tern (Appendix H). There were nine plastic bands found in coyote scat in 2007; no bands were found in scat from 2008-11 (CDPR 2007).
>
> The protracted occurrence of coyote on the shoreline in 2012 coincided with a period of high snowy plover chick loss. As concerns of coyote impact on plover chick survival grew, coyotes were trapped in an attempt to decrease activity on the shoreline, however, shoreline activity continued throughout the season."

The 2015 Predator Management Report, contained similar issues, and included discussion about the problems associated with underestimating predation by species such as coyotes.

> "Coyotes presented a predation threat to CLTE and SNPL nesting success in 2015. One concern stemmed from predation problems during past nesting seasons. Chicks had been missing with no direct evidence to suggest why. It was suspected that coyotes could have been responsible for predation since coyote tracks were observed along the shoreline each morning."

Red fox

The red fox is an invasive species in coastal California, and are a major predator on western snowy plovers, as well other ground-nesting birds in coastal habitats (CDPR 2007). Historic occurrence and genetic data show that colonization and spread of red fox were the result of releases and/or escaped animals from fox farms (Lewis et al. 1993; Neuman et al. 2004; Statham et al. 2012).

The risk of red fox colonization of the Oceano Dunes SVRA is underscored by the fact that recent peer reviewed, published analyses have shown that Oceano Dunes SVRA and the proposed project area is within "high quality" red fox habitat and has "high connectivity" with other red fox populations (Sacks et al. 2016). This elevates the level of risk of predation to snowy plovers and least terns from the proposed vegetation plantings. These plantings, as illustrated in figures 2-8 and 2-9 in the DEIR, would bridge the gaps and create the ecological equivalent of close "stepping stones" across dune fields for red fox (and other mammalian predators) to move between heavily vegetated areas to the east and ocean-side critical habitat and nesting areas, less than 250 feet to the west. By developing vegetation cover upon currently barren dunes, mammalian predators would be provided with cover for hunting, resting, and movements, and the soil stability necessary for denning. The inevitable result will be additional predation on snowy plovers and least terns, and degrading the recovery value of western snowy plover critical habitat.

The removal of foxes in 2011 and 2012 from Oceano Dunes SVRA was a harbinger of red fox predation to come if the proposed vegetation planting occurs next to the core nesting areas and western snowy plover critical habitat in the adjacent exclosures (6, 7, and 8). As noted on page 42-44 of the 2012 predator report, all of these tracks and removals were in or adjacent to vegetated or revegetated areas:

> "In 2012, red fox tracks were documented near the Southern Exclosure and Oso Flaco nesting area for the first time. Tracks were present on seven days around Pavilion Hill (revegetation area near marker post 4), three days within the Pipeline revegetation area (adjacent to 8 exclosure), and one day within the Maidenform revegetation area (east of Boneyard exclosure). No red foxes were removed in 2012. In 2011, three red foxes were removed between Grand Avenue and Pier Avenue in an effort to control a nonnative invasive species and to prevent its spread into the plover and tern nesting area to the south."

It is well documented in the scientific literature that red foxes around the world utilize vegetation for cover during movements, as well as resting during the day, hunting, and denning in coastal and dune areas (Krim et al. 1990; Cavallini and Lovari 1994; Ruiz-Olmo and Vidal 2003; Frey et al. 2006). Red fox predation on shorebirds, including the western snowy plover and California least tern is well documented (Baeyens and Martinez 2004; White et al. 2006; Hardy and Colwell 2012).

In addition to the predation caused by all of the species above, bobcats were a new mammalian predator discovered in Oceano Dunes SVRA in 2015: bobcat tracks encountered in South Oso Flaco and inside the Southern Exclosure predator fencing on four different days and two bobcats were captured near the Oso Flaco boardwalk.

Why western snowy plovers avoid vegetated habitat
And finally, as I have pointed out in previous correspondence (attached) that western snowy plovers avoid vegetated habitat to avoid nest predation (Hardy and Colwell 2012; Webber et al. 2013; Pearson et al. 2016). Therefore, vegetation plantings in close proximity to plover and tern nesting areas are a poor idea, especially as there is no proposed mitigation commitment to preventing vegetation encroachment or additional plantings if the proposed dust mitigation is found to be inadequate.

Conclusion:

Regardless of the Herman and Colwell 2015 exclosure and removal program proposed, creating coyote and red fox denning opportunities and habitat adjacent to western snowy plover critical habitat and the most productive nesting areas for both plovers and California least terns will lead to increased predation and take of the protected species.

The solution for avoiding impacts to western snowy plovers and their critical habitat is simple – develop an alternative approach to vegetation plantings in the barren sand dunes which are not favorable habitat for mammalian predators (coyote, red fox, raccoon, opossum, and, skunk).

Sincerely,

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Literature Cited

Baeyens G, Martínez ML. 2004. Animal Life on Coastal Dunes: From Exploitation and Prosecution to Protection and Monitoring. In: ML.Martínez and NP Psuty (Eds.) Coastal Dunes Ecology and Conservation. *Ecological Studies*. 171: 279-296.

Cavallini P, Lovari S. 1994. Home range, habitat selection and activity of the red fox in a Mediterranean coastal ecotone. *Acta Theriologica* 39(3):279-287.

Frey NS and Conover MR. 2006. Habitat Use by Meso-Predators in a Corridor Environment. *The Journal of Wildlife Management* 70(4):1111-1118.

Hardy MA, Colwell MA. 2012. Factors Influencing Snowy Plover Nest Survival on Ocean-Fronting Beaches in Coastal Northern California. *Waterbirds* 35(4):503-656.

Herman DM, Colwell MA. 2015. Lifetime reproductive success of Snowy Plovers in coastal northern California. *The Condor* 117(3):473-481.

Krim PM, Bashore TL, Kirkland GL, Jr. 1990. Den site characeristics and food habits of he red fox (Vulpes vulpes) on Assateague Island, Maryland. Virgina Journal of Science 41(4a): 340-351.

Lewis JC, Sallee KL, Golightly Jr. RT. 1993. Introduced Red Fox In California. Red fox sightings were recorded in the coastal areas from Mission Bay just north of San Diego in San Diego County to Point Reyes National Seashore in Marin County. Final Report To California Department of Fish and Game, Contract FG8612 (FY90/92).

Neuman KK, Page GW, Stenzel LE, Warriner JC, Warriner JS. 2004. Effect of mammalian predator management on snowy plover breeding success. *Waterbirds* 27(3):257-263.

Pearson SF, Shannon MK, Sundtrom C. 2016. Evaluating the ecological and behavioural factors influencing Snowy Plover *Charadrius nivosus* egg hatching and the potential benefits of predator exclosures. *Bird Conservation International* 26(01):100-118.

Sacks BN, Brazeal JL, Lewis JCarea. 2016. Landscape genetics of the nonnative red fox of California. *Ecology and Evolution* 6(14):4775-4791.

Statham MJ, Sacks BN, Aubry KB, Perrine JD, Wisely SM. 2012. The origin of recently established red fox populations in the United States: translocations or natural range expansions? *Journal of Mammalogy* 93(1):52-65.

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Evolutionary biology, ecology, and conservation biology
Scientific review, advising, research, and expert testimony
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Research and Professional experience:
President, Wildlife Science International, Inc., Nederland, CO (2007 - present)

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Continuing Legal Education International, American Law Institute, and University of Pennsylvania Workshops on Markets and the Environment - invited faculty to lecture on the U.S. Endangered Species Act (2004-2008)

Colorado Bar Association, invited faculty to lecture on the U.S. Endangered Species Act (2014)

The Watershed School, Boulder, CO - instructor for May Term course on *Biodiversity And Conservation Issues In Hawaii* (2010, 2013)

University of Colorado, Boulder. Instructor of Genetics (1998 - 1999)

University of Colorado, Boulder - Hughes Undergraduate Research Initiative (1996 - 1999)

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Academic Awards, Fellowships, Memberships, and Affiliations:

International Union for the Conservation of Nature, Caprinae Specialist Group (2000 - 2013)

Desert Lion and Elephant Conservation - Board Member (2012 to present)

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University of Colorado, Denver, Department of Environmental Science - Adjunct Faculty (2002 - 2006)

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Community Service:

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Avocations:

Rock climbing, backcountry telemark skiing, river rafting, and travel to remote locations.

Scientific Publications:

Ramey II, R.R., J.L. Thorley, A.S. Ivey (2015) Recent greater sage grouse (*Centrocercus urophasianus*) population dynamics in Wyoming are primarily driven by climate, not oil and gas development. Preprint available at: http://biorxiv.org/content/early/2015/10/04/028274

Ramey, E.M., R.R. Ramey, L.M. Brown, and S.T. Kelley (2013) Desert-dwelling elephants dig wells to purify drinking water. *Pachyderm* 53:66-72.

Ramey, R.R. (2012) On the origin of *specious* species. In: *Institutions and Incentives in Regulatory Science*. J. Johnston (ed.), Lexington Books.

Miller, B.J, B.F.J. Manly, D. Murphy, D. Fullerton, and R.R. Ramey (2012) Primary factors associated with the decline of delta smelt (*Hypomesus transpacificus*) in the San Francisco Bay-Delta Estuary:1972-2006. *Reviews in Fisheries Science* 20(1):1-19.

Ramey, R.R., L.M. Brown, and F. Blackgoat (2011) Oil and gas development and greater sage grouse (*Centrocercus urophasianus*): a review of threats and mitigation measures. *The Journal of Energy and Development* 35(1):49-78.

Leggett, K.E.A., L.M. Brown, and R.R. Ramey (2011) Matriarchal associations and reproduction in a remnant subpopulation of desert-dwelling elephants in Namibia. *Pachyderm* 49:20-32.

Wehausen, J.D., S.T. Kelley, and R.R. Ramey (2011) A review of experimental evidence concerning respiratory disease transmission between domestic sheep and bighorn sheep. *California Fish and Game* 97(1):7-24.

Ley, R.E. M. Hamady, C. Lozupone, P. Turnbaugh, R.R. Ramey, S. Bircher, M.L. Schlegel, T.A. Tucker, M.D. Schrenzel, R. Knight, and J.I. Gordon (2008) Evolution of mammals and their gut microbes. *Science* 320:1647-1651.

Ramey, R.R., J.D. Wehausen, H.P. Liu, C.W. Epps, and L. Carpenter (2007) How King et al. (2006) define an "evolutionarily distinct" mouse subspecies: a response. *Molecular Ecology* 16: 3518–3521.

Safaee, S., G.C. Weiser, E.F. Cassirer, R.R. Ramey, and S.T. Kelley (2006) Microbial diversity in bighorn sheep revealed by culture-independent methods. *Journal of Wildlife Disease* 42(3):545-559.

Ramey, R.R., J.D. Wehausen, H.P. Liu, C.W. Epps, and L. Carpenter (2006) Response to Vignieri et al. (2006): Should hypothesis testing or selective post hoc interpretation of results guide the allocation of conservation effort? *Animal Conservation* 9:244–247.

Turner, J.C., C.L. Douglas, C.R. Hallum, P.R. Krausman, and R.R. Ramey (2006) Osterman's assumption of a flawed habitat model is premised on facts not in evidence: Turner et al. (2005) response to Osterman et al. (2005). *Wildlife Society Bulletin* 33(4):1465-1473.

Timm, R.M., R.R. Ramey, and the Nomenclature Committee of the American Society of Mammalogists (2005) What constitutes a proper description? *Science* 309:2163-2164.

Epps, C.W., P.J. Palsboll, J.D. Wehausen, G.K. Roderick, R.R. Ramey II and D.R. McCullough (2005) Highways block gene flow and cause a rapid decline in genetic diversity of desert bighorn sheep. *Ecology Letters* 8:1029-1038.

Ramey, R.R., H.P. Liu, C.W. Epps, L. Carpenter, and J.D. Wehausen (2005) Genetic relatedness of the Preble's meadow jumping mouse (*Zapus hudsonius preblei*) to nearby subspecies of *Z. hudsonius* as inferred from variation in cranial morphology, mitochondrial DNA, and microsatellite DNA: implications for taxonomy and conservation. *Animal Conservation* 8:329-346.

Charif, R., R.R. Ramey, K. Payne, W. Langbauer, R. Martin, and L.M. Brown (2005) Spatial relationships and matrilineal kinship in African savanna elephant (*Loxodonta africana*) clans. *Behavioral Ecology and Sociobiology* 57(4):327-338.

Wehausen, J.D., V.C. Bleich, and R.R. Ramey (2005) Correct Nomenclature for Sierra Nevada Bighorn Sheep. *California Fish and Game* 91:216-218.

Brown, L.M., R.R. Ramey, B. Jiron, and T. Gavin (2004) Population structure and mtDNA variation in sedentary Neotropical birds isolated by forest fragmentation. *Conservation Genetics* 5:743-757.

Wehausen, J.D., R.R. Ramey, and C.W. Epps (2004) Experiments in DNA extraction and PCR amplification from bighorn sheep feces: the importance of DNA extraction method. *Journal of Heredity* 95(6):503-509.

Ramey, R.R., T. Tserenbataa, S. Amgalanbaatar, and Z. Namshir (2004) A new method of argali (*Ovis ammon*) capture using horsemen and drive nets. *Mongolian Journal of Biological Sciences* 2(1):19-21.

Turner, J.C., C.L. Douglas, C.R. Hallum, P.R. Krausman, and R.R. Ramey (2004) Determination of critical habitat for the endangered Nelson's bighorn sheep in southern California. *Wildlife Society Bulletin.* 32(2):427-448.

Tserenbataa, T., R.R. Ramey II, O.A. Ryder, T.W. Quinn, and R.P. Reading (2004) A population genetic comparison of Argali sheep (*Ovis ammon*) in Mongolia using ND5 gene of mtDNA: Implications for conservation. *Molecular Ecology* 13:1333-1339.

Ramey, R.R., G. Luikart, and F.J. Singer (2000) Genetic bottlenecks resulting from restoration efforts: the case of bighorn sheep in Badlands National Park. *Journal of Restoration Ecology.* 8(4S):85-90.

Ramey, R.R., W.M. Boyce, B. Farrell, and S. Kelley (2000) Phylogeny and host specificity of psoroptic mange mites as indicated by ITS sequence data. *Journal of Medical Entomology* 37(6):791-796.

Wehausen, J.D. and R.R. Ramey (2000) Cranial morphometric and evolutionary relationships in the northern range of *Ovis canadensis. Mammalogy* 81(1):145-161.

Ramey, R.R. (2000) New perspectives on the evolutionary origins, historic phylogeography, and population structure of North American mountain sheep. In Thomas, A.E, and H.L Thomas (eds.). *Transactions of the 2nd North American Wild Sheep Conference.* April 6-9, 1999, Reno, NV 470pp.

Boyce, W.M., R.R. Ramey, T.C. Rodwell, E.S. Rubin, and R.S. Singer (1999) Population subdivision among desert bighorn sheep (*Ovis canadensis*) ewes revealed by mitochondrial DNA analysis. *Molecular Ecology* 8:99-106.

R.R. Ramey and K. Gottleib (1998) Keep your DNA dry and in the dark: Considerations on the preservation of DNA forensic evidence. *Forum Conveniens* 9(1):7.

Young, B., S. Johnson, M. Bahktiara, D. Shugarts, R.K. Young, M. Allen, R.R. Ramey, and D. Kuritzkes. (1998) Resistance mutations in protease and reverse transcriptase genes of human immunodeficiency virus type 1 isolates from patients with combination antiretroviral therapy failure. *Journal of Infectious Diseases* 178:1497-1501.

Boyce, W.M., P.W. Hedrick, N.E. Muggli-Cockett, C.T. Pendo, and R.R. Ramey (1997) Comparative analysis of intra and interpopulation genetic variation in mountain sheep at major histocompatibility complex and microsatellite loci. *Genetics* 145:421-433.

Bleich, V., J.D. Wehausen, R.R. Ramey, and K. Rechel (1996) Metapopulation theory and desert dwelling mountain sheep: Implications for conservation. In: *Metapopulations and Wildlife Conservation.* D.R. McCullough (ed.), Island Press. pp 353-373.

Ramey, R.R. (1995) Mitochondrial DNA variation, population structure and evolution of mountain sheep in the southwestern United States and Mexico. *Molecular Ecology* 4:429-439.

Wehausen, J.D. and R.R. Ramey (1993) A morphometric reevaluation of the Peninsular bighorn subspecies. *Desert Bighorn Council Transactions* 37:1-10.

Ramey, R.R. (1991) The evolutionary genetics of mountain sheep in the Owens Valley region: Preliminary results from proteins and mitochondrial DNA. In: *Natural History of Eastern California and High-altitude Research: White Mountain Research Station Symposium Volume 3.* C.A. Hall, Jr., V. Doyle-Jones, and B. Widawski (eds.), White Mountain Research Station, UCLA.

Snyder, N.R.F., R.R. Ramey and F. Sibley (1986) The nest-site biology of the California condor. *Condor* 88:228 - 241.

Jessup, D. and R.R. Ramey (1995) Genetic variation of bighorn sheep as measured by blood protein electrophoresis. *Desert Bighorn Council Transactions* 39:17-25.

Andaloro, L. and R.R. Ramey (1981) The Relocation of Bighorn Sheep in the Sierra Nevada Mountains of California. *Environmental Field Program Publication #7*, University of California, Santa Cruz. 60 pp.

Manuscripts submitted for publication:

Ramey, R.R., J.D. Wehausen, and L.M. Brown (in prep) Peer review and information quality breakdown in an Endangered Species Act decision: the case of the greater sage grouse.

Congressional testimony:

April, 8 2014, United States House of Representatives, Committee on Resources, Hearing on: *H.R. 4315, (Hastings), "21st Century Endangered Species Transparency Act,"* *H.R. 4316, (Lummis), "Endangered Species Recovery Transparency Act,"* *H.R. 4317, (Neugebauer), "State, Tribal, and Local Species Transparency and Recovery Act," and* *H.R. 4318, (Huizenga), "Endangered Species Litigation Reasonableness Act."* (Provided oral and written testimony.)

August 1, 2013, United States House of Representatives, Committee on Resources. Oversight Hearing on: *"Transparency and Sound Science Gone Extinct?: The Impacts of the Obama Administration's Closed-Door Settlements on Endangered Species and People."* (Provided oral and written testimony.)

July 3, 2012, California State Legislature, Senate Committee on Natural Resources and Wildlife. Provided oral and written testimony on scientific issues concerning supposed human disturbance of bighorn sheep, relevant to Assembly Bill AB880. (AB880 was subsequently passed and signed into law by Governor Brown).

July 31, 2007, United States House of Representatives, Committee on Resources. Legislative Hearing on: *"Crisis of Confidence: The Political Influence of the Bush Administration on Agency Science and Decision-Making"* (Provided written testimony.)

April 28, 2004, United States House of Representatives, Committee on Resources. Legislative Hearing on: *"H.R. 2933, To amend the Endangered Species Act of 1973 to reform the process for designating critical habitat under that Act."* (Provided oral and written testimony.)

Other publications:

Ramey, R.R. (2014) A doctor's battle with Ebola is a moral tonic for the world. Letter to the Editor of *The Washington Post*. 5 August 2014.

Ramey, R.R and L.M. Brown. (2011) Extinct Predictions: Dire extinction estimates have not been confirmed in the wild. Invited op ed for the *Financial Post* (Canada). 14 June 2011.

Ramey, R.R. (2011) Species nomenclature, classification and problems of application. *In* Grzimek's Animal Life Encyclopedia: Evolution. Gale, Farmington Hills, MI.

Ramey, R.R. (2003). Argali capture in Mongolia. *Museum Monthly* 4(1):18-21.

Ramey, R.R. (2002) The science and adventure of bighorn conservation. *Museum Monthly* 3(7):1-2.

Ramey, R.R. (1992) Journey into the past: the Morden-Clark and Roy Chapman Andrews expeditions of the 1920's. *ISHA Ram*.

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Home range, habitat selection and activity of the red fox in a Mediterranean coastal ecotone

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Ranging behaviour and activity of five (2 females, 3 males) red foxes *Vulpes vulpes* (Linnaeus, 1758) in the Mediterranean coastal area of Maremma Natural Park (central Italy, an area of great habitat diversity) are described. One female ranged over a very small area and had diurnal activity rhythms. For other foxes, home range size (100% minimum convex polygon) varied between 86 and 485 ha (larger than fox ranges in urban areas and smaller than in northern or homogeneous areas), and core areas (50% harmonic mean) between 4.0 and 13.7 ha. Habitat diversity within home ranges was significantly higher than that of the overall area. Within their home ranges, foxes selected scrubwood for resting. When active, they showed individual differences in habitat selection. Peak activity was between 20.00 h and 22.00 h, but foxes were active also during the day.

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Key words: *Vulpes vulpes*, home range, activity, habitat selection

Introduction

The red fox *Vulpes vulpes* (Linnaeus, 1758) is one of the most widespread mammals (Zimen 1980b). Its ecology and behaviour have been studied extensively in central and northern Europe (Zimen 1980a) and North America (Ables 1975), but few studies have been conducted in the Mediterranean region (Amores 1975, Reynolds 1979, Prigioni and Tacchi 1991). In most previous studies, fox populations under study were rarely free from human interference, either by hunting or by manipulating the environment. Because of high variability in size of home range (10–3420 ha; e.g. Jones and Theberge 1982, Voigt and Macdonald 1984, Lovari *et al.* 1991) geographical and individual variation is expected. As a rule, foxes are most abundant in mixed, heterogeneous, fragmented or discontinuous habitats (Ables 1975, Lloyd 1975), and select mosaic or shrub areas over homogeneous forests or open areas (Jones and Theberge 1982, Nakazono 1989). Inter-

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ference competition by other canids, however, may change this pattern (Theberge and Wedeles 1989). In the coastal ecotone of the Maremma Natural Park the diet of the red fox is varied, consisting mainly of fruits (especially juniper berries) and arthropods (especially *Orthoptera* and *Coleoptera*; Ciampalini and Lovari 1985, Calisti *et al.* 1990), and food consumption is well correlated with the availability of these resources. Habitat use is related to both the local availability and dispersion of food (Cavallini and Lovari 1991). In simple environments, where resources are exclusively concentrated in particular areas, individual variation in the home range size of carnivores has been explained by the distribution of key habitats. Home ranges encompass similar areas of "fruitful" habitat, but different areas of "useless" habitats (red fox – Macdonald 1981, arctic fox – Hersteinsson and Macdonald 1982, European badger – Kruuk and Parish 1982, Blanford's fox – Geffen *et al.* 1992b). Where several resources are available at the same time in different habitats, predictions are more difficult (Carr and Macdonald 1986). We hypothesise that in an ecotonal area with a high diversity of food resources foxes will: (1) select habitat diversity *per se* (thus obtaining access to a wider variety of food resources) rather than any particular habitat type; (2) show large individual differences in habitat selection. In comparatively small home ranges, where travelling costs are negligible (Corts and Lindzey 1984, Geffen *et al.* 1992a), habitat selection while resting will be independent from feeding areas, and will be determined by cover availability.

Study area

An ecotonal area in the centre of the Maremma Natural Park (9,800 ha; 42°39' N, 11°05' E), Grosseto County, along the Thyrrenian coastline, central Italy was selected for this study. The Park (established in 1975) is one of the last stretches of undisturbed Tyrrhenian coastline, and includes wetlands and wooded hills. Owing to the great environmental diversity, it is very rich in wildlife, both mammals (e.g. wild boar *Sus scrofa*, fallow deer *Dama dama*, roe deer *Capreolus capreolus*, badger *Meles meles*, martens *Martes* spp., and porcupine *Hystrix cristata*) and birds (especially abundant are the jay *Garrulus glandarius* and other scrubwood passerines, and wetland migratory birds, e.g. Arrigoni *et al.* 1976). The main habitats in the study area were: (1) very thick scrubwood (92–100% total cover; mainly composed by *Quercus ilex*, with *Arbutus unedo*, *Phillyrea latifolia*, *Erica arborea*, *Pistacia lentiscus*), (2) meadow (55–92% total cover; mainly composed by a wide and variable array of grasses and forbs, with very sparse bushes of *Rosmarinus officinalis*, *Cistus monspeliensis*, *Erica multiflora*), (3) pinewood (80–100% total cover; thick bush of *Phillyrea angustifolia*, *Erica multiflora*, *Myrtus communis* and *Juniperus oxycedrus* under an overstorey of *Pinus pinea*, *P. pinaster* and *P. halepensis*), (4) sandy dune (15–60% total cover; abundant juniper *Juniperus oxycedrus* and sparse grasses), (5) sandy beach (almost devoid of vegetation), (6) olive grove (*Olea europaea* with an understorey of grasses and forbs), and (7) marsh (flooded in winter; dominated by *Juncus maritimus*) (Arrigoni *et al.* 1985). There was little human interference with vegetation or wildlife, except limited cutting of the scrubwood and seasonal tourism mainly confined to the beach. We estimated that about 30 adult foxes lived in the area (Cavallini and Lovari 1991). Average weekly temperatures ranged from 4.5 to 28°C; rainfall was scarce (average of 648 mm/year in the period 1955–1974) and concentrated in winter (Cavallini and Lovari 1991).

Methods

From November 1985 through December 1986, five adult (> 1 year) foxes (3 males, 2 females) were captured, fitted with radiocollars and radiotracked at close range (< 200 m) for 48 h/week. A hand-held, three-element Yagi antenna and a portable receiver were used. Tracking periods (8 h each) were distributed evenly during the 24 h. Time to independence of successive locations was evaluated by a biological (≥ double the time necessary to cross the entire fox range at average speed) rather than a statistical method (Swihart and Slade 1985, Solow 1989). Therefore, one location per animal was recorded every 2 h, which agrees with other estimates for the same species (Harris *et al.* 1990). From sightings of collared animals while radiotracking, error radii were < 25 m in most conditions. For each fix, activity (basing on signal amplitude fluctuations, Garshelis and Pelton 1980) and habitat type were recorded. Because none of the current measures of the home range size is free of problems (e.g. Harris *et al.* 1990) and also to make possible comparisons with past and future studies, four methods were used to calculate home range size: harmonic mean (Dixon and Chapman 1980; with Spencer and Barrett 1984 modification); kernel analysis (Worton 1989); minimum convex polygon (Hayne 1949), both including all the locations and excluding the 5% of active fixes farthest from the harmonic centre; and grid method (Voigt and Tinline 1980). Based on the accuracy of fixes, a square size of 0.39 ha was used. Core areas were evaluated by the harmonic mean method (50% isopleth). The Micro-Computer Program for the Analysis of Animal Loctions (MCPAAL; Stüwe and Blohwiak 1989) was used for home range size computation. The distribution of habitats in the study area was plotted on a map (1:5,000 scale), and the areas occupied by each habitat were measured. Habitat selection was evaluated at two levels: the proportion of each habitat type within each home range was compared with its availability in a reference area (i.e. the minimum rectangular area encompassing the home ranges of all radiotracked foxes; second-order selection of Johnson 1980), and the use (i.e. percentage of fixes) was compared with the availability of each type of habitat within the home range (third-order selection of Johnson 1980). Analyses were conducted at the individual level, because Thomas and Taylor (1990) and Harris *et al.* (1990) have shown that pooling data across individuals makes it difficult to evaluate the conclusions. Significant differences between use and abundance of habitats were determined with the χ^2-test and the Bonferroni confidence intervals (Neu *et al.* 1974, Byers *et al.* 1984). Separate analyses were conducted for active and inactive locations, because the determinants of habitat selection are likely different for a foraging and for a resting or sleeping fox. Habitat diversity was evaluated by the Shannon-Wiener index. The difference between the habitat diversity of the overall area and that of the foxes has been evaluated by the test for difference between two diversity indices (Zar 1984). To evaluate activity rhythms the percentage of locations in which the fox was active (in total locations) was used.

Results

Altogether 3,780 locations were recorded for 5 foxes. Less than 5% of fixes were missing (i.e. the animal was not found when searched for) for each of the collared foxes (range 1.1–4.3%). With the exception of one female, ranging over a small area (15–43 ha, according to various computing methods), home range size varied from 62 to 461 ha (harmonic mean) and from 86 to 485 ha (minimum convex polygon), without differences between the sexes (Mann-Whitney: $p > 0.3$; Table 1). However, study foxes used only a small proportion of their harmonic mean or polygon home ranges (31–70 ha, grid method; 6.6–29.1% of minimum convex polygon). Excluding the 5% of locations farthest from the harmonic centre, the range size become considerably smaller (80–230 ha). Although ranges of foxes

Table 1. Home range sizes (ha) of foxes in the Maremma Natural Park, Italy. See text for references to computational methods. Id – sex and identification number of individual foxes. [a] two home ranges occupied sequentially (see text), [b] probably underestimated because of small number of locations, n – number of locations.

Id	Tracking period	n	Harmonic mean		Kernel analysis	Minimum convex polygon		Grid
			95%	50%	95%	100%	95%	
M1	4/11/85–20/12/86	1332	62.2	10.3	73.6	193.8	91.1	56.3
M2[a]	4/11/85–24/1/86	163	394.9	4.0	219.8	86.3	79.8	31.3[b]
			461.4	13.7	433.1	388.5	233.0	
M3	26/1–20/12/86	1116	62.4	5.3	73.3	257.4	93.4	54.3
F1	4/11–20/12/85	153	29.9	0.4	37.4	42.6	19.4	14.8[b]
F2	11/2–20/12/86	1016	316.8	12.0	297.5	484.8	226.1	69.5

Table 2. Habitat use by foxes in the Maremma Natural Park, Italy. Habitats used significantly ($p < 0.05$, Bonferroni confidence intervals) more or less than expected are indicated with + or –, n – number of locations.

Id	Scrubwood	Meadow	Pinewood	Dune	Olive grove	Marsh	n
	Proportion in home ranges (grid method) compared to proportion in study area						
Study area	0.57	0.18	0.08	0.08	0.04	0.05	
M1	0.54	0.14	0.10	0.06	0.12+	0.03	1332
M2	0.54	0.05–	0.15	0.13	0.05	0.09	163
M3	0.37–	0.13	0.19+	0.16	0.08	0.07	1116
F1	0.21–	0.32	0.45+	0.03	0	0	153
F2	0.30–	0.26	0.12	0.13	0.19+	0	1016
Average	0.39	0.18	0.20	0.11	0.09	0.04	
	Proportion of active locations compared to proportion in home range						
M1	0.48–	0.32+	0.03–	0.03–	0.13	< 0.01–	724
M2	0.60	0.05–	0.15	0.14	0.03	0.04	79
M3	0.48+	0.07–	0.21	0.16	0.03–	0.05	599
F1	0.26	0.28	0.40	0.06	0	0	53
F2	0.26	0.35	0.20+	0.13	0.07	0	463
Average	0.42	0.21	0.20	0.10	0.05	0.02	
	Proportion of inactive locations compared to proportion in home range						
M1	0.92+	0.08–	0	0	< 0.01–	< 0.01–	608
M2	0.63	0	0.09	0.19	0.02	0.06	84
M3	0.75+	0	0.23	< 0.01–	0	0.02–	517
F1	0.89+	0.04–	0.06–	0.01–	0	0	100
F2	0.88+	0.01–	0.01–	0.02–	0.08–	0	553
Average	0.81	0.03	0.08	0.05	0.02	0.02	

tracked for the longer periods were remarkably stable, one of the males (M2) occupied first a range in the centre of the study area (harmonic mean = 395 ha), then, in November (the usual dispersal period, e.g. Zimen 1984) moved to a larger, disjunct one (harmonic mean = 461 ha). Core areas (50% harmonic mean) ranged from 4.0 to 13.7 ha (Table 1). The proportion of scrubwood in the home range was less (M3, F1, F2) or equal (M1, M2) to that in the study area (Table 2). Pinewood (M3, F1) or olive grove (M1, F2) were over-represented in the home ranges. The proportions of other habitats were similar to those in the study area, with the exception of the meadow, which was under-represented in the range of M2 (Table 2). As a result, diversity of habitats within home ranges was higher than that of the overall area (Shannon-Wiener index for the study area = 0.57; average for home ranges of foxes = 0.68; t = 2.32, p < 0.03). Active foxes differed in habitat use with no consistent trend across individuals: over-utilized habitats were meadow for M1, scrubwood for M3, and pinewood for F2; under-utilized habitats were scrubwood for M1, meadow for M2 and M3, and pinewood for M1; dune, olive grove, and marsh were never over-utilized (under-utilized or not used at all by some individuals; Table 2). Foxes consistently over-utilized scrubwood (the habitat with the densest cover) for resting (with one exception), under-utilizing or not

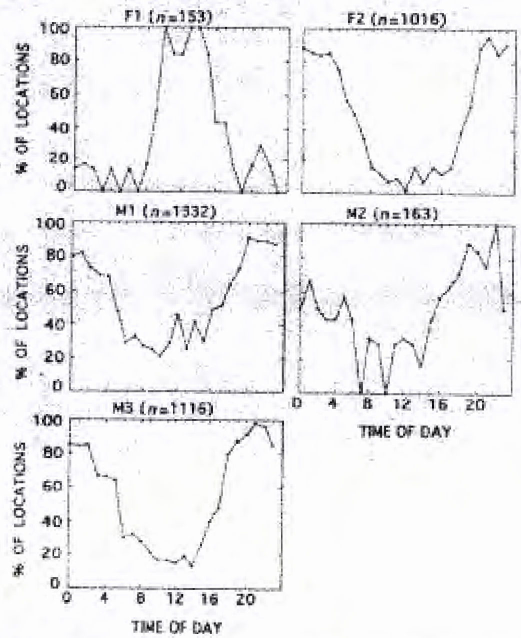

Fig. 1. Activity rhythms (percentage of active locations in total locations) of five adult foxes in the Maremma Natural Park, Italy. Symbols (M, F; 1, 2, 3) indicate sex and individual number of foxes (as in Tables 1 and 2). n – number of locations.

using most of the other habitats (Table 2). Total activity summed to about 50% of the time (M1 = 55.0%, M2 = 48.5%, M3 = 53.7%, F2 = 45.6%). F1 was active only 34.6% of the time, significantly less than the other animals ($\chi 2 = 7.3$, $p = 0.006$). Furthermore her activity pattern was negatively correlated with that of each of the other foxes (Spearman rank correlation, $r_s < -0.48$, $p < 0.02$), whereas all other foxes had coincident activity rhythms ($r_s > 0.65$, $p < 0.001$). Indeed, F1 was found dead in poor physical conditions during the study period. We therefore excluded the data of this animal from the analyses. Usually activity was high during the night (73.6% ± 11.5 SD of total active fixes were recorded between sunset and sunrise), starting around 16.00–18.00 h and ceasing around 06.00–08.00 h, but foxes were also active during the day (26.4% ± 7.3 SD of total active fixes were recorded between sunrise and sunset). The maximum activity levels, close to 100% of fixes, were reached between 20.00 and 22.00 h (Fig. 1).

Discussion

The mean home range size for red foxes in this Mediterranean ecotone (282 ha ± 141 SD, minimum convex polygon) was much larger than that reported for urban or suburban foxes (e.g. Harris 1980, Voigt and Macdonald 1984, Doncaster and Macdonald 1991), much smaller than those of northern areas (e.g. Jones and Theberge 1982, Voigt and Macdonald 1984) or homogeneous neighbour habitat (pinewood, Lovari *et al.* 1994), and similar to those of temperate or woodland areas (e.g. Artois *et al.* 1990, Cavallini 1992). Minor differences may be ascribed to different computing methods (e.g. some of the authors excluded occasional forays). Unfortunately, almost all studies reported only the minimum convex polygon size (or some modification thereof), whereas no study (except Cavallini 1992) reported the harmonic mean values. The harmonic mean ranges of two foxes were similar to those reported for a rural area of Japan, whereas the others were much smaller. All core areas were much smaller (average = 9 ha vs 39.5 ha; Cavallini 1992). The foxes in Maremma therefore concentrated their activity in a small area, while maintaining regular access to a large area. Foxes did not consistently select a particular habitat, as in simpler environments (Macdonald 1981, Hersteinsson and Macdonald 1982, Kruuk and Parish 1982, Geffen *et al.* 1992b), but included heterogeneous areas in their ranges. Within their home range, all foxes strongly and consistently selected the habitat with the densest cover for resting. This behaviour is unexpected, when considering that foxes in the area have not been hunted for about 10 years. Either more favourable thermic conditions (cf Cavallini and Lovari 1991) or the permanence of a previously adaptive behaviour (with either a genetic or a cultural basis) may explain this tendency. On the contrary, foxes showed flexible and individually variable strategies for the selection of habitat used for feeding. Our results suggest that the resource-dispersion hypothesis (Macdonald 1983) cannot explain ranging behaviour in a complex environment with several productive habitats, if only food resources are considered.

The fox is described as a predominantly nocturnal animal (Ables 1975, Maurel 1980, Artois 1985, Blanco 1986), with seasonal variation (Ables 1975, Cavallini and Lovari 1991). Some papers report of a higher activity during the day (Eguchi and Nakazono 1980, Phillips and Catling 1991, Lovari *et al.* 1994). The diurnal activity of one female found in this study has a parallel in the inversion of activity rhythms shown by a female in Australia, attributed to breeding (Phillips and Catling 1991). In our case, the poor physical conditions and the very small home range of the diurnal female rather suggest an attempt of minimizing direct confrontation with the more fit individuals. Furthermore, the tracking period of this female was outside the breeding season. A quantitative comparison of our results with those of other studies is difficult because of the different techniques used and the lack of other relevant data (e.g. food habits, hunting regime) for many areas. In our study area (where hunting is forbidden and disturbance is limited), foxes are more diurnal when eating diurnal insects, and more nocturnal when eating fruits, which are available for 24 h (Cavallini and Lovari 1991). Night time activity may be favoured by foxes, but they can switch to diurnal activity when induced by social or trophic factors.

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References

Ables E. D. 1975. Ecology of the red fox in North America. [In: The wild canids. Their systematics, behavioral ecology and evolution. M. W. Fox, ed]. Van Nostrand Reinhold Co., New York: 216–236.

Amores F. 1975. Diet of the red fox (*Vulpes vulpes*) in the western Sierra Morena (south Spain). Doñana Acta Vertebrata 2: 221–239.

Arrigoni P. V., Gellini R., Innamorati M., Lenzi Grillini C., Piussi P., Sartori G., Lovari S., Renzoni A. and Sanesi G. 1976. Relazione al Consorzio per l'istituzione del Parco della Maremma. Informatore Botanico Italiano 8: 283–324.

Arrigoni P. V., Nardi E. and Raffaelli M. 1985. La vegetazione del parco naturale della Maremma (Toscana). Università degli Studi di Firenze, Dipartimento di Biologia Vegetale, Firenze: 1–39.

Artois M. 1985. Utilization de l'espace et du temps chez le renard (*Vulpes vulpes*) et le chat forestier (*Felis silvestris*) en Lorraine. Gibier Faune Sauvage 3: 33–57.

Artois M., Aubert M. and Stahl P. 1990. Organisation spatiale du renard roux (*Vulpes vulpes* L., 1758) en zone d'enzootie de rage en Lorraine. Rev. Ecol. (Terre Vie) 45: 113–134.

Blanco J. C. 1986. On the diet, size and use of home range and activity patterns of a red fox in central Spain. Acta theriol. 31: 547–556.

Byers C. R., Steinhorst R. K. and Krausman P. R. 1984. Clarification of a technique for analysis of utilization – availability data. J. Wildl. Manage. 48: 1050–1053.

Calisti M., Ciampalini B., Lovari S. and Lucherini M. 1990. Food habits and trophic niche variation of the red fox *Vulpes vulpes* (L., 1758) in a Mediterranean coastal area. Rev. Ecol. (Terre Vie) 45: 309–320.

Carr G. M. and Macdonald D. W. 1986. The sociality of solitary foragers: a model based on resource dispersion. Anim. Behav. 34: 1540–1549.

Cavallini P. 1992. On the ranging behaviour of red foxes in rural southern Japan. J. Mammal. 73: 321–325.

Cavallini P. and Lovari S. 1991. Environmental factors influencing the use of habitat in the red fox, *Vulpes vulpes* (L., 1758). J. Zool., Lond. 223: 323–339.

Ciampalini B. and Lovari S. 1985. Food habits and trophic niche overlap of the badger (*Meles meles* L.) and the red fox (*Vulpes vulpes* L.) in a Mediterranean coastal area. Z. Säugetierk. 50: 226–234.

Corts K. E. and Lindzey F. G. 1984. Basal metabolism and energetic cost of walking in cougars. J. Wildl. Manage. 48: 1456–1458.

Dixon K. R. and Chapman J. A. 1980. Harmonic mean measure of animal activity areas. Ecology 61: 1040–1044.

Doncaster C. P. and Macdonald D. W. 1991. Drifting territoriality in the red fox *Vulpes vulpes*. J. Anim. Ecol. 60: 423–439.

Eguchi K. and Nakazono T. 1980. Activity studies of Japanese red foxes, *Vulpes vulpes japonica* Gray. Jap. J. Ecol. 30: 9–17.

Garshelis D. L. and Pelton M. R. 1980. Activity of black bears in the Great Smoky Mountains National Park. J. Mammal. 61: 8–19.

Geffen E., Degen A. A., Kam M., Hefner R. and Nagy K. A. 1992a. Daily energy expenditure and water flux of free-living Blanford's foxes (*Vulpes cana*), a small desert carnivore. J. Anim. Ecol. 61: 611–617.

Geffen E., Hefner R., Macdonald D. W. and Ucko M. 1992b. Habitat selection and home range in the Blanford's fox, *Vulpes cana*: compatibility with the resource dispersion hypothesis. Oecologia 91: 75–81.

Harris S. 1980. Home ranges and patterns of distribution of foxes (*Vulpes vulpes*) in an urban area, as revealed by radiotracking. [In: A handbook on biotelemetry and radiotracking. C. J. Amlaner and D. W. Macdonald, ed]. Pergamon Press, Oxford, U.K.: 685–690.

Harris S., Cresswell W. J., Forde P. G., Trewhella W. J., Woollard T. and Wray S. 1990. Home-range analysis using radiotracking data – a review of problems and techniques particularly as applied to the study of mammals. Mammal Rev. 20: 97–123.

Hayne W. D. 1949. Calculation of size of home range. J. Mammal. 30: 1–17.

Hersteinsson P. and Macdonald D. W. 1982. Some comparison between red and arctic foxes, *Vulpes vulpes* and *Alopex lagopus*, as revealed by radio tracking. Symp. zool. Soc. Lond. 49: 259–289.

Johnson D. H. 1980. The comparison of usage and availability measurements for evaluating resource preference. Ecology 61: 65–71.

Jones D. M. and Theberge J. B. 1982. Summer home range and habitat utilization of the red fox (*Vulpes vulpes*) in a tundra habitat, northwest British Columbia. Can. J. Zool. 60: 807–812.

Kruuk H. and Parish T. 1982. Factors affecting population density, group size and territory size of the European badger, *Meles meles*. J. Zool., Lond. 196: 31–39.

Lloyd H. G. 1975. The red fox in Britain. [In: The wild canids. Their systematics, behavioral ecology and evolution. M. W. Fox, ed]. Van Nostrand Reinhold Co., New York: 207–215.

Lovari S., Cavallini P., Crema G., Lazzeretti L., Lucherini M., Ricci Lucchi M. and Valier P. 1991. Environmental variables and the use of habitat of the red fox in the Maremma Natural Park, Italy. Hystrix 3: 21–29. [In Italian with English summary]

Lovari S., Valier P. and Ricci Lucchi M. 1994. Ranging behaviour and activity of red foxes in relation to environmental variables, in a Mediterranean mixed pinewood. J. Zool., Lond. 232: 323–339.

Macdonald D. W. 1981. Resource dispersion and the social organization of the red fox (*Vulpes vulpes*). Worldwide Furbearer Conference Proceedings, University of Maryland Press, Frostburg, MD: 918–949.

Macdonald D. W. 1983. The ecology of carnivore social behaviour. Nature 301: 379–384.

Maurel D. 1980. Home range and activity rhythm of adult male foxes during the breeding season. [In: A handbook on biotelemetry and radiotracking. C. J. Amlaner and D. W. Macdonald, eds]. Pergamon Press, Oxford, U.K.: 697–701.

Nakazono T. 1989. The habitat utilization pattern of Japanese red fox, *Vulpes vulpes japonica*, in Kyushu. Honyurui Kagaku (Mammalian Science) 29: 51–62.

Neu C. W., Byers C. R. and Peek J. M. 1974. A technique for analysis of utilization – availability data. J. Wildl. Manage. 38: 541–545.

Phillips M. and Catling P. C. 1991. Home range and activity patterns of red foxes in Nadgee Nature Reserve. Wildl. Res. 18: 677–686.

Prigioni C. and Tacchi F. 1991. Trophic niche of the red fox *Vulpes vulpes* in the Ticino valley. Hystrix 3: 65–75.

Reynolds P. 1979. Preliminary observations on the food of the fox (*Vulpes vulpes* L.) in the Camargue, with special reference to rabbit (*Oryctolagus cuniculus* L.) predation. Mammalia 43: 295–307.

Solow A. R. 1989. A randomization test for independence of animal locations. Ecology 70: 1546–1549.

Spencer W. D. and Barrett R. H. 1984. An evaluation of the harmonic mean measure for defining carnivore activity areas. Acta zool. Fenn. 171: 255–259.

Stüwe M. and Blohwiak C. E. 1989. McPAAL. Micro-computer Programs for the Analysis of Animal Locations. Ver. 2.0. Smithsonian Institution, Front Royal, VA, USA.

Swihart R. K. and Slade N. A. 1985. Testing for independence of observations in animal movements. Ecology 66: 1176–1184.

Theberge J. B. and Wedeles C. H. R. 1989. Prey selection and habitat partitioning in sympatric coyote and red fox populations, southwest Yukon. Can. J. Zool. 67: 1285–1290.

Thomas D. L. and Taylor E. J. 1990. Study designs and tests for comparing resource use and availability. J. Wildl. Manage. 54: 322–331.

Voigt D. R. and Macdonald D. W. 1984. Variation in the spatial and social behaviour of the red fox, *Vulpes vulpes*. Acta zool. Fenn. 171: 261–265.

Voigt D. R. and Tinline R. R. 1980. Strategies for analyzing radio tracking data. [In: A handbook on biotelemetry and radiotracking. C. J. Amlaner and D. W. Macdonald, eds]. Pergamon Press, Oxford, U.K.: 387–404.

Worton B. J. 1989. Kernel methods for estimating the utilization distribution in home-range studies. Ecology 70: 164–168.

Zar J. H. 1984. Biostatistical analysis. Second ed. Prentice-Hall, Inc., Englewood Cliffs, New Jersey: 1–718.

Zimen E., ed. 1980a. The red fox. Biogeographica Vol. 18. W. Junk B.V. Publishers, The Hague, The Netherlands: 1–285.

Zimen E. 1980b. A short history of human attitudes towards the fox. [In: The red fox. Biogeographica Vol. 18. E. Zimen, ed]. W. Junk B.V. Publishers, The Hague, The Netherlands: 1–6.

Zimen E. 1984. Long range movements of the red fox, *Vulpes vulpes* L. Acta zool. Fenn. 171: 267–270.

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Research Article

Habitat Use by Meso-Predators in a Corridor Environment

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Abstract

Red foxes (Vulpes vulpes), raccoons (Procyon lotor), and striped skunks (Mephitis mephitis) are found throughout the United States, wherever there is suitable denning habitat and food resources. Densities of these predators have increased throughout the Intermountain West as a consequence of human alterations in habitat. Within the Bear River Migratory Bird Refuge (hereafter, refuge), in northern Utah, USA, upland nesting habitat for ducks is limited to the levee banks and roadsides. Red foxes, raccoons, and striped skunks, which prey on upland nesting birds, are also abundant on the refuge. We studied red foxes, raccoons, and striped skunks' use of levees and the edges associated with them within a wetland environment. Red fox, raccoon, and striped skunk locations were negatively correlated with distance to the nearest dike (−0.78, −0.69, and −0.45, respectively). Animals incorporated more roads and/or levees into their home ranges than expected by chance ($\bar{x} = 2.6$; $Z < 0.001$); incorporation of levees was greater during the dispersal season than the rearing season ($P = 0.03$). Skunk home ranges (average size, 3.0 km^2) were oriented along roads and levees ($P = 0.03$), whereas raccoon (average size, 3.6 km^2) and fox home ranges (average size, 3.5 km^2) were not ($P = 0.93$, $P = 0.13$, respectively). Fox home ranges in the refuge were more oblong in shape than reported elsewhere ($P = 0.03$). However, home-range shapes of raccoons and striped skunks were similar to previous studies ($P = 0.84$, $P = 0.97$, respectively). The use of roads and levees within the refuge increases the possible travel distance and penetration of predators into wetland environments. This contributes to increased depredation of waterfowl nests and to decreased recruitment. Managers of similar areas might decrease depredation of waterfowl by disrupting the linear pattern of corridors, thereby decreasing the congestion of animal roads and levees. This would, then, decrease the encounter rates of predators and prey. (JOURNAL OF WILDLIFE MANAGEMENT 70(4):1111–1118; 2006)

Key words

Corridors, habitat use, linear habitat, predators, raccoon, red fox, striped skunk, waterfowl.

Historically, in the Intermountain West of the United States, suitable denning and foraging habitat for red foxes and raccoons was limited. Much of this region was characterized by dry, arable land, dominated by sagebrush and grasses (Foote 1989, Wagner 1995). However, human settlement of the land in the Intermountain West, especially irrigated agriculture, increased the distribution of water throughout the dry landscape. Subsequently, populations of red foxes and raccoons increased in Utah, USA, although neither species was native to the area (Durrant 1952, Zeveloff 1988, Garrettson et al. 1996).

Federal and state wildlife management agencies in Utah, USA, developed several waterfowl management areas during the early 1900s, principally around river deltas flowing into the Great Salt Lake (GSL). Often, the wetland refuges were created by developing levees to impound river water coming into the GSL. Originally created as oases for migratory birds, these wetlands have also become a haven for meso-predators, which prey upon migratory and nesting birds, their nests, and their young.

Agricultural field edges, footpaths, roads, right-of-ways, and similar openings into a habitat may serve as corridors for predators, increasing access into an environment (Askins 1994, Urdang 1995). Furthermore, such corridors may serve to attract and funnel predators into an area, thereby increasing prey exposure and risk (Kuehl and Clark 2002). Ease of travel provided by small roads or paths increases predator travel speed; thus, they can hunt more ground in less time.

Halpin and Bissonette (1988) noted that foxes used roads and trails to travel through habitat when there was snow cover. Similarly, raccoons usually display directed foraging, moving along edges and corridors to access a hunting area (Urban 1970, Hoffman and Gottschang 1977, Ough 1979). The use of roads may be more pronounced in flooded marshes because predators may be able to move much faster, with less energy expenditure, by traveling on levees rather than wading through marshes.

Many species of waterfowl and game birds use upland areas adjacent to wetlands for nesting (Greenwood and Sovada 1996). For wetlands such as the Bear River Migratory Bird Refuge, which was created by a system of levees, upland habitat is often restricted to the levees and the roads built on top of them. These areas may also concentrate alternative prey for mammalian predators, such as small mammals and invertebrates. Thus, increased depredation of nesting birds or eggs at times may be an opportunistic response to a resource found while searching for other prey in the same area (Cowardin et al. 1983). When nesting areas consist entirely of linear strips of habitat along dirt roads and levee banks, there is an increased chance of predators locating hens and their nests while moving through the area.

Few studies on mammalian corridor use have focused on small- to medium-sized predators. Previous studies of predator–prey interactions along corridors suggest that the predator use of human trails and roads increases the depredation rate of prey (Trewhella and Harris 1990, James and Stuart-Smith 2000). Our objective was to determine how red foxes, raccoons, and striped skunks use levee roads, and the edges associated with them, within a wetland environment. We hypothesized that if red foxes, raccoons, and striped skunks were attracted to levees and dirt roads, their home range might reflect a linear shape. Additionally,

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their home ranges might reflect the propensity to incorporate roads into space-use patterns. If predators are using similar vegetation types as upland nesting waterfowl, as well as increasing their use of habitat via roads and levees, then there might be an increased potential for predators to impact waterfowl recruitment.

Study Area

The Bear River Migratory Bird Refuge was created in 1928 from the delta of the Bear River, near the northeastern end of the GSL, Utah, USA. The refuge, with more than 65,000 ha of wetlands, was created to increase feeding and breeding grounds for migratory birds. We conducted our study in the delta section of the refuge, which contained >26,000 ha of wetland habitat. Historically, this area supported the highest densities of nesting waterfowl before the GSL flood. This section of the refuge was created by a system of levees that control the flow of the Bear River into the GSL (Williams and Marshall 1938; Fig. 1). The topography was relatively flat, falling approximately 0.1 m/km to the south, with most elevation at 1,280 m. The area experienced moderate spring and fall seasons, with dry hot summers and short, cold winters. Summer temperatures often exceed 38°C, whereas winters sometimes fell below −23°C. The average annual precipitation ranged from 29 cm in the eastern side of the refuge to 31 cm in the western portion (A. Trout, U.S. Fish and Wildlife Service, unpublished report).

Before 1983, the delta of the refuge was the predominant nesting area for most of the duck species nesting within the refuge, and many other avian species foraged there (Williams and Marshall 1938). The average annual waterfowl production during 1953–1964 was 41,000 ducklings, 2,000 goslings, and 8,000 coots (A. F. Halloran, United States Fish and Wildlife Service, unpublished report). In 1983, the GSL flooded, covering the refuge with salt water for more than 7 years and destroying most of the dikes along with all vegetation (Foote 1989).

During the time that the refuge was under water, red foxes and raccoons, which were previously rare in the area, set up residence around the refuge. As a consequence of the flood and the arrival of these new predators, as few as 100 ducklings per year were produced during the 2000 nesting season at the refuge, as compared with historical levels of more than 79,000 in 1964 (A. F. Halloran, unpublished data). During our study, mammalian predators were identified as the main predators of duck nests at the refuge. Therefore, refuge managers believed mammals to be the primary impediment preventing waterfowl production from returning to historic levels.

Methods

Establishing Predator Locations

We trapped and radiocollared red fox, raccoon, and striped skunk from December 1999 to February 2000. We trapped foxes using neck snares, with deer stops fixed to them, and with foothold traps (Meia and Weber 1995). We trapped raccoons and skunks with box traps baited with commercial cat food (Endres and Smith 1993). To handle the trapped animals, we tranquilized each animal using 0.1 mg/kg of an acepromazine/ketamine mixture (0.01 mg acepromazine and 0.09 mg ketamine; Bigler and Hoff 1974). We then sexed, weighed, and ear-tagged trapped animals with a numbered tag. We only fitted raccoons and foxes weighing >5 kg and skunks weighing >1.5 kg with a radiocollar (Advanced Telemetry Systems, Isanti, Minnesota) to minimize the collaring of subadults (Major and Sherbourne 1987, Gehrt and Fritzell 1998). Upon recovery from the tranquilizer, the animals were released on-site. We conducted trapping periodically to maintain a base level of 10 radiocollared animals per species.

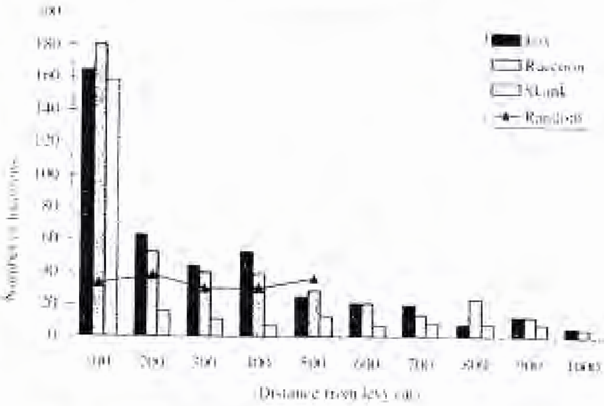

Figure 1. Number of locations of red foxes, raccoons, and striped skunks located within 1,000 m from the nearest levee or road, Bear River Migratory Bird Refuge, Utah, USA, 2000–2002.

We radiotracked animals throughout the day by dividing the day into 3 time periods: 1) 0800–dusk, 2) dusk to midnight (in winter, this time period was usually from 1800 to 2400 hours), and 3) midnight to dawn (this period was usually from 2400 to 0600 hours, extending to 0700 at the longest part of winter). During each daylight radiotracking session, we visually located animals. Upon locating the animal, we recorded its position using a handheld Global Positioning System (GPS) unit (Magellan Tracker, Thales Navigation, Inc.). During each nocturnal radiotracking session, we estimated animals' locations using triangulation (Mech 1983).

To triangulate the study animals, we drove the levees to find a frequency. Upon hearing a signal, we acquired a bearing for the animal. We then drove to another location to obtain a second bearing. We obtained 2–3 bearings for each location; 3 bearings were preferred. We obtained subsequent bearings within 10 minutes of the last bearing, to minimize the error attributed to animal movement. Bearings were also >20° and <160° apart from each other to further minimize error (Kitchen et al. 2000). There were times when travel by motor vehicles affected the movements of the radiocollared animals; therefore, we discarded locations characterized with sudden predator movements (Ellis 1964).

We analyzed triangulated bearings using the software package Locate (Pacer, Truro, Nova Scotia, Canada) to obtain an estimated location for a particular animal. Locate established an error estimate for locations determined by 3 points. We deleted all estimated locations with an associated error >100 m. In addition, we randomly placed test collars, which were collars unattached to animals, in the refuge so that estimation error for each technician could be established. Each technician triangulated test collars twice a year to maintain a level of integrity through minimal triangulation error.

Linear Aspects of Use

Correlation with levees and roads.—We investigated the relationship between the number of animals found and the distance from the nearest levy. To avoid any bias created by telemetry error, we only analyzed the locations of red foxes, raccoons, and striped skunks that we found visually during the day. Visual observations were exact locations, whereas we estimated the majority of nighttime locations using triangulation. We established visual locations by using radiotelemetry to find the approximate location of the animal within the refuge. Once we detected a radiosignal, we walked or canoed toward the origin of the signal until we acquired a visual sighting of the target animal. We used a handheld GPS to record the animal's location at the time that it was sighted. Often, we found animals while they were sleeping or in dens. However, sometimes we spotted an animal as it arose from its resting spot. When this occurred, we walked to where the animal was when we first sighted it, and we took the GPS location from that spot. However, sometimes when trying to obtain a visual location, it became apparent, through the bearing estimates, that the target animal was moving, although we couldn't see it. In those circumstances, we did not record a visual location, and we did not use that data in analysis of location to the nearest road.

Once we collected the locations, we examined the distance of each animal's location to the nearest levee of the refuge, using GIS/ArcInfo (ESRI, Redlands, California). First, we calculated the distance from each visually sighted location to the nearest road, regardless of the road's condition or use. Then, we grouped those distances into 10-m intervals, up to 1,000 m from the nearest road, and we calculated the number of locations in each interval. We chose 10 m as the distance interval because that was the average width of a levee and its banks; thus, distances of 0–10 m from a road would indicate animals located on a levee. Next, we conducted a nonparametric correlation test of interval data, using Pearson Correlation Coefficients in Statistical Analysis Software (Version 8, SAS Institute, Cary, North Carolina) to determine the relationship between the number of locations found in each interval and the distance from the nearest levee. We hypothesized that the number of animals in each interval would decrease as the distance from the nearest levee increased.

If there was a correlation between the roads and locations, it could have been an effect of the distribution of roads. Therefore, using a random-number generator, we created a subset of 500 locations to compare with the distribution of actual locations. Following the same procedure for fox, raccoon, and skunk locations, we calculated the number of random locations within each 10-m interval. Then, we executed a Pearson Correlation Coefficients test to determine this subset's relationship with distance from the nearest levee. Finally, we compared the random location data set with the locations of red foxes, raccoons, and striped skunks in the refuge, using a Mann–Whitney U test for nonparametric statistics.

Incorporation of roads into home ranges.—The number of roads incorporated into an individual's home range may reflect the extent to which predators prefer home ranges that contain roads. To determine that, we compared the observed number of roads and levees within an animal's home range on the refuge to the expected number of roads. Using ArcView (ESRI), we estimated a home range area for each study animal (95% minimum convex polygon) for the rearing and dispersal season. We defined the rearing season as March 15–July 15; the dispersal season lasted from July 15–November 15 (Kitchen et al. 2000). For each home range, we determined the number, length (km), and location of roads that were used within a home range. To estimate expected use, we randomly placed 10 polygons onto a map of the refuge and its roads, and we calculated the length of levees overlapped by each polygon. Each polygon represented a home range of 3.5 km^2, which is the average size of a fox and raccoon home range within the refuge (Frey 2004), to the scale of the map of the refuge. Next, we conducted a signed-rank, nonparametric t-test, comparing the relationship of the levees (no. of roads used, total kilometers of roads, location of home range) in the randomly created home ranges to those of the observed home ranges. We repeated this process 10 times for comparison.

Orientation of home ranges.—We also evaluated the importance of the location of a road or trail within each home range. Roads and trails may be randomly incorporated into the home ranges, or animals may orient their home ranges around roads. For each home range, we determined the largest axis, which was the longest straight line that could be drawn through the home range. Then, we measured the angle created by the crossing of this axis with the nearest road. In the event that >1 road was incorporated into a home range, we used the measurement for the intersection of the axis with the longest road within the home range. If home ranges were randomly oriented in the habitat relative to roads, then the mean angle between this created axis and the road incorporated in the home range should be 45°, with a range from 0° (parallel) to 90° (perpendicular). If home ranges were oriented along roads, the mean angle between the axis and the incorporated road would be similar to 0°; home ranges arranged perpendicular to roads would have a mean angle similar to 90°. Therefore, we conducted a signed-rank nonparametric t-test to determine whether home-range axes were randomly oriented around roads and trails ($\overline{x} = 45°$), oriented along roads ($\overline{x} < 45°$) or oriented away from roads ($\overline{x} > 45°$).

Shape of home range.—If the study animals frequently used roads and areas near them, their home ranges should reflect that. If a predator makes extensive use of levees and roads, its home range should be linearly shaped. To determine whether animals within the refuge were using roads extensively, we measured the length-to-width ratio of each red fox, raccoon, and striped skunk home range (95% minimum convex polygon). A circular or square home-range shape would have a ratio close to 1. The more linear the shape of the home range, the larger the length-to-width ratio would be. To compare the findings of the home-range shape of the refuge to other regions of the world, we examined literature concerning home ranges, territories, and habitat use for foxes, raccoons, and striped skunks (Table 1). We used only articles with figures of home ranges for analysis. For each figure, we measured the length and width of the printed home range, in millimeters. Then, we created a length-to-width ratio from those measurements, for comparison.

Table 1. Published literature used to establish mean length-to-width ratios for home-range shape-comparisons of red foxes, raccoons, and striped skunks.

Species	Reference	$\bar{x}$ ratio	Region	Setting	n[a]
Raccoon	Fritzell (1978)	1.46	N.D.	Rural	8
Raccoon	Gehrt and Fritzell (1998)	1.66	Tex.	Rural	3
Raccoon	Jordan (1986)	1.36	Md.	Rural	11
Raccoon	Slate (1985)	2.29	N.J.	Suburban	19
Red fox	Adkins and Scott (1998)	2.13	Toronto, Canada	Suburban	4
Red fox	Coman et al. (1991)	2.00	Victoria, Australia	Rural	4
Red fox	Harris (1980)	1.50	Bristol, United Kingdom	Urban	8
Red fox	Hough (1980)	1.42	Oxford, United Kingdom	Urban	4
Red fox	Jones and Theberge (1982)	3.00	B.C., Canada	Rural	4
Red fox	Klett (1978)	2.22	La.	Rural	4
Red fox	MacDonald and Newdick (1980)	2.14	Oxford, United Kingdom	Urban	10
Red fox	Meek and Saunders (2000)	2.47	N.S.W., Australia	Suburban	5
Red fox	Meia and Weber (1995)	1.63	Switzerland	Rural	4
Red fox	Pandolfi et al. (1997)	1.85	Italy	Rural	5
Red fox	Phillips and Catling (1991)	1.87	SE Australia	Rural	5
Red fox	Poulle et al. (1994)	1.55	France	Rural	5
Red fox	Sargeant (1972)	1.56	Minn.	Rural	3
Red fox	Saunders et al. (2002)	1.72	N.S.W., Australia	Rural	8
Red fox	Schloeder (1988)	1.42	W.Va.	Rural	3
Red fox	Sunquist (1989)	1.80	Fla.	Rural	4
Red fox	Travaini et al. (1993)	1.31	Spain	Rural	7
Red fox	Tsukada (1997)	1.75	Japan	Rural	6
Red fox	White et al. (1996)	1.71	Bristol, United Kingdom	Urban	5
Striped skunk	Bixler and Gittleman (2000)	3.54	Tenn.	Rural	12
Striped skunk	Lariviere and Messier (1998)	1.78	Sask., Canada	Rural	18

[a] Abbreviation: n, number of home ranges.

Using past studies, we measured 98 red fox home ranges in 16 regions of the world in urban, suburban, and rural settings. Additionally, we measured the shapes of 41 raccoon home ranges, from 5 regions in North America, in rural and suburban settings. Published literature of striped skunk home ranges was scarcer; therefore, we used only 30 home ranges from 2 studies, in 2 regions of North America. Both were in rural settings (Table 1).

Next, we conducted an ANOVA using Statistical Analysis Software (SAS) to compare the length-to-width ratios of home ranges for each species from our study with those calculated from the literature; this allowed us to determine whether the shapes of the home ranges of our study animals differed from those reported in past studies.

Results

Linear Aspects of Use

Distance from levee or road.—For each species, we found most locations within 1,000 m of the nearest levee. There were 418 raccoon locations (99.5% of all day locations) within 1,000 m of the nearest levee. There was a strong inverse correlation between the distance from the nearest levee and the number of raccoon locations. In other words, we counted fewer animals as the distance interval increased ($r = -0.69$, $P < 0.001$; Figs. 1, 2). We found similar results for red foxes. We recorded 418 locations (100%) for foxes within 1,000 m of the nearest levee. Fewer fox locations occurred as the distance from the levee increased ($r = -0.78$, $P < 0.001$; Figs. 1, 2). We recorded 237 locations (100%) for skunks within 1,000 m of the nearest levee. We found fewer skunk locations as the distance from a levee increased ($r = -0.45$, $P < 0.0001$; Figs. 1, 2).

In contrast, there was no correlation to the number of random locations found within each distance interval ($r = -0.19$, $P = 0.54$; Figs. 1, 2). Random points were distributed differently than actual red fox (df = 1, $U = 2{,}945$, $P = 0.004$), raccoon (df = 1, $U = 2{,}793$, $P = 0.06$), and skunk (df = 1, $U = 3{,}090$, $P = 0.001$) locations.

Incorporation of roads.—Within the refuge, actual home ranges incorporated an average of 2.5 roads, whereas mean expected home range incorporated 1.3 roads. The difference between actual and randomly located home ranges was significant ($\chi^2 = 38.32$, df = 7, $P < 0.001$). Red fox, raccoon, and striped skunk home ranges incorporated a similar number of roads within their home ranges ($F = 0.40$, df = 2, $P = 0.68$; Fig. 3). The study animals incorporated more roads within home ranges during the dispersal season than in the rearing season ($F = 5.30$, df = 1, $P = 0.03$; Fig. 3).

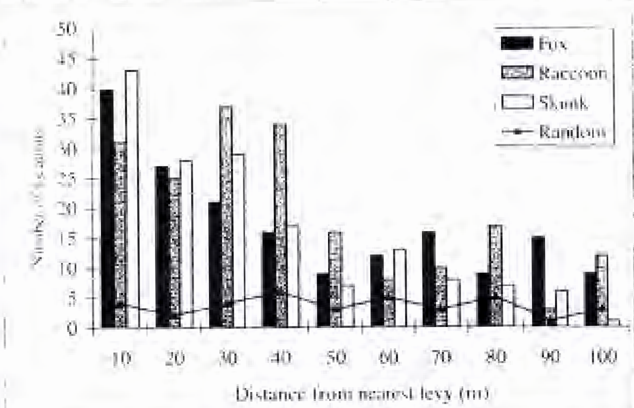

Figure 2. Number of locations of red foxes, raccoons, and striped skunks located within 100 m of the nearest levee or road, Bear River Migratory Bird Refuge, Utah, USA, 2000–2002.

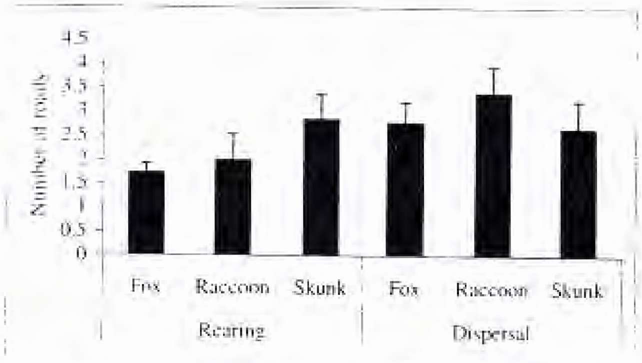

Figure 3. Mean number of roads contained within home ranges by red foxes, raccoons, and striped skunks on Bear River Migratory Bird Refuge, Utah, USA, 2000–2002.

Red fox home ranges incorporated 3.5 km of roads during the dispersal season and 3.4 km of roads during the rearing season (Table 2, Fig. 4). Raccoon home ranges incorporated an average of 7.1 km of roads during the dispersal season and 3.3 km during the rearing season (Table 2, Fig. 5). Additionally, skunks had, in their home ranges, an average of 5.2 km of roads during the dispersal season and 3.2 km during the rearing season (Table 2, Fig. 6). The length (km) of roads incorporated into the home ranges of each species was similar ($F = 0.51$, df $= 2$, $P = 0.61$). Study animals incorporated more kilometers of roads into home ranges during the dispersal season than the rearing season ($F = 6.28$, df $= 1$, $P = 0.02$). Study animals' home ranges in the refuge incorporated more kilometers of roads than home ranges that were randomly placed in the refuge ($t = 4{,}893$, $P < 0.001$). Home ranges were not oriented along roads for foxes ($\bar{x} = 33.7°$, $S = -4$, $P = 0.89$), raccoons ($\bar{x} = 44.5°$, $S = -7$, $P = 0.85$), or skunks ($\bar{x} = 23.3°$, $S = -14.5$, $P = 0.34$).

Shape of home ranges.—Red fox and raccoon home ranges on the refuge had length-to-width ratios of 2.1 and 1.8, respectively (Table 3). Home ranges of red foxes and raccoons calculated from past studies had mean length-to-width ratio of 1.8 and 1.7, respectively (Table 3). Skunk home ranges in the refuge had mean length-to-width ratios of 2.5 (Table 3). Skunk home ranges figured in past studies had a mean length-to-width ratio of 2.5 (Table 3). The length-to-width ratios of red fox home ranges in the refuge were greater than those figured in previous studies ($t = 2.34$, df $= 32$, $P = 0.03$). However, home range length-to-width ratios of raccoons and skunks in the refuge were similar to those figured in previous studies ($t = -0.21$, df $= 65$, $P = 0.84$; $t = 0.04$, df $= 20$, $P = 0.97$; respectively).

Table 2. Mean kilometers of roads incorporated into raccoon, red fox, striped skunk home ranges, by season, compared with the expected value, Bear River Migratory Bird Refuge, Utah, USA, 2000–2002.

Factor	Season	*n* polygons	$\bar{x}$	SE
Raccoon	Rearing	12	3.3	1.1
	Dispersal	12	7.1	1.4
Red fox	Rearing	11	3.4	0.5
	Dispersal	8	3.5	0.5
Striped skunk	Rearing	7	3.2	0.7
	Dispersal	5	5.2	2.2
Expected	—	90	2.3	0.2

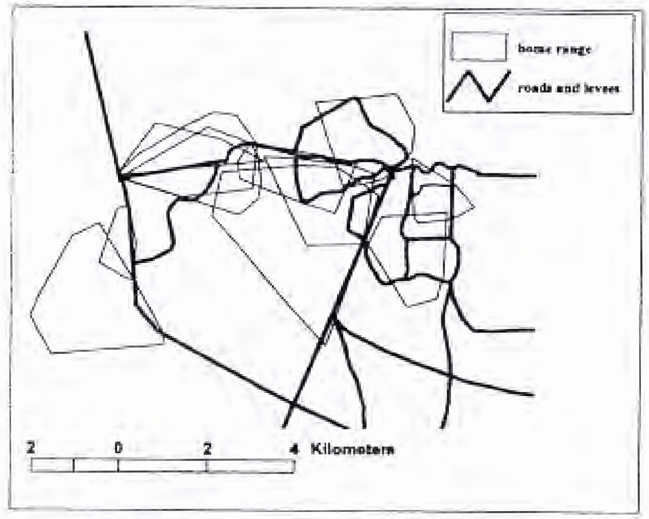

Figure 4. Location of fox home ranges (95% minimum convex polygon) during the rearing season in relation to the roads and levees present on Bear River Migratory Bird Refuge, Utah, USA, 2000–2002.

Discussion

Use of Levees and Roads

Red foxes, raccoons, and striped skunks concentrated their day activities to the levees of the refuge. Additionally, roads were also a focus of these predators' activities, as evidenced by the presence of the roads in the animals' home ranges. During periods of high water, red foxes and striped skunks probably relied on the dense vegetation found along the levees for dry, sheltered resting sites. Because of their ability to travel through shallow water and forage for aquatic invertebrates and fish (Dorney 1954, Urban 1970),

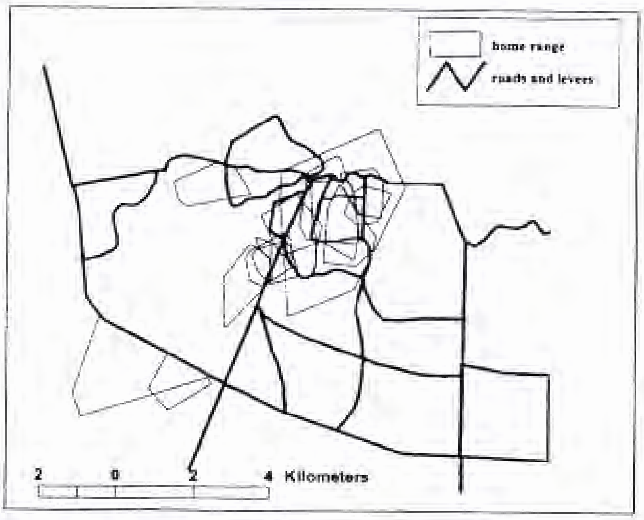

Figure 5. Location of raccoon home ranges (95% minimum convex polygon) during the rearing season in relation to the roads and levees present on Bear River Migratory Bird Refuge, Utah, USA, 2000–2002.

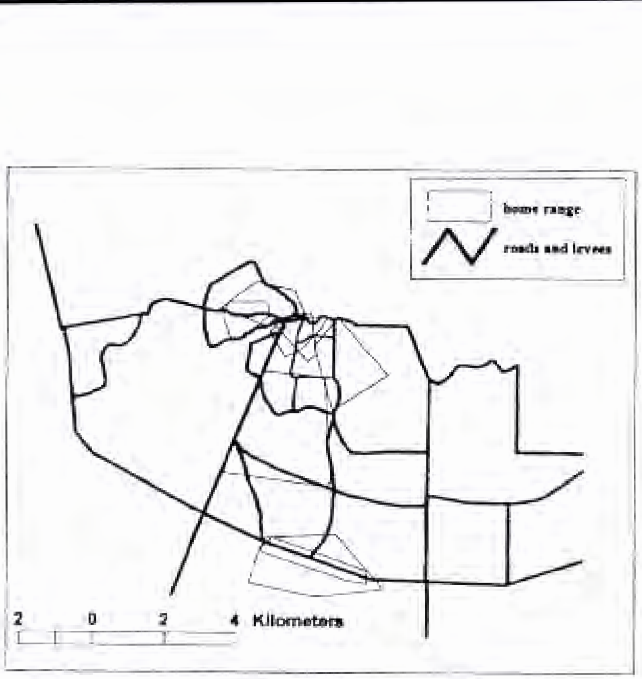

Figure 6. Location of striped skunk home ranges (95% minimum convex polygon) during the rearing season in relation to the roads and levees present on Bear River Migratory Bird Refuge, Utah, USA, 2000–2002.

raccoons were probably less dependent on the levees during the high-water periods. Instead, they could spend the day resting on matted rushes within emergent vegetation. During low-water periods, the majority of vegetation was found along the banks and wet meadows, possibly contributing to the linearity of day locations and home-range shapes.

Our results only took into account day locations; however, our study animals were active in the crepuscular and nocturnal time periods. Whereas these animals are also known to have limited movements during the day, it can be said that day locations classified as resting periods for our study animals. Although we could not definitively determine how linear the home ranges would be during the night, without incorporating a large error bias, we could make some inferences.

Even during times of low water, such as during summer months, the levees contained more suitable vegetative cover for nesting ducks than other sections of the refuge, and most ducks selected the levees as resting sites (Williams and Marshall 1938). Frey (1994) determined that red foxes, raccoons, and striped skunks were attracted to areas with emergent vegetation (found predominantly along the levee banks), presumably via their search for food. Thus, waterfowl nesting along the dikes increased the foraging opportunities for predators there. Additionally, wetland edges provided a diverse array of prey items (Greenwood et al. 1999), which may have increased the attractiveness of this habitat for striped skunks (Phillips et al. 2003). The shallow water along the edges of the levees also provided the opportunity for raccoons to capture carp and, consequently, would be an area for scavenging by skunks and red foxes. Therefore, it is logical to determine that these predators were continuing to use the areas close to the levee banks even after they awoke.

The levee banks were also the only source of upland habitat available for den sites within the refuge. During late spring–early summer, when mothers were denning and before young animals left the dens, parental red foxes, raccoons, and striped skunks would necessarily be restricted to the levee banks during the day. This may have impacted our results slightly. The effect of denning was limited by the fact that we collected data year-round, not just during the rearing season. Additionally, only a fraction of our study animals (females of each species and male foxes) were involved in rearing young. Those animals not responsible for rearing young would not necessarily be limited to the levee banks during the birthing and early rearing periods.

The use of these roads and trails while foraging may have increased the distance traveled and the amount of hunting ground covered by predators in a night. That increased the opportunity for predators to locate and depredate foraging and nesting waterfowl and shorebirds. Phillips et al. (2003) suggested that patches of habitat that were repeatedly selected by predators are likely to be efficiently searched, with high levels of depredation in those specific areas. If foxes, raccoons, and skunks on the refuge were searching the habitat along the roads and trails within their home range on a daily basis, the result may be an increased likelihood that any nest located there would be found by at least one predator.

Table 3. Comparison of home range length-to-width ratios of red foxes, raccoons, and striped skunks from past studies to Bear River Migratory Bird Refuge, Utah, USA, 2000–2002.

	Data set					
	BRMBR[a]			Literature		
Species	n[a]	$\bar{x}$ ratio	SE	n	$\bar{x}$ ratio	SE
Raccoon	26	1.8	0.11	41	1.8	0.15
Red fox	23	2.1	0.17	53	1.7	0.08
Striped skunk	12	2.5	0.63	30	2.5	0.4

[a] Abbreviations: BRMBR, Bear River Migratory Bird Refuge; n, number of independent home-range polygons.

Home-Range Shape

Theoretically, a circular home range or one with a length-to-width ratio of 1 would be the most energetically efficient shape in terms of reaching the most area with the least movement (Ables 1969). This is assuming that resources were evenly distributed across the landscape and that the predator started foraging from the center of its home range each evening. We hypothesized that in linear environments, such as the refuge, resources were not distributed evenly, and predators would have a linearly shaped home range rather than circular. However, we found that length-to-width ratios for raccoons and striped skunks were similar to those reported elsewhere and not linear. Yet, red foxes had higher length-to-width ratios on the refuge than home ranges reported elsewhere. This may have occurred because red foxes used the refuges roads for travel more than the other 2 predator species.

Predator uses of levees and roads have implications for the success of nesting birds in managed wetlands. Historically, nesting waterfowl in the refuge used vegetation cover on the banks of the levees as nesting habitat (Williams and Marshall 1938, Crabtree 1983). However, at the time of our study, raccoons, striped skunks, and red foxes were making extensive use of the same habitat as nesting waterfowl. Few duck nests located on the refuge's levees could complete nest incubation without being located by a predator. Hence, there was little duck production in the refuge during the years of our study because of high rates of nest predation.

Management Implications

We recommend that methods to create a spatial separation between the levee habitat used by predators and the habitat used by waterfowl would be beneficial to the management of this refuge and similar habitats. Essentially, managers might try to disrupt the linear nature of the refuge to reduce the ease of travel and congestion of activity in these areas. Additionally, we recommend that managers interested in increasing waterfowl recruitment in corridor environments consider methods to control predator numbers during the waterfowl-nesting season when the use of the dikes by both predators and prey are greatest.

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Literature Cited

Ables, E. D. 1969. Home range studies of red foxes. Journal of Mammalogy 50:108–122.

Adkins, C. A., and P. Stott. 1998. Home ranges, movements and habitat associations of red foxes, *Vulpes vulpes*, in suburban Toronto, Ontario, Canada. Journal of Zoology (London) 244:335–346.

Askins, R. A. 1994. Open corridors in a heavily forested landscape: impact on shrubland and forest-interior birds. Wildlife Society Bulletin 22:339–347.

Coman, B. J., J. Robinson, and C. Beaumont. 1991. Home range, dispersal and density of red foxes (*Vulpes vulpes*) in Central Victoria. Wildlife Research 18:215–223.

Cowardin, L. M., A. B. Sargeant, and H. F. Duebbert. 1983. Problems and potentials for prairie ducks. The Naturalist 34(4):4–11.

Crabtree, R. L., L. S. Broome, and M. L. Wolfe. 1983. Effects of habitat characteristics on gadwall nest predation and nest-site selection. Journal of Wildlife Management 53:129–137.

Dorney, R. S. 1954. Ecology of marsh raccoons. Journal of Wildlife Management 2:217–225.

Durrant, S. D. 1952. Mammals of Utah, taxonomy and distribution. University of Kansas, Lawrence, USA.

Ellis, R. J. 1964. Tracking raccoons by radio. Journal of Wildlife Management 28:363–368.

Endres, K. M., and W. P. Smith. 1993. Influence of age, sex, season and availability on den selection by raccoons within the Central Basin of Tennessee. American Midland Naturalist 129:116–131.

Foote, A. L. 1989. Response of nesting waterfowl to flooding in Great Salt Lake wetlands. Great Basin Naturalist 4:614–617.

Frey, S. N. 2004. Habitat use and movements of predators on a managed waterfowl refuge. Dissertation, Utah State University, Logan, USA.

Fritzell, E. K. 1978. Habitat use by prairie raccoons during the waterfowl breeding season. Journal of Wildlife Management 42:118–127.

Garrettson, P. R., F. C. Rohwer, J. M. Zimmer, B. J. Mense, and N. Dion. 1996. Effect of mammalian predator removal on waterfowl and non-game birds in North Dakota. Transactions of the North American Wildlife and Natural Resource Conference 61:94–101.

Gehrt, S., and E. K. Fritzell. 1998. Resource distribution, female home range dispersion and male spatial interactions: group structure in a solitary carnivore. Animal Behaviour 55:1211–1227.

Greenwood, R. J., A. B. Sargeant, J. L. Piehl, D. A. Buhl, and B. A. Hanson. 1999. Foods and foraging of prairie skunks during the avian nesting season. Wildlife Society Bulletin 27:823–832.

Greenwood, R. J., and M. A. Sovada. 1996. Prairie duck populations and predation management. Transactions of the North American Wildlife and Natural Resources Conference 61:31–42.

Halpin, M. A., and J. A. Bissonnette. 1988. Influence of snow depth on prey availability and habitat use by red fox. Canadian Journal of Zoology 66:587–592.

Harris, S. 1980. Home ranges and patterns of distribution of foxes (*Vulpes vulpes*) in an urban area, as revealed by radiotracking. Pages 685–690 *in* C. J. Amlaner and D. W. MacDonald, editors. A handbook on biotelemetry and radiotracking. Pergamon, Oxford, England.

Hoffman, C. O., and J. L. Gottschang. 1977. Numbers, distribution, and movements of a raccoon population in a suburban residential community. Journal of Mammalogy 58:623–636.

Hough, N. G. 1980. The ranging behavior of a maturing female red fox, *Vulpes vulpes*. Pages 691–696 *in* C. J. Amlaner and D. W. MacDonald, editors. A handbook on biotelemetry and radiotracking. Pergamon, Oxford, England.

James, A. R. C., and A. K. Stuart-Smith. 2000. Distribution of caribou and wolves in relation to linear corridors. Journal of Wildlife Management 64:154–159.

Jones, D. M., and J. B. Theberge. 1982. Summer home range and habitat utilization of the red fox (*Vulpes vulpes*) in a tundra habitat, northwest British Columbia. Canadian Journal of Zoology 60:807–812.

Jordan, R. A. 1986. Raccoon use of farmland habitats on Remington Farms. Thesis, West Virginia University, Morgantown, USA.

Kitchen, A. M., E. M. Gese, and E. R. Schauster. 2000. Long-term spatial stability of coyote (*Canis latrans*) home ranges in southeastern Colorado. Canadian Journal of Zoology 78:458–464.

Klett, S. B. 1978. Home ranges, movement patterns, habitat use and interspecific interactions of red foxes and coyotes in northwest Louisiana. Thesis, Colorado State University, Ft. Collins, USA.

Kuehl, A. K., and W. R. Clark. 2002. Predator activity related to landscape features in northern Iowa. Journal of Wildlife Management 66:1224–1234.

Larivere, S., and F. Messier. 1998. Spatial organization of a prairie striped skunk population during the waterfowl nesting season. Journal of Wildlife Management 62:199–204.

MacDonald, D. W., and M. T. Newdick. 1980. The distribution and ecology of foxes (*Vulpes vulpes*) in urban areas. Urban Ecology 2:123–135.

Major, J. T., and J. A. Sherbourne. 1987. Interspecific relationships among coyotes, bobcats, and red fox in western Maine. Journal of Wildlife Management 51:606–616.

Mech, L. D. 1983. Handbook of animal radio-tracking. University of Minnesota, Minneapolis, USA.

Meek, P. D., and G. Saunders. 2000. Home range and movement of foxes (*Vulpes vulpes*) in coastal New South Wales, Australia. Wildlife Research 27: 663–668.

Mea, J. S., and J. M. Weber. 1995. Home ranges and movements of red foxes in central Europe: stability despite environmental changes. Canadian Journal of Zoology 73:1960–1966.

Ough, W. D. 1979. Influence of probability and magnitude of reward upon raccoon foraging behavior. Thesis, University of Nebraska, Lincoln, USA.

Pandolfi, M., P. Forconi, and L. Montecchiari. 1997. Spatial behaviour of the red fox (*Vulpes vulpes*) in a rural area of central Italy. Italian Journal of Zoology 64:351–358.

Phillips, M., and P. C. Catling. 1991. Home range and activity patterns of red foxes in Nadgee Nature Reserve. Wildlife Research 18:677–686.

Phillips, M. L., W. R. Clark, M. A. Sovada, D. J. Horn, R. R. Koford, and R. J. Greenwood. 2003. Predator selection of prairie landscape features and its relation to duck nest success. Journal of Wildlife Management 67:104–114.

Poulle, M. L., M. Artois, and J. J. Roeder. 1994. Dynamics of spatial relationships among members of a fox group (*Vulpes vulpes*). Journal of Zoology, London 233:93–106.

Sargeant, A. J. 1972. Red fox spatial characteristics in relation to waterfowl predation. Journal of Wildlife Management 36:225–236.

Saunders, G., J. McIlroy, M. Berghout, B. Kay, E. Gifford, R. Perry, and R. Van deVan. 2002. The effects of induced sterility on the territorial behaviour and survival of foxes. Journal of Applied Ecology 39:56–66.

Schloeder, C. A. 1988. Home ranges, habitat selection, and activity patterns of gray and red foxes in West Virginia. Thesis, West Virginia University, Morgantown, USA.

Slate, D. 1985. Movement, activity, and home range patterns among members of a high-density suburban raccoon population. Dissertation, Rutgers University, New Brunswick, New Jersey, USA.

Sunquist, M. E. 1989. Comparison of spatial and temporal activity of red foxes and gray foxes in north-central Florida. Florida Field Naturalist 17:11–18.

Travaini, A., J. J. Aldama, R. Laffitte, and M. Delibes. 1993. Home range and activity patterns of red fox, *Vulpes vulpes*, breeding females. Acta Theriologica 38:427–434.

Trewhella, W. J., and S. Harris. 1990. The effects of railway lines on urban fox numbers and dispersal movements. Journal of Zoology 221:321–326.

Tsukada, H. 1997. A division between foraging range and territory related to food distribution in the red fox. Journal of Ethology 15:27–37.

Urban, D. 1970. Raccoon populations, movement patterns, and predation on a managed waterfowl marsh. Journal of Wildlife Management 34:372–382.

Urdang, L. 1995. The American century dictionary. L. Urdang, editor. Oxford University, New York, New York, USA.

Wagner, F. H. 1995. Ecosystem management of natural resources in the Intermountain West. Utah State University, Logan, USA.

White, P. C. L., G. Saunders, and S. Harris. 1996. Spatio-temporal patterns of home range use by foxes (*Vulpes vulpes*) in urban environments. Journal of Animal Ecology 65:121–125.

Williams, C. S., and W. H. Marshall. 1938. Duck nesting studies, Bear River Migratory Bird Refuge, Utah. Journal of Wildlife Management 2:29–45.

Zeveloff, S. I. 1988. Mammals of the Intermountain West. University of Utah, Salt Lake City, USA.

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Factors Influencing Snowy Plover Nest Survival on Ocean-Fronting Beaches in Coastal Northern California

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Abstract.—Selection of a nest site that affords camouflage of eggs or incubating adults is thought to be strongly influenced by predation, especially for ground-nesting birds. Data from 115 Snowy Plover (*Charadrius nivosus*) nests were used to model relationships between nest survival, habitat characteristics, predator activity and human activity on four sandy, ocean-fronting beaches in coastal northern California from 2007-2009. Plover daily nest survival was higher at two southern sites (South Spit range = 0.98-0.99; Eel River Wildlife Area range = 0.91-0.96) compared with two northern sites (Mad River Beach range = 0.77-0.88; Clam Beach range = 0.79-0.89) where predator activity was appreciably higher. Nest survival was positively related to debris heterogeneity and negatively related to the amount of debris near the nest, but these relationships were weaker than the site-level effect. Although plovers select nest sites among cryptic debris in sparsely vegetated areas, restoration that creates and enhances such habitats may have limited utility at sites where predators are abundant. Thus, managers must carefully consider predator activity at the landscape level in order to maximize the effectiveness of fine-scale restoration efforts. *Received 29 August 2011, accepted 24 August 2012.*

Key words.—California, *Charadrius nivosus*, Common Raven, nest predation, nest success, nest survival, shorebird, Snowy Plover.

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Predation is a leading cause of nest failure for birds (Ricklefs 1969) and is likely a strong selective force shaping the behavior of habitat selection for nest sites (Martin 1993), especially among ground-nesting birds such as waterfowl (e.g. Cowardin *et al.* 1985; Anthony *et al.* 1991; Bailey 1993), gallinaceous birds (e.g. Erikstad *et al.* 1982), and shorebirds (e.g. Grover and Knopf 1982; Haig 1992; Page *et al.* 1995). In many of these taxa, nests are concealed in vegetation and the secretive behavior of incubating adults serves to reduce the likelihood that eggs will be found by predators. In waterfowl and gallinaceous birds that conceal their nests with vegetation, hatching success often has been shown to correlate positively with increased cover (e.g. Livezey 1981; Keppie and Herzog 1978), although this result is not universal (e.g. Storaas and Wegge 1987). However, many shorebirds (e.g. plovers, avocets, stone-curlews) establish nests in open, sparsely vegetated habitats (Koivula and Rönkä 1998; Muir and Colwell 2010) where an unobstructed view of approaching predators facilitates early detection of danger and allows incubating birds to leave the nest undetected. In these shorebird species, camouflaged eggs often blend in with substrate, debris and vegetation to enhance nest survival (Colwell *et al.* 2011). For example, Koivula and Rönkä (1998) posited that success of Temminck's Stint (*Calidris temminckii*) nests in coastal meadows was compromised in habitats where encroaching vegetation did not allow incubating birds to detect predators early, leave the nest, and allow the eggs to blend in with the surrounding habitat.

Studies of nest site selection in plovers have shown that many species select habitats that differ from surrounding landscapes, which can positively influence nest survival. For example, European Golden-Plovers (*Pluvialis apricaria*) that nest on plateaus have higher nesting success than those nesting on slopes, presumably because they detect predators early and leave the nest undetected (Whittingham *et al.* 2002). Additionally, the type of habitat in the immediate vicinity of the nest may increase nest survival by making eggs more difficult to detect following departure of the incubating adult. American Golden-Plover (*P. dominicus*) nests in lichen habitats survived better than those in non-lichen habitats (Byrkjedal 1989). Snowy Plovers (*Charadrius nivosus*) breeding in a riverine system nested in heterogeneous substrates, especially those matching the size of eggs, which enhanced egg crypsis and increased nest survival (Colwell *et al.* 2011).

In contrast, other studies of shorebird nesting have found no relationship between habitat and nest survival (e.g. Burger 1987; Powell 2001; Nguyen *et al.* 2003). For example, Piping Plover (*C. melodus*) nest sites had more stones and rocks than random sites but selection of this substrate was not associated with nest predation rates (Espie *et al.* 1996). In shorebirds that conceal their nests, measures of vegetation cover often were not associated with either hatching success or nest survival (Colwell 1992; Mabee and Estelle 2000; Smith *et al.* 2007). In their review of literature on shorebird nest predation in Europe, MacDonald and Bolton (2008) found that daily nest predation rates (DPR) were often "unsustainably high," even in otherwise high-quality habitats, and identified only one study (O'Brien 2001) that found a relationship between DPR and nest crypsis. Thus, although shorebirds often select cryptic nest sites, predation may overwhelm the more subtle effects of camouflage provided by habitat.

A threatened population of Snowy Plovers breeds along the Pacific coast of North America (U.S. Fish and Wildlife Service 2007), typically on ocean-fronting beaches amidst fine, uniform (sandy) substrates that afford minimal crypsis for eggs. However, nests are often placed in patches of driftwood, shells and other debris that hide the eggs and incubating adults (Page *et al.* 1995). Nest predation by native and introduced vertebrates, especially corvids (Common Raven, *Corvus corax*; American Crow, *C. brachyrhynchos*) has been identified as an important factor limiting recovery of this listed population (U.S. Fish and Wildlife Service 2007). Corvids search for nests of other birds using visual cues, either the presence of eggs or the movement of adults leaving nests (Colwell *et al.* 2011). In coastal northern California, ravens are strongly implicated in predation of nests and chicks and the majority of plover nest failures are attributable to raven predation (Burrell 2010; Colwell *et al.* 2010, 2011). Managers commonly alter habitat by removing introduced vegetation to create the open habitat selected by plovers (Muir and Colwell 2010) and spreading discarded bivalve shells in order to enhance nest crypsis and reduce predation of plover nests, but plover productivity remains consistently low and the population is sustained by immigration from elsewhere along the Pacific coast (Mullin *et al.* 2010).

The objective of this study was to understand relationships between nest survival and factors limiting Snowy Plover productivity (U.S. Fish and Wildlife Service 2007). Accordingly, we used three years of data collected at four beaches in coastal northern California to model the influence of habitat characteristics, human activity and predator activity near nest sites on the daily survival rate (DSR) of plover nests. Based on previous research in our study area (Colwell *et al.* 2010, 2011) and elsewhere, we predicted that nest survival would decline with corvid activity and that survival would be enhanced by features of the habitat that afforded greater crypsis to eggs. Further, based on findings reported by the U.S. Fish and Wildlife Service (2007), we suspected that human recreational use of breeding sites might have a negative influence on nest survival.

METHODS

Study Area

We monitored plover nests at four ocean-fronting beaches (Clam Beach, Mad River Beach, South Spit and Eel River Wildlife Area; Fig. 1) in northern Humboldt County, California from 2007-2009. Over the ten years that we studied plovers in this region, these four locations represented the most important breeding sites based on high occupancy and nest density, coupled with challenges associated with managing habitats frequented by humans and anthropogenic food sources that attract Common Ravens, the principal predators

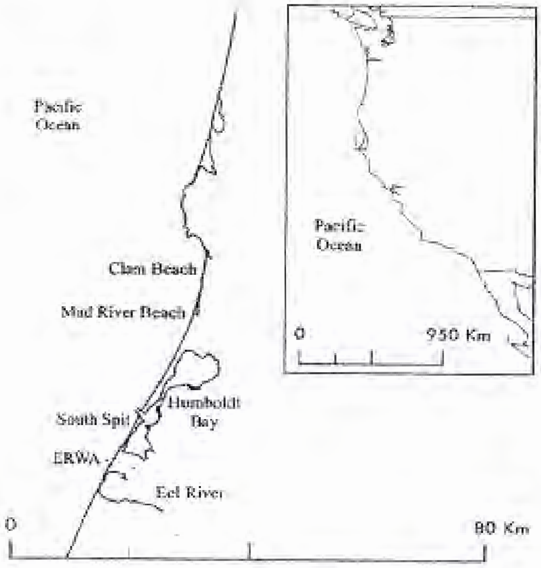

Figure 1. Snowy Plover nests were monitored from 2007-2009 at Clam Beach, Mad River Beach, South Spit and Eel River Wildlife Area (ERWA) in Humboldt County, California.

that compromise plover productivity (Burrell 2010). Beach habitats were characterized by fine, sandy substrates strewn with a mixture of driftwood of varying sizes, stones, mollusc shell fragments and crustacean remains. The dominant vegetation included both native (e.g. *Leymus mollis, Abronia latifolia, Cakile maritima*) and introduced species (*Ammophila arenaria*). Colwell *et al.* (2010) provided a detailed characterization of the study area.

Survey Methods

Each year, observers (eleven in 2007 and 2008, 15 in 2009) surveyed suitable habitat (i.e. debris fields upslope from the wrack line, foredunes and sparsely-vegetated backdunes) for breeding plovers from early March until late summer when the last young had fledged. Ten observers conducted surveys in all three years and individuals without prior experience surveying in our study area were paired with an experienced observer. Observers systematically surveyed the full length of each of the four sites at a minimum of seven to ten day intervals and supplemented these full surveys with occasional partial surveys to check known nest locations and areas where courting plovers had been observed. Surveys were conducted from 0600-1100 h. During surveys, nests were found by observing courting plovers, following their tracks in sandy substrates, and observing incubating adults. When a nest was found, its location was recorded using a personal digital assistant (PDA) equipped with a global positioning system (GPS) unit and ArcPad 6.0 Software (Environmental Systems Research Institute, Inc. 2002). In nearly all cases, the age of eggs was known because observers found nests prior to the completion of the three-egg clutch. When nests were discovered after clutch completion, the eggs were floated to determine their age (Liebezeit *et al.* 2007). Nests were monitored at one to seven day intervals until the eggs hatched or the nest failed. Nests were checked daily as they approached the end of the 28-day incubation period. From these observations, we maintained an annual record of each nest, including its fate (hatched at least one chick or failed).

During nest visits, surveyors confirmed that a nest was active by observing an incubating adult through a spotting scope. During most visits, the incubating adult did not leave the nest. After initial discovery, observers did not approach active nests except when 1) an adult was not incubating, 2) both parents had been observed elsewhere since the previous nest visit, 3) the nest was 1-2 days from the expected hatch date (i.e. to check eggs for pipping/starring), or, in rare cases, 4) to float eggs when a nest was discovered after clutch completion. When incubating adults were not present, observers only approached close enough to confirm that eggs were present in the nest cup (typically through binoculars). In all cases, observers were careful to minimize disturbance to the substrate near the nest and the time spent at the nest. Consequently, we are confident that the vast majority of nest checks were not likely to have an appreciable effect on DSR.

During surveys for plovers, observers sampled habitat using three methods and geo-referenced the data using the GPS-equipped PDA. These three approaches characterized habitat near the nest (i.e. within 15 cm and 3 m radii), within 100 m of the nest and throughout the study area. To describe fine-scale variation in habitat near the nest, observers counted the number of objects (sticks, shells, live vegetation, dead vegetation and garbage) within 15 cm of the nest cup. Then, observers visually estimated percentage of debris cover (0; 1-10%; 11-50%; 51-90% and >90%) within 3 m of the nest and estimated the number of objects (0; 1-10; 11-100; 101-1000; >1000) in various debris categories (large stumps, smaller wood, shells, live vegetation, dead vegetation, garbage, brown algae, bundles of eelgrass (*Zostera marina*), stones and dried husks of cnidarians (*Velella velella*). Finally, observers characterized danger posed to eggs by humans and corvids by recording an index of tracks (none; 1-10 sets; >10 sets) left within 3 m of the nest by vehicles, pedestrians, dogs, horses and corvids, respectively, in the prior 24 h.

To describe habitat, observers recorded the same set of variables that were recorded within 3 m of the nest in randomly-placed plots sampled throughout the study area. Observers sampled these plots during regular surveys (i.e. Mar-Aug) for plovers at all sites by stopping every 20 min as signaled by a pre-determined wristwatch alarm. When observers stopped, they also recorded an instantaneous point count of the number of vehicles, pedestrians, dogs, horses and corvids within 500 m of their location. We used the subset of these 3-m plots that fell within 100 m of a nest to calculate incidence values (i.e. proportion of plots where a given track or debris type was detected) for each of the habitat features. Similarly, we derived incidence values from point counts for vehicles, pedestrians, dogs, horses and corvids within 100 m of a nest.

Observers conducted 5,754 point counts (2007: N = 1,985, 2008: N = 2,185, 2009: N = 1,584) and recorded data in a total of 6,130 3-m plots (2007: N = 2,056, 2008: N = 2,284, 2009: N = 1,790) between 2007 and 2009; only a small percentage of these observations occurred near nests. Overall, there were only minor (i.e. non-significant) annual differences in the average number of points sampled within 100 m of nests (2007: range = 3-22, $\bar{x}$ = 12.9, SE = 5.5; 2008: range = 3-28, $\bar{x}$ = 12.4, SE = 6.1; 2009: range = 2-25, $\bar{x}$ = 12.4, SE = 6.1).

Modeling Approach

We developed an index of debris heterogeneity at the 100 m scale using the Shannon-Wiener index (H') of diversity $[-\Sigma p_i \ln(p_i)]$; with p_i values calculated from the proportional abundance of small debris types (small woody debris, shells, stones and *Velella*) sampled in 3-m plots within 100 m of a nest. We selected these debris types because they afford camouflage to eggs and incubating adults without interfering with the adult's ability to detect approaching predators. We derived an additional habitat variable ("clutter") based on the mean number of occurrences of small woody debris, shells, stones and *Velella* in 3-m plots sampled within 100 m of a nest. We included these two variables in our set of candidate models because we knew that nesting substrates affected egg crypsis and influenced nest survival elsewhere in our study area (Colwell *et al.* 2011) and because managers frequently alter habitats by supplementing debris that increases heterogeneity and clutter with the aim of enhancing nest survival (e.g. Powell and Collier 2000).

We used program MARK to calculate the daily survival rate of nests and evaluate the effects of danger posed by humans and corvids, habitat at the nest, site, and time (Table 1). Initially, we tested for correlations among variables and used nests monitored in 2007 (N = 37) to develop a set of preliminary models. We then ranked models according to Akaike's Information Criterion corrected for small sample size, (AIC_c; Burnham and Anderson 2002) and reduced the number of explanatory variables based on a combination of model ranking and biological relevance (i.e. when two variables related to nest crypsis, predation threat or human

Table 1. Variables representing habitat characteristics, human activity and predator activity within 15 cm, 3 m, and 100 m of Snowy Plover nests at four sites in coastal northern California. The influence of these variables on plover nest survival was investigated in preliminary analyses (p) using data from 2007 and the most informative variables were included in final analyses (f) using pooled data from 2008-2009.

Variable	Description	15 cm	3m	100 m[a]
Debris				
stump	Large (≥ 10 cm diameter) woody debris	—	p	p
woody	small (< 10 cm diameter) woody debris	p	p	p
shell	mollusk shells and crustacean carapaces	p	p	p
vegetation	live (green) vegetation	p	p	p, f
deadveg	dead (brown) vegetation	p	p	p
garbage	anthropogenic refuse	p	p	p
algae	brown algal mats (e.g., *Macrocystis, Fucus, Postelsia, Egregia*)	—	p	p
eelgrass	*Zostera marina* bundles	—	p	p
stone	stones	—	p	p
Velella	dry and fresh *Velella*	—	p	p
cover	visual estimate of percent debris cover	—	p	—
clutter	index of cryptic debris ≤ 100 m from the nest[b]	—	—	p, f
H'	index of debris diversity ≤ 100 m from the nest[c]	—	—	p, f
Tracks (< 24 hold)				
human	human tracks	—	p	p
dog	dog tracks	—	p	p, f
horse	horse tracks	—	p	p
vehicle	vehicle tracks	—	p	p
corvid	corvid tracks	—	p	p
Human and predator activity				
humans	humans detected during point counts ≤ 100 m from the nest	—	—	p
dogs	dogs detected during point counts ≤ 100 m from the nest	—	—	p
horses	horses detected during point counts ≤ 100 m from the nest	—	—	p
vehicles	vehicles detected during point counts ≤ 100 m from the nest	—	—	p
corvids	corvids detected during point counts ≤ 100 m from the nest	—	—	p, f

[a]For all variables except clutter and H', incidence = proportion of plots ≤ 100 m from the nest where at least one observation occurred.

[b]Mean number of detections of woody debris, shells, stones, and *Velella* within ground plots ≤ 100 m of the nest.

[c]Shannon-Weiner Index of diversity: considers woody debris, shells, stones, and *Velella* within ground plots ≤ 100 m of the nest.

disturbance were positively correlated, we retained the variable that we thought would have the most direct effect on DSR based on *a priori* knowledge of plover breeding biology).

We used the results of preliminary analysis with 2007 data (Hardy 2010) to develop a set of 21 candidate models and fitted them to pooled data from nests monitored in 2008 (N = 39) and 2009 (N = 25). Our 2008-2009 models included combinations of the most informative indices of predation threat (incidence of corvids), nest crypsis (clutter, H', and incidence of vegetation) and human activity (incidence of dog tracks) within 100 m of nests (Table 1). Each model included a site effect because the various beaches differ in activity of humans and corvids, as well as being managed by separate county, state and federal agencies. Each model also included a quadratic time effect owing to the general observation that nest survival varies seasonally, especially in our study area where plovers initiate nests over ~120 days from early March until mid-August. None of our candidate models included ≥2 correlated covariates.

Results

During 2007-2009, observers found 115 plover nests distributed unevenly among four sites (Table 2). Most nests (N = 95) were on Clam Beach, where apparent nest success was especially low, ranging from 5-8% annually. In final (2008-2009) analyses, daily nest survival was higher at two southern sites (South Spit range = 0.98-0.99; Eel River Wildlife Area range = 0.91-0.96; Fig. 2) compared with two northern sites (Mad River Beach range = 0.77-0.88; Clam Beach range = 0.79-0.89; Fig. 2). In contrast, human and corvid activity during 2007-2009 was appreciably higher at the northern sites than at the southern sites (Burrell 2010).

Results of preliminary analysis using 2007 data (Hardy 2010) showed that habitat variables measured within 15 cm and 3 m of the nest described very little of the variation in DSR: each variable explained 0-4% of the null model deviance. Furthermore, variables calculated using point counts and ground plots within 100 m of nests described only slightly more variation in DSR than did those nearer the nest (0-6% deviance explained). A site-level effect accounted for ~10% of the null deviance and indicated that DSR was higher at the two southern sites than at the two northern sites. A quadratic time trend better captured variation in DSR than did a linear trend (deviance explained = 12% and 6%, respectively) and suggested that nest survival was highest mid-season. Based on these results, we retained five covariates (H', clutter, and incidence of dog tracks, corvids and vegetation) to use in final (2008-2009) analyses. Additionally, each of the 21 models in the final set included a site effect, a quadratic time trend, or both.

Most (95%) of the final models performed better than the null model, but no model explained more than 7% of the null deviance. The top model (Table 3) indicated that DSR varied appreciably among sites, with higher nest survival on South Spit and Eel River Wildlife Area compared with Mad River Beach and especially Clam Beach, although 95% confidence intervals for Mad River Beach and Eel River Wildlife Area included zero. There was only limited evidence that habitat characteristics in the vicinity of the nest influenced nest survival. Nest survival was positively correlated with H' but negatively associated with clutter. Two other models were within two AIC_c units of the top model. In the second-ranked model, H' was replaced with corvid incidence (these two variables were correlated; r = 0.48, $P < 0.05$). A third-ranked model was identical to the top model but also included the incidence of dog tracks.

Table 2. Apparent hatching success of Snowy Plover nests monitored at four sites in coastal northern California. Apparent nesting success is the number of nests hatching at least one chick divided by the total (x100).

Site	2007		2008		2009	
	N	% hatched	N	% hatched	N	% hatched
Clam Beach	31	6.5	39	5.1	25	8.0
Mad River Beach	3	33.3	3	0	3	0
Eel River Wildlife Area	2	100	2	50.0	3	33.3
South Spit	1	100	3	33.3	0	—
All nests	37	16.2	47	8.5	31	12.9

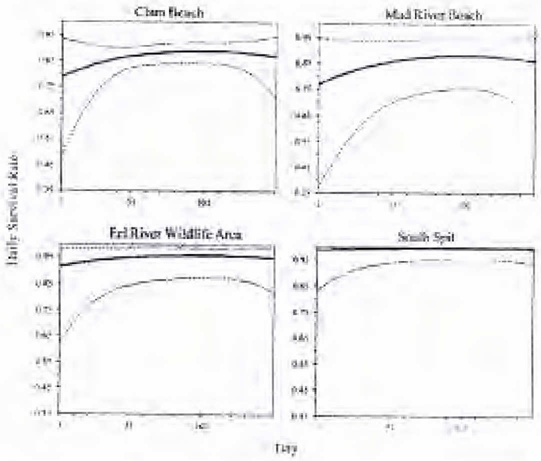

Figure 2. Daily survival rates and 95% confidence intervals for Snowy Plover nests at four sites in Humboldt County, California, 2008-2009. Day 1 corresponds to 4 March and day 150 corresponds to 31 July.

However, dog tracks were an exceptionally poor predictor of variation in DSR: the coefficient estimate was not significantly different from zero and the addition of dog tracks to the top model only explained an additional 0.05% of the null model deviance.

DISCUSSION

Our results are noteworthy for several reasons. First, the beach-nesting plovers we studied experienced very low reproductive success, a pattern that has prevailed over much of the 10+ years that we have monitored the population. Secondly, we found weak relationships between plover nest survival and habitat characteristics near the nest, whereas our strongest modeling result showed that nest survival was appreciably lower at two northern sites (Clam Beach and Mad River Beach) where corvid activity was especially high (Burrell 2010). Finally, the absence of strong statistical relationships between nest survival, habitat, and human and predator activity near the nest suggests that the influence of habitat characteristics (e.g.

Table 3. Coefficient estimates and 95% confidence intervals for the three top-ranked models examining variation in daily survival rate (DSR) of Snowy Plover nests in relation to indices of human and corvid activity, habitat characteristics within 100 m of nests, site, and time (TT = quadratic time trend).

Model	ΔAIC_c	Covariate	Estimate	Lower 95% CI	Upper 95% CI
S(site + H' + clutter + TT)	—	*Intercept*	1.6325	-0.6377	3.9026
		Eel River Wildlife Area	1.0564	-0.2105	2.3233
		Mad River	-0.1090	-1.0423	0.8242
		South Spit	3.0086	0.7984	5.2188
		H'	2.4408	0.2834	4.5983
		clutter	-1.5317	-2.6434	-0.4199
		T	0.0160	-0.0207	0.0527
		TT	-0.0001	-0.0003	0.0001
S(site + corvids + clutter + TT)	1.117	*Intercept*	2.2513	-0.0305	4.5331
		Eel River Wildlife Area	1.0026	-0.2468	2.2519
		Mad River	-0.4713	-1.4435	0.5008
		South Spit	2.6841	0.8101	4.5581
		corvids	1.8087	0.0160	3.6014
		clutter	-1.1535	-2.0469	-0.2601
		T	0.0230	-0.0150	0.0610
		TT	-0.0001	-0.0003	0.0001
S(site + H' + clutter + dog tracks + TT)	1.893	*Intercept*	1.7484	-0.6044	4.1012
		Eel River Wildlife Area	0.9784	-0.3472	2.3039
		Mad River	-0.1535	-1.1135	0.8065
		South Spit	3.0312	0.7877	5.2747
		H'	2.5701	0.2941	4.8461
		clutter	-1.5989	-2.7785	-0.4193
		dog tracks	-0.4669	-2.7385	1.8047
		T	0.0145	-0.0232	0.0521
		TT	-0.0001	-0.0003	0.0002

enhanced camouflage of nests and incubating adults; Colwell *et al.* 2011) may be minimal at sites where predators are abundant. Collectively, these results pose challenges to the conservation and management of plovers in our study area and throughout the range of the listed population segment (USFWS 2007).

Although reproductive success of shorebirds is known to vary considerably from year to year (Colwell 2010), apparent hatching success (Table 2) was low in each of the three years we quantified relationships between plover nest site characteristics and nest survival, and this pattern of low hatching success has been the case for beach-nesting plovers throughout the 10+ years that we have studied plovers in northern California (Colwell *et al.* 2005, 2010). Elsewhere we showed that corvids are the main predator affecting plover productivity in our study area (Burrell 2010) and that cryptic substrates enhanced nest survival (Colwell *et al.* 2011). Therefore, we expected to find strong relationships between nest survival and variables describing corvid activity and habitat characteristics near the nest. However, these relationships were weak in both preliminary analyses and final model results.

Unlike many other ground-nesting birds, plovers nest in sparsely-vegetated habitats that afford an unobstructed view of surrounding landscapes; they rely on early predator detection and departure from the nest, coupled with nest crypsis, to avoid egg predation (Colwell 2010). Studies on several plover species that demonstrate selection for breeding in open habitats (e.g. Whittingham *et al.* 2002; Muir and Colwell 2010), selection of nesting substrates that camouflage eggs (e.g. Flemming *et al.* 1992; Colwell *et al.* 2011), and relationships between these habitat features and nest success (Colwell *et al.* 2011) support this generalization. Why, then, did we find weak relationships between habitat characteristics and nest survival? We think there may be several contributing factors, including: 1) small sample size, with most nests concentrated at one site (Clam Beach) where overall corvid activity was especially high and nest success was low; 2) differences in predator abundance at the landscape level overwhelming the effects of within-site variation in predator activity, human activity and habitat characteristics; and 3) the importance of adult responses to predators near the nest (Koivula and Rönkä 1998; Colwell *et al.* 2011).

Although our index of corvid activity within 100 m of nests was only weakly associated with nest survival, we note that the incidence of corvids at the site level varies considerably within our study area and is strongly correlated with the daily predation rate of plover nests (Burrell 2010). We believe that these broad-scale differences in corvid activity, and thus nest predation, are driven largely by differences in land use and human activity near plover breeding sites. Specifically, residential development and public campgrounds adjacent to Clam Beach and Mad River Beach subsidize high numbers of corvids that depress nest survival through frequent opportunistic predation of plover nests. Human recreational activity is also more common at Clam Beach and Mad River Beach than at other sites in our study area (Burrell 2010), which may directly or indirectly influence nest survival. For example, video evidence from nest cameras at Clam Beach showed that ravens often depredated eggs immediately after incubating plovers flushed from nests in response to disturbance, suggesting that they used the movement of plovers to locate nests amidst cryptic debris. Thus, numerous factors interact to influence plover reproductive success in our study area, emphasizing the importance of understanding relationships among behavior of incubating adults, physical features of habitat, human activity and predator activity at multiple spatial scales.

We found no evidence that variation in human activity near the nest correlated with nest survival. In fact, only an index of dog activity entered the final set of models (Table 3), albeit with low explanatory power. The absence of a strong relationship between human activity and nest survival is, perhaps, not surprising given that in our study area: 1) human use is low compared to other locations along the Pacific coast (e.g. Lafferty *et* *al.* 2006); 2) humans have only occasionally caused nest failure (e.g. vehicle strike, trampling, taking of eggs; Colwell *et al.* 2011); and 3) most nests were depredated by corvids shortly after the onset of incubation and thus were not exposed to human-related disturbance for extended periods. Nevertheless, the U.S. Fish and Wildlife Service (2007) lists human disturbance as one of several factors negatively affecting plover reproductive success and population recovery, and we note that humans can indirectly influence nest survival by 1) leaving garbage on the beach, which attracts corvids; and 2) flushing incubating plovers from nests, which provides a visual cue to nest predators. We further note that efforts to manage human activity in the vicinity of breeding plovers in our study area (Wilson and Colwell 2010) and elsewhere along the Pacific coast (Lafferty *et al.* 2006) have produced positive results.

Habitat restoration for plovers often is coupled with measures to enhance survival of nests and broods by adding clutter to substrates in the form of discarded bivalve shells (i.e. shell hash; Powell and Collier 2000). However, our results, combined with evidence that corvids (Common Ravens and American Crows) are efficient egg predators in much of our study area (Burrell 2010), suggest that the benefits of increased nest crypsis may be overwhelmed at sites (e.g. Clam Beach and Mad River Beach) where corvids are particularly abundant. In these scenarios (i.e. suitable breeding habitat and high predator activity), habitat enhancement alone is probably insufficient to boost plover productivity. Therefore, we suggest that managers carefully consider the landscape context of the danger posed by predators if the objective is to restore and enhance habitats to increase plover reproductive success and achieve recovery of the listed population.

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LITERATURE CITED

Anthony, R. M., P. L. Flint and J. S. Sedinger. 1991. Arctic Fox removal improves nest success of Black Brant. Wildlife Society Bulletin 19: 176-184.

Bailey, E. P. 1993. Introduction of foxes to Alaskan Islands-history, effects on avifauna, and eradication. United States Fish and Wildlife Service, Resource Publication 193, Washington, D.C.

Burger, J. 1987. Physical and social determinants of nest-site selection in Piping Plover in New Jersey. Condor 89: 811-818.

Burnham, K. P. and D. R. Anderson. 2002. Model selection and multimodel inference: A practical information-theoretic approach. 2nd ed. Springer-Verlag, New York, New York.

Burrell, N. S. 2010. Breeding patch dynamics of the Western Snowy Plover (*Charadrius alexandrinus nivosus*) in Humboldt County, California. Unpublished M.Sc. Thesis, Humboldt State University, Arcata, California.

Byrkjedal, I. 1989. Nest habitat and nesting success of Lesser Golden-Plovers. Wilson Bulletin 101: 93-96.

Colwell, M. A. 1992. Wilson's Phalarope nest success is not influenced by vegetation concealment. Condor 94: 767-772.

Colwell, M. A. 2010. Shorebird ecology, conservation, and management. UC Press, Berkeley, California.

Colwell, M. A., C. B. Millett, J. J. Meyer, J. N. Hall, S. J. Hurley, S. E. McAllister, A. N. Transou and R. R. LeValley. 2005. Snowy Plover reproductive success in beach and river habitats. Journal of Field Ornithology 76: 373-382.

Colwell, M. A., N. S. Burrell, M. A. Hardy, K. Kayano, J. J. Muir, W. J. Pearson, S. A. Peterson and K. A. Sesser. 2010. Arrival times, laying dates, and reproductive success of Snowy Plovers in two habitats in coastal northern California. Journal of Field Ornithology 81: 349-360.

Colwell, M. A., J. J. Meyer, M. A. Hardy, S. E. McAllister, A. Transou, R. R. LeValley and S. J. Dinsmore. 2011. Western Snowy Plovers *Charadrius alexandrinus nivosus* select nesting substrates that enhance egg crypsis and improve nest survival. Ibis 153: 303-311.

Cowardin, L. M., D. S. Gilmer and C. W. Shaiffer. 1985. Mallard recruitment in the agricultural environment of North Dakota. Wildlife Monographs 92: 1-37.

Environmental Systems Research Institute, Inc. 2002. ArcPad version 6.0. Redlands, California.

Erikstad, K. E., R. Blom and S. Myrberget. 1982. Territorial Hooded Crows as predators on Willow Ptarmigan nests. Journal of Wildlife Management 46: 109-114.

Espie, R. H. M., R. M. Brigham and P. C. James. 1996. Habitat selection and clutch fate of Piping Plovers (*Charadrius melodus*) breeding at Lake Diefenbaker, Saskatchewan. Canadian Journal of Zoology 74: 1069-1075.

Flemming, S. P., R. D. Chiasson and P. J. Austin-Smith. 1992. Piping Plover nest site selection in New Brunswick and Nova Scotia. Journal of Wildlife Management 56: 578-583.

Grover, P. B. and F. L. Knopf. 1982. Habitat requirement and breeding success of charadriiform birds nesting at Salt Plains National Wildlife Refuge, Oklahoma. Journal of Field Ornithology 53: 139-148.

Haig, S. M. 1992. The Piping Plover (*Charadrius melodus*) *in* The Birds of North America, No. 2 (A. Poole and F. Gill, Eds.). The Academy of Natural Sciences, Washington, D.C. and The American Ornithologists' Union, Philadelphia, Pennsylvania.

Hardy, M. A. 2010. Western Snowy Plover nest survival on ocean-fronting beaches in coastal northern California. Unpublished M.Sc. Thesis, Humboldt State University, Arcata, California.

Keppie, D. M. and P. W. Herzog. 1978. Nest site characteristics and nest success of Spruce Grouse. Journal Wildlife Management 42: 628-632.

Koivula, K. and A. Rönkä. 1998. Habitat deterioration and efficiency of antipredator strategy in a meadow-breeding wader, Temminck's Stint (*Calidris temminckii*). Oecologia 116: 348-355.

Lafferty, K. D., D. Goodman and C. P. Sandoval. 2006. Restoration of breeding by Snowy Plovers following protection from disturbance. Biodiversity and Conservation 15: 2217-2230.

Liebezeit, J. R., P. A. Smith, R. B. Lanctot, H. Schekkerman, I. Tulp, S. J. Kendall, D. M. Tracy, R. J. Rodrigues, H. Meltofte, J. A. Robinson, C. Gratto-Trevor, B. J. McCaffery, J. Morse and S. W. Zack. 2007. Assessing the development of shorebird eggs using the floatation method: species-specific and generalized regression models. Condor 109: 32-47.

Livezey, B. C. 1981. Locations and success of duck nests evaluated through discriminant analysis. Wildfowl 32: 23-27.

Mabee, T. J. and V. B. Estelle. 2000. Nest fate and vegetation characteristics for Snowy Plover and Killdeer in Colorado, USA. Wader Study Group Bulletin 93: 67-72.

MacDonald, M. A. and M. Bolton. 2008. Predation on wader nests in Europe. Ibis 150 (Suppl. 1): 54-73.

Martin, T. E. 1993. Nest predation and nest sites. Bioscience 43: 523-533.

Muir, J. J. and M. A. Colwell. 2010. Influences of European beachgrass on Snowy Plover nest site selection. Condor 112: 507-510.

Mullin, S. M., M. A. Colwell, S. A. McAllister and S. J. Dinsmore. 2010. Apparent survival and population growth of Snowy Plovers in coastal Northern California. Journal of Wildlife Management 74: 1792-1798.

Nguyen, L., E. Nol and K. F. Abraham. 2003. Nest success and habitat selection of the Semipalmated Plover on Akimiski Island, Nunavut. Wilson Bulletin 115: 285-291.

O'Brien, M. G. 2001. Factors affecting breeding wader populations on upland enclosed farmland in Northern Britain. Unpublished Ph.D. Dissertation, University of Edinburgh, Edinburgh, Scotland, UK.

Page, G. W., J. S. Warriner, J. C. Warriner and P. W. C. Paton. 1995. Snowy Plover (*Charadrius alexandrinus*) in The Birds of North America, No. 154 (A. Poole and F. Gill, Eds.). The Birds of North America, Inc., Philadelphia, Pennsylvania.

Powell, A. N. 2001. Habitat characteristics and nest success of Snowy Plovers associated with California Least Tern colonies. Condor 103: 785-792.

Powell, A. N. and C. L. Collier. 2000. Habitat use and reproductive success of Western Snowy Plovers at new nesting areas created for California Least Terns. Journal of Wildlife Management 64: 24-33.

Ricklefs, R. E. 1969. An analysis of nesting mortality in birds. Smithsonian Contributions to Zoology 9: 1-48.

Smith, P. A., H. G. Gilchrist and J. N. M. Smith. 2007. Effects of nest habitat, food, and parental behavior on shorebird nest success. Condor 109: 15-31.

Storaas, T. and P. Wegge. 1987. Nesting habitats and nest predation in sympatric populations of Capercaillie and Black Grouse. Journal of Wildlife Management 51: 167-172.

U.S. Fish and Wildlife Service. 2007. Recovery plan for the Pacific coast population of the Western Snowy Plover (*Charadrius alexandrinus nivosus*). Endangered Species Program, Sacramento, California.

Whittingham, M. J., S. M. Percival and A. F. Brown. 2002. Nest-site selection by Golden Plover: why do shorebirds avoid nesting on slopes? Journal of Avian Biology 33: 184-190.

Wilson, C. A. and M. A. Colwell. 2010. Movements and fledging success of Snowy Plover (*Charadrius alexandrinus*) chicks. Waterbirds 33: 331-340.

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Den Site Characteristics and Food Habits of the Red Fox (Vulpes vulpes) on Assateague Island, Maryland

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ABSTRACT

Aerial searches and ground surveys were used to locate red fox (*Vulpes vulpes*) excavations on Assateague Island, Maryland. Aerial searches were not successful since excavation entrances were concealed by vegetation and shadows from sand dunes. Red fox excavations on Assateague Island were located predominantly in shrub succession and *Hudsonia* dune habitats. Sand dunes within these habitats provided suitable denning sites. Average height and width measurements of fox excavations were significantly smaller in 1987 compared to 1985. These differences may be related to an increase in the number of juveniles. In 1985 and 1987, red fox excavations were predominantly oriented towards the northeast and northwest quadrants. Number of red fox denning areas increased from an estimated 8 to 11 between 1985 and 1987. Although the number of denning sites increased, the average distance between centers of denning areas decreased by 0.8 km. Red foxes on Assateague Island had a typically varied diet during summer 1987. Major components of the red fox diet as revealed by scat analysis included mammals (87.0%), crustaceans (64.8%), and birds (46.3%). Among the mammals, eastern cottontail rabbits (*Sylvilagus floridanus*) had the highest frequency of occurrence followed by meadow voles (*Microtus pennsylvanicus*) and white-footed mice (*Peromyscus leucopus*).

Key words: Red fox, *Vulpes vulpes,* Assateague Island, barrier island, denning habits, aerial searches.

INTRODUCTION

"Red fox are so variable in their behavior that any extrapolations leading to the management of foxes in one area based on studies from another should be viewed with caution" (Voigt and Macdonald, 1984). This statement based on the comparisons of red fox (*Vulpes vulpes*) populations in England and Canada, demonstrates the need for research to be conducted on individual red fox populations before developing management programs.

On 1 January 1985 the National Park Service prohibited trapping of red foxes within Assateague Island National Seashore, Maryland. Chincoteague National Wildlife Refuge, located just south of the Maryland/Virginia border (Fig. 1) still maintains a red fox trapping season. A study was initiated during summer 1985 to estimate the size of the red fox population on Assateague Island. Due to the

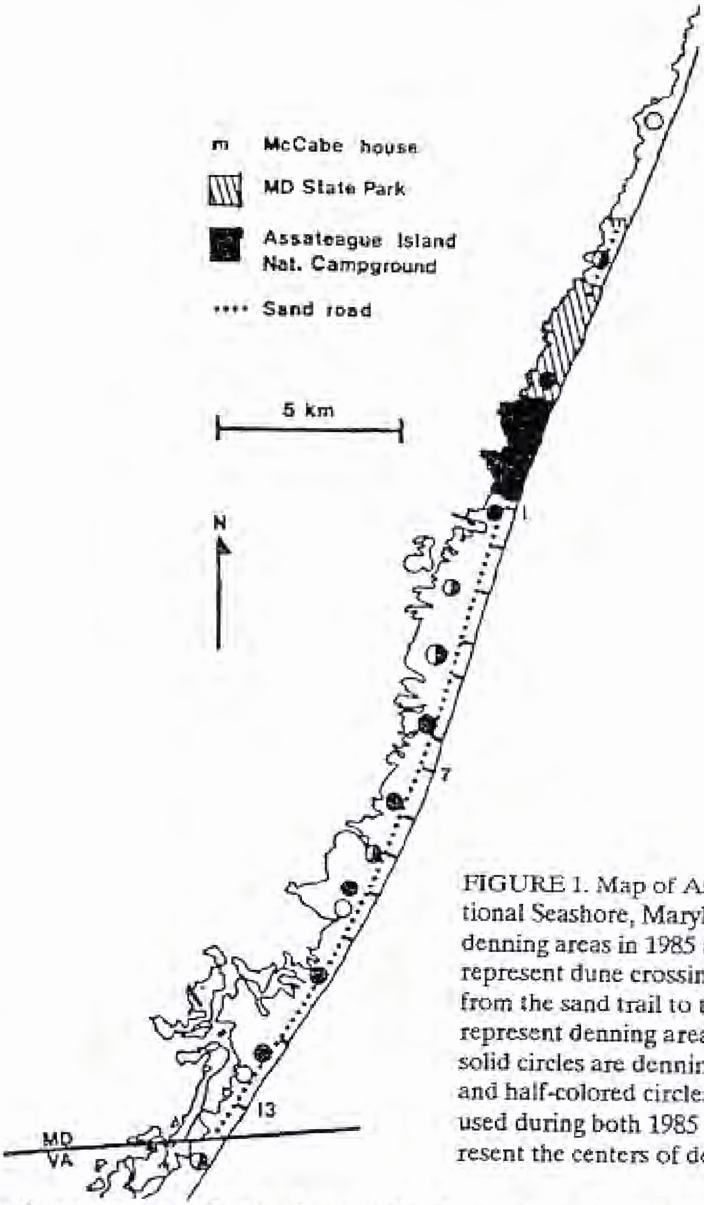

FIGURE 1. Map of Assateague Island National Seashore, Maryland showing red fox denning areas in 1985 and 1987. Numbers represent dune crossings permitting access from the sand trail to the beach. Open circles represent denning areas from 1985, while solid circles are denning areas used in 1987, and half-colored circles are denning areas used during both 1985 and 1987. Circles represent the centers of denning areas.

absence on Assateague Island of mortality factors, such as farm machinery, highways, and predation (Storm *et al.*, 1976; Pils and Martin, 1978), we believed this population would increase after trapping ceased.

These studies were undertaken in order to augment existing knowledge on the Assateague Island red fox population and to help the National Park Service formulate a management plan for this species. In this paper den-site characteristics and population estimates from two study years were compared to evaluate changes in these aspects of insular red fox ecology. In addition, we report on the first analysis of fox food habits from the Atlantic barrier islands.

STUDY AREA

The study area consisted of 25.4 km^2 of Assateague Island National Seashore, Worcester Co., Maryland. The study area extended from Ocean City Inlet on the northern end of Assateague Island southward 0.8 km beyond the Virginia border, and included 0.4 km^2 of the Chincoteague National Wildlife Refuge, immediately south of the State Line (Fig. 1). This area is bounded by the Atlantic Ocean on the east, and Chincoteague and Sinepuxent bays on the west. From east to west across the island the typical sequence of terrestrial communities was: high energy beach, primary dunes, *Hudsonia* dunes, shrub succession, pine woods, and wetlands, with fresh water ponds interspersed within individual communities in the interior of the island (Hill, 1986).

MATERIALS AND METHODS

The first year of the study extended from 20 May to 18 August 1985, while the second year extended from 20 May until 30 August 1987. Five low level (approximately 30.5 m above M.S.L.; 70 $\pm$ 10 kts.) aerial searches to locate red fox excavations were flown during April (1), May (3), and August (1) 1985. Flights were made in a Cessna-150 by a pilot and one observer, who was experienced with the appearance of fox excavations. Two transect paths were flown per flight; North to South and South to North over the entire study area.

Ground surveys were undertaken by one to six people to locate fox excavations throughout the study area between 20 May - 23 July 1985 and 20 May - 20 July 1987. Survey and measurement techniques were identical in both years. Excavations were considered active based on the presence of fox tracks and whether the entrance was cleaned out (Sheldon, 1950). Excavations were further classified as dens (depth $>$1.0 m), pseudo-dens (depth 0.5-1.0 m), and digs (depth $<$0.5 m) (Bashore and Krim, 1986). Only dens and pseudo-dens were analyzed in this study, because digs were usually related to caching or other non-denning activities. Orientation of entrance openings (in degrees) was determined by using a Warren-Knight forester's compass. Hourly records of wind speed and direction for both 1985 and 1987 were obtained from NASA, Wallops Island, Virginia, 32 km southwest of Assateague Island. Entrance height and width were measured using expandable kitchen corn tongs. These were inserted 45 cm into the opening, expanded to the height or width of the tunnel, held in position as they were extracted, and placed on a meter stick to obtain measurements. The 45 cm depth was chosen to minimize bias caused by sand blown into or fallen at the entrance. Collapsed excavations could not be measured.

In North America, red fox families traditionally consist of a pair of foxes (one adult male and female) and their pups, and occupy well-defined contiguous territories (Scott, 1943). Sargeant *et al.* (1975) assigned dens within 1.6 km of each other to the same fox family. Bashore and Krim (1986) defined a red fox denning area as a section of Assateague Island which contained at least one active den in association with other dens, pseudo-dens, and digs. Denning areas were identified by plotting fox excavations on vegetation maps. When plotted, these excavations often took the form of distinctive clusters, which usually occurred within 1.6 km of each other. Denning areas lacking distinct clusters were determined by drawing a circle (1.6 km in diameter) from the center of a major group of excavations.

In 1987, relative coverage of open ground, grasses and forbs, shrubs, and trees was estimated for a 10 m radius circle centered on the excavation. This was determined by running four transect lines (10 m in length) from the excavation opening, and were oriented to cover the four ordinal directions. The length of transect passing under the dripline of a tree was measured to determine relative coverage of trees. The portion of transect length intercepted by plants or by a perpendicular projection of their foliage was measured for grasses, forbs, and shrubs. The amount of open ground (non-vegetated) which intercepted the transect also was measured (Brower and Zar, 1977).

All excavations from the two years were plotted on a vegetation map (1:8640 scale) (Hill, 1984) and on a U.S. Department of Agriculture Soil Survey map (1:15840 scale) (Hall *et al.*, 1973). Chi-square tests were performed to determine if red fox excavations were distributed randomly among seven habitat types. To compute expected values, the areal percent for each habitat was multiplied by the total number of excavations located. To meet the assumptions of the chi-square test (Zar, 1984), two habitat types (non-vegetated plus washes and pans) were combined.

Red fox scat collected between May - August 1987 was analyzed to determine food habits. The scat was washed and broken up, floated in a sieve of clean water to separate it further and dried at 50° C for at least 24 hours (Lockie, 1959; Green *et al.*, 1986). Scat contents were separated into eight major categories: mammals, birds, crustaceans, fish, insects, plants, molluscs, and unknown. Where possible mammal remains were identified to genus or species by analyzing bone fragments, teeth, and hair present in the scat.

Statistical analyses followed the procedures of Zar (1984) and were performed using BIOSTAT I (Pimentel and Smith, 1985).

RESULTS

Three potential fox excavations were observed during the two afternoon flights and no sightings occurred during morning flights. One sighting was verified as a shallow dig (depth < 50 cm) in a sparsely vegetated sand dune. The second possible excavation was not located during a ground search four days later, while the third sighting was verified as a previously located pseudo-den in a sparsely vegetated primary dune.

In 1985, 61 red fox excavations were located from ground searches. Of these, 49 (80.3%) were classified as dens (16 active; 33 inactive) and 12 (19.7%) were pseudo-dens (3 active; 9 inactive). In 1987, 96 fox excavations were located. Of these, 70 (72.9%) were classified as dens (41 active; 29 inactive) and 26 (27.1%) were pseudo-dens (6 active; 20 inactive). Pseudo-dens were found both in association with dens and other pseudo-dens and isolated from other fox excavations. Dens and pseudo-dens with one opening were common on Assateague, 43 of the 61 excavations in 1985 and 75 of 96 excavations in 1987 had only one opening.

Height and width measurements of fox excavations from 1985 were compared to those from 1987 (Table 1). Some excavations had collapsed before height and width measurements could be made. Active pseudo-dens were not analyzed due to small sample sizes in both 1985 ($n = 3$) and 1987 ($n = 4$). There were significant differences between years in the heights and widths of all three excavation types (active and inactive dens, and inactive pseudo-dens), with sample means in 1987 smaller than those in 1985. Average height and width dimensions of active dens in 1985 were 23 x 25 cm and in 1987 were 20 x 22 cm. In 1985, 32 (54.2%) excavations were oriented towards the northwest, 14 (23.7%) faced southwest, 12 (20.3%) faced northeast, and 1 (1.7%) faced southeast. In 1987, fox excavations were oriented predominantly towards the northeast (n = 34; 36.9% of the total) and northwest (29; 31.5%), with fewer being oriented toward the southwest and southeast (19; 20.7% and 10; 10.9%, respectively). Directional orientation of excavations differed significantly between 1985 and 1987 ($X^2 = 12.25$, $P < 0.01$). Between 1985 and 1987 there was a significant increase in the frequency of excavations oriented towards the southeast ($Z = -3.54$, $P < 0.01$). However, in 1987, 68.4% of the excavation entrances were oriented towards the northeast and northwest quadrants. No significant correlations were observed between wind direction and excavation orientation or between winds above 20 mph, representing major storms, and excavation openings in either 1985 or 1987.

In 1985, 31 excavations were located in shrub succession, 19 in *Hudsonia* dune habitat, 7 in dunegrass and 1 in woodland communities. A Chi-square analysis was not performed on the data from 1985 because after combining two habitat types, the data still did not conform to the assumptions of the Chi-square test (Zar, 1984) (*i.e.* more than 20% of expected frequencies were less than 5.0). Fox excavations were distributed non-randomly among habitat types in 1987 (Table 2) ($X^2 = 781.8$, df = 6, $P < 0.001$). Of the 96 excavations located, 59 were in the *Hudsonia* dune habitat, with 31 in shrub succession, while woodland and dunegrass communities supported fewer numbers (4 excavations, and 2 excavations, respectively). In order to meet the assumptions of the Chi-square test (Zar, 1984), data from two similar habitats having small numbers of excavations (non-vegetated plus washes and pans) were combined. Between 1985 and 1987 there was a significant increase in the use of *Hudsonia* dune habitat for red fox excavation location ($Z = -2.30$, $P < 0.05$). There was also a corresponding significant decrease ($Z = 1.73$, $P < 0.05$) in red fox use of shrub succession habitat for excavation location.

There were an estimated eight breeding pairs of foxes (16 individuals) on Assateague Island in 1985. This increased to an estimated 11 pairs (22 individuals) in 1987. Because Assateague is a narrow barrier island oriented parallel to the coasts of Maryland and Virginia, denning sites were located from north to south in basically a straight line (Fig. 1). Therefore, measurements between the centers of adjacent denning areas were made continuously from north to south. The average distance between centers of adjacent denning areas decreased from 3.4 km in 1985 to 2.6 km in 1987.

In 1985, 51 excavations (83.6% of the total) were located in soils with a dominant sandy texture (coastal beach soils), while 9 excavations (14.8%) were in soil with a loamy sand texture (klej soil). During 1987, 93 excavations (96.9% of the total) were located in sandy soils, while 3 excavations (3.1%) were found in a soil with a sandy loam texture. There was a significant increase in the use of sandy textured soil for the location of fox excavations from 1985 to 1987 ($Z = -2.42$, $P < 0.01$).

Results from the analysis on the amount of barren ground and vegetative cover surrounding fox excavations were varied (Table 3). Open ground and shrubs were the only ground covers which showed significant differences among the different excavation types. ANOVA tests were performed on the average length of transect intercepted by barren ground and vegetative covers, while percent cover is recorded in Table 3. Although ANOVA tests revealed significant differences, the

TABLE 1. Comparison of average height and width measurements (in cm) of red fox excavations within Assateague Island National Seashore, Maryland, from 1985 and 1987. Active pseudo-dens from 1985 and 1987 were not included in the analysis due to the small sample sizes (3 and 4, respectively).

Excavation Type	1985	1987	Statistic
Active Dens			
Height	23	20	U = 288
	(n=13)	(n=32)	P < 0.05
Width	25	22	t =2.116
	(n=13)	(n=32)	P < 0.05
Inactive Dens			
Height	19	17	t =2.593
	(n=15)	(n=17)	P < 0.02
Width	25	21	U = 192
	(n=15)	(n=17)	P < 0.02
Active Pseudo-dens			
Height	23	25	
	(n=3)	(n=4)	
Width	23	27	
	(n=3)	(n=4)	
Inactive Pseudo-dens			
Height	24	16	t =3.820
	(n=9)	(n=10)	P <0.002
Width	27	20	t =4.227
	(n=9)	(n=10)	P <0.001

results of multiple range tests were ambiguous. In analyzing the amount of shrub cover, active and inactive dens, as well as active pseudo-dens grouped together, however, inactive dens and active pseudo-dens also grouped with inactive pseudo-dens. This could have resulted from the low sample sizes in both active and inactive pseudo-dens (4 and 19, respectively). The amount of open ground showed less ambiguity. Inactive pseudo-dens grouped with inactive dens and active pseudo-dens, but active dens also grouped with active pseudo-dens. Again this could be the result of only having four active pseudo-dens in the analysis.

Prey remains were often observed in the vicinity of red fox excavations. The most common prey item was the eastern cottontail rabbit (*Sylvilagus floridanus*), although skate (*Raja erinacea*) and blue fish (*Pomatomus saltatrix*) were fairly common. The skate and bluefish were probably left on the beach by fishermen and scavenged by foxes. A pony (*Equus caballus*) leg was also discovered outside a fox den, most likely from a carcass found by the foxes. Remains of other prey items found at fox excavations included muskrat (*Ondatra zibethicus*), meadow vole (*Microtus pennsylvanicus*), and willet (*Catoptrophorus semipalmatus*).

Based on the analysis of 56 scats, the diet of red foxes on Assateague Island, during the 1987 study, consisted primarily of mammals, crustaceans, and birds (Table 4). Of the identified mammals consumed, the eastern cottontail rabbit had the highest frequency of occurrence (44.4%), followed by the meadow vole (31.5%) and white-footed mouse (*Peromyscus leucopus*) (24.1%). From field observations

TABLE 2. Number and distribution of red fox excavations among habitats on Assateague Island National Seashore, Maryland from 1985 and 1987. Aerial extents of each habitat are from Bashore and Krim (1986). Numbers in parentheses are percent of total yearly sample.

Habitat Type	1985	1987	Percent of Total Area
Shrub succession	31 (50.8)	31 (32.3)	15.3
Hudsonia dunes	22 (36.1)	59 (61.5)	4.5
Dune grass	7 (11.5)	2 (2.1)	10.0
Woodland	1 (1.6)	4 (4.2)	6.7
Fresh water marsh	0	0	14.9
Tidal marsh	0	0	35.4
Non-vegetated plus Washes and Pans	0	0	13.2
Totals	61	96	

during summers 1985 and 1987, rabbits appeared abundant on the island. The status of the meadow vole and white-footed mouse was unknown during this study.

DISCUSSION

Aerial surveys were not useful for locating red fox excavations on Assateague Island because most excavation entrances were concealed by vegetation or dune shadows. All fox excavations on Assateague Island were believed to have been dug by red foxes. This is in contrast with Pils and Martin (1978), who noted that red foxes in Wisconsin modified dens dug by badgers and woodchucks.

In 1987, both adult and juvenile red foxes were flushed from pseudo-dens; however, no foxes were flushed from excavations in 1985. Pseudo-dens may function as resting places for both adults and juveniles. Scott (1943) reported that red foxes in the northern Great Plains utilized nearby dens as outlying retreats, and Kolosov (1935) found that 70% of dens located in Russia were temporary retreats. These were shallow, short excavations having few, if any, branches and may have been similar to pseudo-dens found on Assateague.

There were significant differences between years in the heights and widths of all excavations types, with means in 1987 smaller than those in 1985. These differences may be related to the fact that more juveniles foxes were observed in 1987 compared to 1985. The average dimensions in 1987 were smaller than those reported by Storm *et al.*, (1976) in Illinois (28 x 23 cm), and in Iowa (25 x 23 cm), and by Pils and Martin (1978) in Wisconsin (28 x 23 cm). These differences may also be related to an increase in juveniles in 1987. More juveniles seen in 1987 may indicate a shift in the age structure of the population.

Directional orientations of red fox excavations differed significantly between 1985 and 1987. Although there was a significant increase in the frequency of

TABLE 3. Percentage composition of vegetative cover surrounding red fox excavations on Assateague Island National Seashore, Maryland in 1987. Letters represent results of multiple range tests and encompasses values that did not differ statistically ($P < 0.05$).

Excavation Type	Open	Grass	Shrub	Tree
Active Dens (N = 34)	56.9a	31.8	10.9a	0.4
Active Pseudo-Dens (N = 4)	47.4ab	23.3	27.7a	0.8
Inactive Dens (N = 27)	44.3b	30.6	23.1a	2.0
Inactive Pseudo-Dens (N = 19)	41.7b	27.6	29.9	0.8

excavations oriented towards the southeast from 1985 to 1987; excavations were still predominantly oriented towards the northeast and northwest quadrants in 1987. If directional orientation of excavations is related to thermal considerations, it would seem reasonable for excavations to be oriented towards cooler northern directions during summer months. It has been hypothesized that arctic foxes select favorable microclimate conditions in which to construct dens (Chesemore, 1969; Smits *et al.*, 1988). Red foxes on Assateague Island may also select microclimate conditions favorable for construction of fox dens.

Shrub succession and *Hudsonia* dune habitats were the two most important sites for red fox excavations on Assateague Island. These two habitats supported 96.2% of the total excavations in 1985 and 93.6% in 1987. Between 1985 and 1987 there was a significant increase in the use of *Hudsonia* dune habitat for red fox excavation location. Although this shift was significant, it probably does not constitute a major habitat change, since *Hudsonia* dune community usually occurs within the shrub succession habitat (Hill, 1984). In many places these two habitats merged together and one side of a dune was characterized by shrub succession habitat while the other side was predominantly *Hudsonia* dune habitat.

Between 1985 and 1987 the red fox population increased from an estimated eight breeding pairs to an estimated 11 breeding pairs. The average distance between centers of adjacent denning areas decreased from 3.4 km in 1985 to 2.6 km in 1987. This suggested that suitable red fox denning sites may not have been limited in 1985.

Red foxes have been reported to exhibit a universal preference for digging dens in sandy loam soils (Soper, 1942; Sheldon, 1950; Storm *et al.*, 1976; Pils and Martin, 1978) and well-drained soils (Scott and Selko, 1939; Layne and McKeon, 1956; Stanley, 1963). Sandy or loamy sand textured soils also appeared to be important factors influencing the location of fox excavations on Assateague Island. These two types of soils permit rapid water drainage and ease in digging excavations. They also were above the water table (Hall *et al.*, 1973), which may be an important factor in determining excavation location on Assateague. There was a significant increase in the use of sandy-textured soil for the location of fox excavations from 1985 to 1987. The sandy loam soil (klej) was restricted to an area west of the primary dunes from dune crossing 10 southward to approximately 1.0 km south of dune crossing

TABLE 4. Percent frequency of occurrence for prey items found in red fox scat on Assateague Island, Maryland. Results were based on the analysis of 56 scats found between May and August 1987.

	PERCENT FREQUENCY
MAMMALS	87.0
Rabbit	44.4
Meadow Vole	31.5
White-footed Mouse	24.1
Unknown	35.2
CRUSTACEANS	64.8
BIRDS	46.3
PLANT	42.6
INSECTS	31.5
FISH	9.3
MOLLUSCS	1.9
UNKNOWN (Organic)	37.0

11 (Fig. 1). Although the increase in the use of sandy-textured soil was statistically significant, it may not represent a major change in red fox preference. The change probably occurred due to a slight shift in the location of a denning area from 1985 to 1987. This shift moved the denning area location from the site where klej soil was restricted to an area just to the north.

Active dens are significantly different from both inactive dens and inactive pseudo-dens in the amount of open ground surrounding them. The large amount of barren ground associated with active dens may reflect the need for increased visibility while raising young. Less vegetation may also have resulted in higher wind velocities and thus fewer numbers of biting insects (Keiper and Berger, 1982) surrounding the excavations. Biting insects, which are abundant on Assateague, may influence red fox excavation location on Assateague Island.

Life expectancy of red fox excavations on Assateague was unknown, but due to constant sand shifting, it appeared that excavations in unprotected areas cover over within days or weeks. However, excavations in protected areas with shrub cover last several years. During the ground search in 1985, a researcher broke through the surface of a dune and discovered an old fox den, although no evidence of a den opening was present.

Although red fox food habits have been studied extensively in southern Wisconsin and Iowa (Errington, 1935, 1937), Michigan (Hamilton *et al.*, 1937), Maryland (Hockman and Chapman, 1983), Missouri (Korschgen, 1959), England (Southern and Watson, 1941), Ireland (Robertson and Whelan, 1987), central Alberta (Dekker, 1983), and Newfoundland (Dodds, 1955; Maccarone and Montevechi, 1981), studies on the food habits of red foxes on Atlantic barrier islands are apparently non-existent.

Red fox diets have been documented to consist largely of lagomorphs and rodents depending on their abundance (Errington, 1935; Scott, 1943; Wood, 1954; Dodds, 1955; Korschgen, 1959; Hockman and Chapman, 1983; Robertson and Whelan, 1987). Insects and fruit show seasonal fluctuations with the peak occurring in summer and autumn (Ewer, 1973). *Microtus* appears to be an important food source for red fox in other regions of its distribution (Errington, 1935; Heit, 1944; Scott and Klimstra, 1955). Heit (1944) studied fox food habits in a salt marsh in Maryland and found *Microtus* to be the most frequent prey item in the scat, although the larger muskrat appeared to be the major food item in terms of total energy intake. Although muskrats were not found in the scat analysis, remains were found outside of red fox excavations. This suggests that muskrats were also consumed by red foxes on Assateague.

Dueser and Porter (1986) found that these species were common to abundant on Assateague Island during June - July 1978. Because this present study included analysis of only 56 red fox scats collected between May and August 1987, the results should not be viewed as representing the complete diet of red foxes on Assateague Island.

MANAGEMENT IMPLICATIONS

Fox den searches by fixed winged aircraft are not recommended for use on east coast barrier islands. Ground surveys, although manpower intensive, allowed us to readily locate fox excavations. Search activities may be expedited by scrutinizing sand dune habitats, since nearly all excavations were found in these areas. Information regarding red fox denning behaviors is important in developing management plans and protection of critical barrier island fox habitat.

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LITERATURE CITED

Bashore, T.L., and P.M. Krim. 1986. Census and ecological aspects of the red fox breeding population within Assateague Island National Seashore, April - August 1985. Available from: Assateague Island Natl. Seashore, RD 2, Box 291, Berlin, MD 21811. 96 pp.

Brower, J.E., and J.H. Zar. 1977. Field and Laboratory Methods for General Ecology. Wm. C. Brown Co. Publ., Dubuque, Iowa. 194 pp.

Chesemore, D.L. 1969. Den ecology of the arctic fox in northern Alaska. Canadian J. Zool. 47:121-129.

Dekker, D. 1983. Denning and foraging habits of the red fox, *Vulpes vulpes*, and their interactions with coyotes, *Canis latrans*, in Central Alberta. Canadian Field-Nat. 97:303-306.

Dodds, D. G. 1955. Food habits of the Newfoundland red fox. J. Mammal. 36:291.

Dueser, D. D. and J. H. Porter. 1986. Habitat use by insular mammals: Relative effects of competition and habitat structure. Ecology 67:195-201.

Errington, P.L. 1935. Food habits of mid-west foxes. J. Mammal. 16:192-200.

______. 1937. Food habits of Iowa red foxes during a drought summer. Ecology 18:53-61.

Ewer, R.F. 1973. The Carnivores. Cornell University Press, Ithaca, New York. 494 pp.

Green, G.A., G.W. Witmer, and D.S. DeCalesta. 1986. NaOH preparation of mammalian predator scats for dietary analysis. J. Mammal. 67:742.

Hall, R.L., C.D. Crocker, C.E. Emery, R. Feuer, F.Z. Hutton, Sr., and M.R. Nichols. 1973. Soil survey of Worchester County, Maryland. Available from: Superintendent of documents, U.S. Printing Office, Wash. D.C. 20402. 78 pp.

Hamilton, W.J., Jr., N.W. Hosely, and D.E. MacGregor. 1937. Late summer and early fall foods of the red fox in central Massachusetts. J. Mammal. 18:366-367.

Heit, W.S. 1944. Food habits of red foxes of the Maryland marshes. J. Mammal. 25:55-58.

Hill, S.R. 1984. A botanical survey of the Maryland portion of Assateague Island. Ref. order no. PX 419040408, Available from: Assateague Island Natl. Seashore, RD 2, Box 291, Berlin, MD 21811. 23 pp.

_____. 1986. An annotated checklist of the vascular flora of Assateague Island (Maryland and Virginia). Castanea. 51:265-305.

Hockman, J.G., and J.A. Chapman. 1983. Comparative feeding habits of red foxes (*Vulpes vulpes*) and gray foxes (*Urocyon cineoargenteus*) in Maryland. Am. Midl. Nat. 84:568-572.

Keiper, R.R., and J. Berger. 1982. Refuge seeking and pest avoidance by feral horses in desert and island environments. Appl. Anim. Ethol. 9:111-120.

Kolosov, A.M. 1935. Sur la biologie du Kursak et du renard des steppes. Bull. Soc. Nat. Moscou. Sect. Biol. 44:165-177. (In Russian with French summary).

Korschgen, L. J. 1959. Food habits of the red fox in Missouri. J. Wildl. Mgmt. 23:168-176.

Layne, J. N. and W. H. McKeon. 1956. Notes on red fox and grey fox den sites in New York. New York Fish Game J. 3:248-249.

Lockie, J. D. 1959. The estimation of the food of foxes. J. Wildl. Mgmt. 23:224-227.

Maccarone, A. D. and W.A. Montevecchi. 1981. Predation and caching of seabirds by red fox (*Vulpes vulpes*) on Baccalieu Island, Newfoundland. Canadian Field-Nat. 95:352-353.

Pils, C. M., and M. A. Martin. 1978. Population dynamics, predator - prey relationships and management of the red fox in Wisconsin. Wisc. Dept. Nat. Resour. Rep. 105. 56 pp.

Pimentel, R. A., and J. D. Smith. 1985. Sigma Soft, Placentia, CA.

Robertson, P.A., and J. Whelan. 1987. The food of the red fox (*Vulpes vulpes*) in Co. Kildare, Ireland. J. Zool. Lond. 213:740-743.

Sargeant, A. B., W. B. Pfeifer, and S. H. Allen. 1975. A spring aerial census of red foxes in North Dakota. J. Wildl. Mgmt. 39:30-39.

Scott, T. G. 1943. Some food coactions of the northern plains red fox. Ecol. Monogr. 13:427-479.

_____ and W. D. Klimstra. 1955. Red foxes and a declining prey population. S. Illinois Univ. Press, Monogr. I.

_____ and L. F. Selko. 1939. A census of red foxes and striped skunks in Clay and Boone counties, Iowa. J. Wildl. Mgmt. 3:92-98.

Sheldon, W. G. 1950. Denning habits and home range of red fox in New York state. J. Wildl. Mgmt. 14:33-42.

Smits, C. M., C. A. Smith, and B. G. Slough. 1988. Physical characteristics of arctic fox (*Alopex lagopus*) dens in northern Yukon Territory. Canadian J. Arctic Inst. of N. Am. 41:12-16.

Soper, J. D. 1942. Mammals of Wood Buffalo Park, northern Alberta and District of Mackenzie. J Mammal. 23:119-145.

Southern, H. N. and J.S. Watson. 1941. Summer food of the red fox in Great Britain. A preliminary report. J. Anim. Ecol. 10:1-11.

Stanley, W. C. 1963. Habits of the red fox in northeastern Kansas. Misc. Publ. Mus. Nat. Hist., Univ. Kansas. 34:1-31.

Storm, G. L., R. D. Andrews, R. L. Phillips, R. A. Bishop, D. B. Siniff, and J. R. Testor. 1976. Morphology, reproduction, dispersal, and mortality of mid-western red fox populations. Wildl. Monogr. 49:1-82.

Voigt, D. R., and D. W. Macdonald. 1984. Variation in the spatial and social behavior of the red fox, *Vulpes vulpes*. Acta Zool. Fennica. 171:261-265.

Wood, J. E. 1954. Food habits of furbearers of the upland post oak region in Texas. J. Mammal. 35:406-414.

Zar, J. H. 1984. Biostatistical Analysis. Prentice-Hall Inc., Englewood Cliffs, New Jersey. 718 pp.

State of California
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INTRODUCED RED FOX IN CALIFORNIA

by

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ABSTRACT

In a telephone survey of wildlife professionals in California, introduced red fox were reported from 36 of 58 (62%) counties in California. The introduced red fox ranged along the Pacific coast from southern San Diego County to Marin County. They were reported in western Riverside County northward through the Sacramento valley and western Sierra foothills to central Shasta County. Populations were contiguous in urban areas and may be contiguous in rural areas as well. The diet of the introduced red fox in the urban environment was diverse and consisted of birds, mammals, insects, seeds, fruit and human foods. Among radio-collared foxes ($n = 23$) in urban Orange County, California, females had the greatest survival rate for both juveniles and adults. Overall, dispersing juveniles had the greatest mortality rate. Sources of mortality for urban foxes included collisions with autos, disease, an attack by a dog, and accidents other than vehicle collisions. Juvenile males were the most likely to disperse. Average dispersal distance for all successful dispersers was 9.8 ± 1.85 km (6.1 ± 1.15 mi.). Three of the radio-collared foxes were known to have bred their first year. Average litter size was 4 pups per litter ($n = 7$ litters) in 1991 and 3 pups per litter ($n = 5$ litters) in 1992. Urban foxes were found to use all aspects of the urban environment, from open fields and beaches to residential developments. Corridors for travel for both resident and dispersing foxes included flood channels, beach strands, railroad tracks, and powerline corriders. Red fox densities varied between sites.

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INTRODUCTION

In California, the red fox (Vulpes vulpes) has been reported to be native to the Sierra Nevada and southern Cascade Mountains (Grinnell et. al. 1937). However, since the 1890's the red fox has been found in several areas of California which were not part of its historical range (Grinnell et al. 1937); these foxes were probably fur farm escapees, fox hunt survivors, and intentionally-released pets or captives that have established breeding populations. Based on morphological parameters, the introduced foxes from the Sacramento Valley appear more closely related to the Northern Great Plains subspecies of red fox (V. v. regalis) rather than the Sierra Nevada red fox (V. v. necator) (Roest 1977).

Introduced red fox have established breeding populations throughout the Sacramento Valley (Gray 1975, 1977). Gould (1980) reported the range expansion of this population into Contra Costa and Alameda counties, as well as additional sightings in Marin, Santa Cruz, Ventura, and Los Angeles counties.

Introduced red foxes are considered a threat to populations of endangered wildlife including the light-footed clapper rail (Rallus lonagirostris levipes), the California clapper rail (Rallus longirostris obsoletus), the California least tern (Sterna antillarum browni), the salt marsh harvest mouse (Reithrodontomys raviventris), Belding's Savannah sparrow (Passerculus sandwichensis beldingi) (U. S. Fish and Wildlife Service and U. S. Navy 1990, U. S. Fish and Wildlife Service 1990), and the San Joaquin kit fox (V. macrotis mutica) (Ralls et. al. 1990). The introduced red fox may also present a threat to the native Sierra Nevada red fox by competing for available habitat, interbreeding or transmitting diseases.

Red fox trapping programs have been used as a means to protect the California least tern and the light-footed clapper rail from predation, but have also created controversy (U. S. Fish and Wildlife Service and U. S. Navy 1990). In some urban parks these foxes were treated as pets, and fed daily by people. In these same areas they may present health risks to the public. These concerns present difficult management problems.

Information about introduced red foxes in California has not been avaliable for wildlife managers. To develop or assess management alternatives to red fox control programs, a better understanding of the ecology of red foxes was needed. Specifically, need existed to understand local sources of depredating red foxes, how they traveled to endangered-species nesting areas, and the age of foxes that colonized on or near these areas. Sex-specific dispersal patterns, dispersal distances, dispersal routes, rates of dispersal, timing of dispersal, and dispersal direction needed to be investigated to answer these questions. Further, identification of home range, food habits, habitat use, and movement characteristics of resident foxes would clarify the impact on native fauna.

An investigation of the distribution of red fox sightings throughout California was necessary to assess the present range and population status. Determining the extent to which an introduced species has become established was important in assessing or forecasting impacts on native species and habitats.

Specific components of juvenile dispersal that were addressed in this study included: dispersal routes, dispersal distances, mortality of dispersing and non-dispersing foxes, proportions of juveniles dispersing, and timing of dispersal. Specific home range and land-parcel use questions that were addressed included: age- and sex-specific home range size and land-parcel use of radio-collared foxes. Questions related to food habits included; what food items were consumed by red foxes?; and how consistant these items were found in the red fox diet? Specific statewide distribution questions included: where have red foxes been sighted outside of the accepted range of the native Sierra Nevada red fox?; and what was the range of the introduced red fox in California?

The California Department of Fish and Game (CDFG), Nongame section, and the U. S. Fish and Wildlife Service (USFWS) cooperatively provided financial support for the project.

STUDY AREA

The distribution of the introduced red fox was investigated throughout California except in areas inhabited by the Sierra Nevada red fox. The northwestern half of Orange County, California, was used as the study area for investigating dispersal, home range and land-parcel use, mortality, survival, reproduction, and age structure (Figure 1). The study area was bounded on the northwest by the San Gabriel River and Coyote Creek flood channels, which delineate Orange County from Los Angeles County. It was bounded on the West by the Pacific Ocean, and to the North by California State Highway 91. The study area included the Pacific coast from Seal Beach to Newport Beach, and included areas as far east as the cities of Tustin and Orange. This portion of Orange County was predominantly urban and suburban in nature and was interspersed with open spaces. These open spaces included golf courses, parks, airfields, cemeteries, wetlands, agricultural fields, powerline and highway corridors, and undeveloped lands.

Much of Orange County (including the study area) is located in the Southern California coastal plain. Orange County has a Mediterranean climate characterized by wet winters and dry summers. Average annual rainfall was 32.0 cm (12.6 inches) (Kehew 1992). Mean temperatures ranged from 13.3 °C (55.9 °F) in January to 22.9 °C (73.3 °F) in August while the annual mean temperature was 17.8 °C (64.0 °F) (Kehew 1992). The elevation of the study area ranged from sea level to approximately 100 m (328 feet).

Research activities were frequently located at specific sites within the study area and these areas warrant detailed description. Mile Square Park is administered as an Orange County Regional Park. It is one mile square in area (2.25 km^2) and includes a park and two privately-owned golf courses in Fountain Valley, California. Orange County Sewage Treatment Plant #2 is an industrial facility with open space; the plant is located adjacent to the Pacific coast at the mouth of the Santa Ana River in Huntington Beach, California. Bolsa Chica Ecological Reserve includes tidal salt marsh, grassy uplands, and scattered oil-pump sites and is located on the Pacific coast in Huntington Beach, California. Los Alamitos Armed Forces Reserve Center is an 8.0 km^2 (3.0 mi^2) military installation located north of Interstate Highway 405 in Los Alamitos, California. It consists of an airfield, open grasslands, agricultural lands, and two golf courses.

METHODS

Red Fox Distribution

The statewide distribution of the introduced red fox was investigated by conducting telephone interviews with wildlife professionals and related individuals throughout the state. A sighting was any red fox that had been seen in the field by the person being interviewed or a red fox that the person had direct knowledge of as a specimen (i.e., museum specimen). Each telephone interview sought to acquire information about each red fox sighting, including reliability, date, and location of the sighting. The reliability of a sighting was based on the experience that the interviewed individual had with red foxes, and/or the accuracy of the description of the reported animal. For efficiency, new locations were mapped only if they were at least 1.6 km (1 mile) distant from the nearest previously reported location.

Presently, no reliable means is available to visually distinguish the native Sierra Nevada red fox from the introduced red fox. Therefore, interviewing efforts were concentrated in areas outside of the historical range of the Sierra Nevada red fox as reported by Grinnell et al. (1937). Consequently, no red fox sightings above 1066 m (3500 ft.) in the Sierra or Cascade Ranges were included in the distribution. With the exception of Orange County and two sightings acquired from letters that included photographs of the red foxes, sightings were collected only by telephone interview. In Orange County, historical references (e.g., reports and books) were also used in determining distribution within that one county.

Red Fox Food Habits

Food habits were investigated by collecting fox fecal material (scat) once each month from specific sites. Collection sites were cleared of scat during each collection; thus subsequent collections contained only recent (since last collection) scat deposition. This allowed assessment of seasonal variation in fox food habits. Scats were air-dried and shipped to the Humboldt State University (HSU) Department of Wildlife. Upon arrival at HSU, scats were frozen until analysis.

Fecal samples were randomly chosen from within each monthly collection at each collection site. Samples (11-13g: 3-5 fecal deposits) were washed and the remaining insolubles were then oven-dried. The oven-dried samples were stored in a desiccator until analyzed. Samples were separated into food items by similar groups of fragments (i.e., feathers, seeds, hair, bones, etc.) with the aid of a dissecting microscope. Each sample was searched until all identifiable fragments had been separated, or for a maximum of 2 hours. Usual search time was approximately 1 hour.

Additional samples from a single collection continued until no new prey items were found in succeeding samples. Once food remains were separated they were identified using reference texts (Ingles 1965, Swanson and Papp 1972) and mammalian, avian, invertebrate, and plant reference collections at HSU. We were assisted by the U. S. Department of Agriculture and the San Diego Museum of Natural History in the identification of seeds. Once identified, food items were summed by season, food type, and specific food item.

Population Information and Dispersal

Red foxes were captured and radio-collared (Mod 300 collar, Telonics, Mesa, AZ) to obtain location data for determining home range, habitat use, arid dispersal. Tomahawk box (cage) traps (121 cm by 68 cm by 52 cm, or 107 cm by 41 cm by 41 cm, or 81 cm by 33 cm by 28 cm; Tomahawk Live Trap Co., Tomahawk, WI) were used in all trapping. Degree of wear on incisors was used as a primary indicator of age (Harris 1978), and weight and coat condition were used as secondary age indicators. For the purposes of this study, distinguishing between adults and juveniles was adequate.

Each radio-collared fox was identifiable by the individual markings on its ear tags and radio-collar. Colored reflective tape was placed on the ear tags and radio-collar so that individual animals had a unique color combination (e.g., red tag in right ear, blue tag in left ear). Color-coded ear tags and radio-collars allowed other biologists and lay individuals without radio-receivers to identify individual foxes. The colored reflective tape could be seen at a 150 m distance at night with a spotlight, or during the day.

Survival and mortality rates of radio-collared foxes were estimated using the Micromort computer program (Heisey and Fuller 1985). The interval over which survival rate was estimated for juveniles began on 9 July (earliest radio-collaring) and continued for 250 days until 15 March, which was the estimated whelping date for observed litters. For adults, a 365-day interval was used (15 March - 14 March). Survival and mortality rates were estimated age- and sex-specifically for dispersers and 1-year olds, and for juveniles captured in July. Mortality rates were estimated cause-specifically.

Midnight spotlight surveys were conducted at Los Alamitos Armed Forces Reserve Center and Mile Square Park to assess population size and trends at these two northwestern Orange County sites. All observed red foxes were counted and the presence or absence of a tag or collar was recorded. Survey routes were chosen to minimize the possibility of recounting any individuals seen while the observer drove once along a predetermined route through the site.

Dispersal characteristics were determined for individuals that moved away from established home ranges or natal sites.

When a radio-collared individual could not be located, a search was conducted to locate its radio signal. This was continued until the individual was found or considered missing (after extensive searches). Once the animal was found, the direction of dispersal from the original home range (or den site for juveniles) and the straight-line distance was recorded. Radio-telemetry locations were obtained at the rate of three locations per week in the new home range (which was calculated as distinct from the pre-dispersal home range).

Home range and land-parcel use by foxes were determined by obtaining at least three independent locations per week per individual fox. Adults and juveniles were followed to observe temporal land-parcel use and movement rates. The Mcpaal computer program (Stuwe and Blohowiak 1985) was used to generate Minimum Convex Polygon (MCP) (Harvey and Barbour 1965) and Harmonic Mean Transformation (HMT) (Dixson and Chapman 1980) estimates of home range size. All HMT estimates were based on a calculation using 15 grid divisions and 95% of the locations.

Juveniles were considered adults when they survived to 15 March. If a fox did not disperse, the total number of locations as a juvenile and adult were included when estimating their adult home range. However, dispersing juveniles had two home ranges.; a juvenile home range prior to dispersal and an adult home range after dispersal. This methodology caused a loss of independence between non-dispersing juvenile and adult home ranges so no tests beyond the average home range size of each group was performed.

Different features of the urban environment, such as residential areas, open fields, parks, etc., were categorized as different land-parcel types. Any land-parcel type or types that were separated only by a road, flood channel, or other thin barrier were considered contiguous. A patch of open space was considered to consist of the total area of contiguous land parcels exclusive of residential and retail business development. Home range size in comparison to the amount of open space was investigated using linear correlation (Zar 1984). The areas of land parcels were calculated from color aerial photographs (1:17400; Airborne Systems, Anaheim, CA).

Movement patterns of red foxes were determined by continual tracking of collared animals. Because constant surveillance of collared foxes was usually difficult, movement information was gathered by analyzing relocations collected as frequently as possible. However, sampling techniques other than constant surveillance cannot fully describe a fox's movement during a single time period.

RESULTS

Red Fox Distribution

Telephone interviews were conducted with 199 individuals. Of these, 125 individuals (63%) had sightings of red foxes. These individuals produced 319 sightings of introduced red fox (below 1066 m or 3500 ft. in elevation) (Table 1, Figure 2, and Appendix 1). Red foxes are extremely mobile, can travel large distances in a short period of time, and can have large home ranges. Locations do not infer the presence of reproductive or large established populations nor do locations infer density or timing of colonization of certain areas; however in some areas the density of locations may be grossly associated with a generalized (and perhaps dense) fox population.

Red fox sightings were recorded in the coastal areas from Mission Bay just north of San Diego in San Diego County to Point Reyes National Seashore in Marin County. Red foxes were sighted throughout the San Joaquin and Sacramento Valleys from an area extending from Bakersfield in Kern County northward to the Whiskeytown National Recreation Area in Shasta County. Sightings were reported as far east as western Riverside County and the western Sierra Nevada foothills (below 1066 m or 3500 ft.) in El Dorado, Madera, Fresno, Placer and Tulare Counties. Other sightings were reported in the Salinas River Valley in Monterey and San Luis Obispo Counties, in the Carrizo Plain in San Luis Obispo County, and in the San Francisco Bay Area in Alameda, Contra Costa, Santa Clara, and San Mateo Counties. Additional sightings for the North Bay and Delta region occurred in Solano, Napa and Sonoma Counties. No sightings were recorded for the coastal area between northwestern Santa Barbara County and Monterey Bay in Monterey County.

Excluding the Sierra and Cascade foothills, red foxes were reported at relatively high elevations in some counties. Sightings were reported as high as 750 m in the coastal ranges in San Luis Obispo county, and 800 m in Santa Clara County. Maximum elevations of 1000 m and 1100 m were recorded for sightings in the San Gabriel mountains in Los Angeles County and the San Jacinto Mountains in Riverside County, respectively.

Two red fox sightings occurred near Fall River Mills in northeastern Shasta County; these sightings were located directly between the 2 northern most portions of the historical Sierra Nevada red fox range. Because of the uncertainty of the taxonomic status of these foxes they were not included in the statewide distribution map (Figure 2). In the Sierra Nevada and Cascade Ranges, only sightings that occurred below 1066 m (3500 ft.) in elevation were considered to be observations of the introduced red fox. Sightings of red fox above this elevation in the Sierra and Cascade Ranges were not included in the statewide distribution of introduced red fox.

The distribution of introduced red foxes in Orange County was also investigated in detail (Appendix 2). Twenty-two den sites and 39 independent sightings were reported in Orange County (Figure 3). Prior to this report, the scientific literature had not reported red foxes in Orange County (Grinnell et al. 1937, Hall and Kelson 1959, Ingles 1965), however we recorded sightings in Orange County as early as 1942 and 1965. Only den sites greater than 1.6 km (1 mile) away from previously mapped den sites were added to the distribution of den sites in Orange County. All den sites, and 35 of the 38 independent sightings occurred in urban areas; urban areas were characterized by residential, industrial, commercial, or similarly developed areas with interspersed open spaces and corridors. These landscape features characterized much of northern Orange County.

Red Fox Food Habits

Fox scats were collected approximately once a month from 7 sites in Orange County (Table 2). Scat was collected once at Seal Beach NWR and Costa Mesa High School.

From the 7 collection sites, 447 fecal samples (approximately 1800 scats) over all seasons were analyzed. Insects, seeds, birds, mammals, and human-food packaging were regularly ingested. Invertebrates, seeds, birds, and mammals were each found in $\geq$ 50% of the samples, regardless of season (Table 3, Figure 4). While anatids and passerines were the most frequently found avian food items in scat samples, their percent occurrence was greatest in the summer and fall samples (Table 4). Pocket gophers (Geomyidae) were the most frequently encountered mammalian food item regardless of the season (Table 5). Invertebrates in scats included insects (6 orders), arachnids, crustaceans, and mollusks (Appendix 3). Seeds occurring in scats included $\geq$ 44 genera in $\geq$ 28 plant families (Appendix 4). Most seeds were consumed as part of a plant fruit. Aluminum foil, plastic, and paper were the most frequently found human food packaging and were consistently found in the samples. Eggshells were found in all seasons.

Opportunistically acquired food was difficult to quantify or observe due to limited access to certain areas (e.g., pet food-dishes in back yards). However, regular feeding of foxes by people was consistent in some areas and was thus measurable. At Mile Square Park a single individual provided an average of 7.12 ± 0.033 kg (mean $\pm$ standard error) of food per day (measured during a 48 day period) to the approximately 40 foxes at Mile Square Park (which equates to 0.177 kg/fox-day). Food provided at this site consisted of beef, chicken, turkey, and fish.

Additional food habits data were collected by observations of predation, and identifying remains at red fox cache sites and den entrances (Table 6). Only vertebrate species were identified at den entrances. Seven species of birds that were not identified in the scats were found at dens. These included gulls (*Larus* sp.), a marbled godwit (*Limosa fedoa*), house sparrow

(*Passer domesticus*), mourning dove (*Zenaida macroura*), crow (*Corvus sp.*), cormorant (*Phalacrorax sp.*) and American avocet (*Recurvirostra americana*).

Red Fox Population Information and Dispersal

Fox Capture and Tagging

From June 1990 to March 1992 red foxes were captured and radio-collared at 8 different sites. A total of 33 red foxes were captured including 18 juveniles and 15 adults (excluding a fox family removed by the CDFG from the 55-freeway in May 1991) (Appendix 5). A total of 23 foxes were radio-collared and ear-tagged (15 juveniles and 8 adults). The remaining 10 were ear-tagged (3 juveniles and 7 adults, all at Mile Square Park). Each radio-collared and ear-tagged fox appeared to be in good condition and was released unharmed.

Of the 23 foxes, 18 were captured in baited box traps. The remaining 5 foxes were captured by chasing them out of a 75 m long culvert (used by these foxes as a diurnal resting area) into unbaited box traps. From June 1990 to January 1991, 15 foxes were captured using box-traps in 444 trap nights (3.38% trap success). The three foxes caught from July 1991 to March 1992 were captured in 67 trap nights following 341 pre-bait nights (4.48% trap success) (Table 7). There were 17 recaptures during the two-year period.

Survival

Fifteen radio-collared juveniles (11 in 1990 and 4 in 1991) were followed over a portion of their first year (Figure 5). Seven of these were captured in July. The remainder of the juveniles were captured between September and January. The survival rate was lowest for dispersing juveniles (all July captures). No juvenile female mortalities were observed; their survival was 100%. Small sample size (n = 6) may contribute to the result; however, lack of mortality may also represent a higher survival likelihood for juvenile females. The small sample sizes for each population segment consequently result in survival estimates that lack precision (as evidenced by the large confidence intervals; Table 8). Survival rates were estimated for 12 radio-collared adults over a 365-day period from 15 March 1991 to 14 March 1992 (Table 8, Figure 5). Adult survival rates ranged from 0.50 for males to 0.72 for females (Table 8).

Mortality

There were 12 (52.2%) mortalities among the radio-collared foxes (Table 9). The causes of the mortalities included collisions with automobiles (n = 4), unknown causes (n = 4), removal via red fox control program (n = 2), suffocation in a tar pit (n = 1), and an attack by a dog (n = 1). The tar pit was labeled a hazardous-substance lagoon by the property owners. Adult males, juvenile males, and dispersing juveniles suffered the highest mortality rates (Table 10). Small sample size may partially explain the lack of juvenile female mortality; however, juvenile and adult females collectively suffered the fewest mortalities among the radio-collared foxes.

Unknown deaths included disappearances and unrecoverable foxes, as well as foxes dying of unknown causes (Table 9). Fox #17 at Los Alamitos Armed Forces Reserve Center was last located on 25 July 1991. Despite extensive searching around the area and on Seal Beach Naval Weapons Station, she was never located. Fox #15 from Mile Square Park had a radio signal in an inaccessible location (under a building). The signal did not move from its location from 27 January 1992 to 1 June 1992. Consequently, the status of the animal was unknown.

Between 1 September 1991 and 31 October 1991, seven fox carcasses were retrieved from Los Alamitos Armed Forces Reserve Center and all were infested with sarcoptic mange. There was a corresponding decrease in the number of live foxes observed during spotlight surveys at Los Alamitos Armed Forces Reserve Center during this same time period (Figure 6).

Density

There were 13 animals with reflective ear-tags at Mile Square Park on 15 November 1991 when a spotlight survey was conducted. By counting the number of marked ($n = 7$) and unmarked animals ($n = 14$) an estimated 39 foxes occupied this site (Seber 1973). This corresponded to a density of 17 red fox per square kilometer (39 per square mile). Density of foxes was not estimated at Los Alamitos Armed Forces Reserve Center, however a maximum of 12 individual foxes were identified during a spotlight survey on 20 August 1991. The 12 individuals probably represented only a portion of the foxes present at this site. Sites including Bristol St. (55-Freeway), Crescent Ave., Orange County sewage treatment plant #2, and the Anaheim powerline site were occupied by single fox families. Densities of foxes at these sites were not determined because an appropriate and bounded area of use could not be delineated for the entire family; consequently mark-recapture techniques could not be used.

Dispersal

Dispersal was defined in 3 ways: 1) a gradual shift from one home range to another; 2) a series of exploratory trips prior to a final departure; and 3) a single, unpredictable exodus (Voigt and Macdonald 1984). Seven dispersals were observed (Table 11) among the 23 radio-collared foxes.

Five of the 15 radio-collared juveniles (33%) dispersed. There were 4 males (80%) and 1 female (20%) among the 5 juvenile dispersers. There were 4 dispersers (44%) among the 9 juvenile males radio-collared. Among the 6 juvenile females radio-collared, 1 (17%) dispersed. Because dispersal occurred as early as August, it was not possible to ascertain if the foxes captured after (or during) August had not already dispersed. Therefore it was possible that some of the foxes captured after August may have completed dispersal prior to capture. When considering only juveniles captured in July, 80% (4 of 5) of the males and 50% (1 of 2) of the females dispersed. Adult males dispersed proportionately less than juvenile males captured in July (40% vs. 80% respectively). Only two of five dispersing juveniles (40%) survived and established home ranges (1 male, fox #9; 1 female, fox #23).

Two of the radio-collared foxes dispersed as adults (n = 18; 11%); both were males > 3 years old. Yearling adults accounted for 10 of the 18 radio-collared adults, however none dispersed as adults. Of the 10 radio-collared adult males, 25% moved their home range.

The timing of dispersal for radio-collared juveniles ranged from 12 August to 5 January (Table 11). Juveniles first dispersed at approximately 5 months of age (using 15 March as an average whelping date). The 2 adult males dispersed on 24 November (fox #1) and 15 December (fox #3).

Flood channels, powerline right-of-ways, beach strands, and railroad corridors were considered the most likely features to facilitate dispersals. Land-parcels with open or green space characteristics that were linked continuously or directly adjacent would also facilitate dispersal. Though not all foxes could be followed during dispersal, continuous tracking data of resident and 2 dispersing foxes have shown that these landscape features were used by foxes.

Straight-line dispersal distances were determined for both successful and unsuccessful dispersers (Table 11). Successful dispersers were those that survived dispersal and established a home range. Unsuccessful dispersers were those that died during dispersal. Successful foxes dispersed an average of 9.8 ± 1.85 km (Figure 7). Fox #1 was known to disperse 9.8 km within a 48 hr period. Unsuccessful dispersal distances varied greatly but only partially reflected the progress of dispersal before mortality (Figure 8). For example, from 2 January to 12 January 1992 fox #15 made a 21 km (13 mi; straight-line distance). exploratory round-trip to Seal Beach Naval Weapons Station and back to Mile Square Park, moving from Seal Beach Naval Weapons Station to Mile Square Park in less than 24 hours. This fox died 1.7 km from the park during a movement the following night.

Dispersal directions ranged from 211 to 75 degrees. Orange County is bounded by the Pacific Ocean on its southwestern border and this limited dispersal direction. Foxes #22 and #23 both dispersed along the coast in a northwesterly direction, and were known to use the beach strand (Figures 7 and 8). Fox #1 dispersed and established a home range that bordered the ocean (Figure 7).

Reproduction

Fox #2 (The Crescent Avenue female) and the Bristol Street female (an untagged female that was associated with fox #1) each used at least 3 different dens to raise single litters of pups. Pups of one litter occupied more than one den at a time; this occurred in one instance when dens were 1.1 km apart. Foxes #21 and #23 were radio-collared yearling females that were observed raising pups. Yearling male #9 apparently mated and raised a litter of pups. Individuals #9 and #23 dispersed prior to mating.

In 1991 litter sizes were observed to range from 1 to 9 pups with a mean of 4.0 pups per litter (n = 7 litters). In 1992 litter sizes were observed to range from 2 to 4 with a mean of 3.0 pups per litter (n = 5 litters). However, litter size estimates used inconsistent methodology because some litters were counted before emergence (n = 3 litters) from the den while other litters were counted at various times after emergence (n = 9 litters). Pup mortality before or after emergence was unknown. Dens which were not located may have contained additional pups.

Den sites at Los Alamitos Armed Forces Reserve Center and Mile Square Park were found in flat open areas. At Mile Square Park 8 active den-sites were observed in both 1990 and 1991. At Los Alamitos Armed Forces Reserve Center, 5 active den sites were observed in 1991. Active den sites however do not correspond directly to numbers of litters, but it is believed that multiple litters were raised at both Mile Square Park and Los Alamitos Armed Forces Reserve Center. At Seal Beach Naval Weapons Station and Seal Beach NWR, 8 red fox dens were found in 1987 and 14 were found in 1988 (U. S. Fish and Wildlife Service and U. S. Navy 1990). Other den sites within Orange County were located in flood channel embankments (n = 7), freeway embankments (n = 4), golf course sand traps (n = 2), Christmas tree plantations (n = 2), scrap metal and rock piles (n = 2), a railroad embankment (n = 1), a pipeline passageway under a road (n = 1), and a salt marsh dike (n = 1).

Home Range and Land Parcel Use

Home range estimates were calculated for all collared foxes (n = 23) as adults and juveniles using data collected from June 1990 to 30 May 1992 (Table 12). Mean home range size as estimated by the Minimum Convex Polygon (MCP) method for adult males (n = 11) and females (n = 8) was 4.35 ± 1.52 km^2 and 4.15 ± 1.58 km^2, respectively. Mean home range size as estimated by the Harmonic Mean Transformation (HMT) method for adult males and females was 3.80 ± 1.21 km^2 and 3.85 ± 1.59 km^2, respectively. Mean juvenile home range size was 71.1% of mean adult home range size as estimated by the MCP method and 87.2% as estimated by the HMT method.

Land-parcel types that were found in red fox home ranges included: (1) non-residential manicured lawns (athletic fields, parks, and golf courses), (2) wetlands and estuaries (vegetated salt flats, tidal salt marshes, and vegetated dunes), (3) flood control channels and riparian areas, (4) vacant fields or undeveloped lands (airport fields, grasslands, and disturbed lands), (5) agricultural land (farmland, tree plantations and nurseries often associated with powerline right-of-ways), (6) residential and retail business areas, (7) beaches, (8) railroad tracks and major highways, (9) and industrial lands (e.g., oil-fields and industrial parks) (Table 13). Vacant fields were found in all (100%), manicured lawns were found in almost all (96%), and flood channels were found in most (68%) of the home ranges. No other single land parcel type occurred in more than 40% of the home ranges.

Four sites had two or more radio-collared foxes. The mean home range size calculated with MCP was 10.02 ± 0.10 km^2 for the foxes at Bolsa Chica Ecological Reserve, 2.84 ± 0.22 km^2 for foxes at Los Alamitos Armed Forces Reserve Center, 0.81 ± 0.14 km^2 for foxes at Mile Square Park, and 0.46 ± 0.05 km^2 for foxes at the Crescent Ave. site. Using a nonparametric ANOVA test (Zar 1984), home range size varied significantly between these sites (H. = 11.9, $P < 0.01$). In addition, there was a positive correlation ($r = 0.90$ for MCP, $r = 0.91$ for HMT) between the log,, of the average home range size and the area of open space

Movements

Movement data were collected for eight individual foxes through continuous tracking for a period of time (Table 14). Travel rates varied from 0.58 km/hr to 3.3 km/hr with a mean of 1.66 ± 0.33 km/hr. Four radio-collared foxes (#1, #8, #17, and #23) crossed streets during tracking episodes. Two foxes (#4 and #15) used home ranges without streets. Collared foxes were found to use an average of 2.67 ± 0.43 land-parcel types per hour.

DISCUSSION

Red Fox Distributions

State-wide Distribution

Red foxes were brought to California for the purposes of fox-hunting (Sleeper 1987) and fur ranching. Roest (1977) suggested that red foxes may have been brought from the midwest via the newly-constructed (in 1869) transcontinental railroad as settlers moved west after the Civil War. Foxes that survived being hunted, or that escaped from fur farms or transporting vehicles (Fichter and Williams 1967) were likely ancestors of foxes that presently occupy much of the range of the introduced red fox. Vail (1942) reported that in the early 1940's, approximately 125 fox farms existed in California which supported approximately 20,000 foxes. Other means of red fox introduction may have included transplantations of previously introduced foxes, escaped or released pet foxes, or intentional introduction of foxes to control rodent populations. Davidson et al. (1992) reported the illegal translocation of red foxes as recent as 1989 from Ohio to South Carolina.

Introduced red fox colonization is not specific to California; it has occurred in other states including Washington (Aubry 1984) and Idaho (Fichter and Williams 1967). Escapees from fur farms, and foxes intended for fox-hunting were also believed to be sources of introduced foxes in these states. In Washington, inbreeding and competition with the native red fox (V. v. cascadensis) were biological concerns of non-native red fox introduction (Aubry 1984). In Idaho, Fichter and Williams (1967) reported public concern over game bird and livestock predation by introduced red foxes but also reported the geographically expanded harvest of red foxes for fur. Macdonald (1987:14) described the introduction of red foxes into Australia for fox-hunting. He stated that introduced red foxes were held partially responsible for the decline of the brush-tailed rock wallaby (Petrogale penicillata), the crescent nail-tailed wallaby (Onychogalea sp.), and the native malee fowl (Leipoa ocellata).

The state-wide distribution described from telephone interviews illustrates the extent of introduced red fox colonization in California (Figure 2). The present distribution appears to be expanding both internally and externally. The increase in the number and distribution of counties with reported red fox sightings represents an external expansion from earlier reports such as Gray 1975 (Table 1). The accumulation of sightings, particularly those after 1985, suggests that recently an expansion has also occurred within several counties. Unfortunately, population density cannot be inferred from the distribution or number of sightings. A single fox could be seen at different times and places; conversely, large numbers of foxes may exist undetected if people do not frequent the site of the population.

Considering only areas actively studied in Orange County and the Orange County Animal Control records for the same time period, 103 individual foxes were counted in the summer of 1991. This was a very conservative estimate given the inabilities to account for all individuals in an area. For example, at Mile Square Park there would have been an estimated 18 foxes (maximum number of foxes seen at one time) had there not been the mark-recapture population estimate, which yielded 39 foxes. Further, the 103 individuals did not include foxes in other areas with multiple families or large fox populations (i.e., Seal Beach NWR and Seal Beach Naval Weapons Station, Westminster Memorial Park, and others; Figure 3) which were not surveyed or counted. For example, in 1988, at least 133 individual red foxes were reported at Seal Beach NWR and Seal Beach Naval Weapons Station (U. S. Fish and Wildlife Service and U. S. Navy 1990).

Areas where introduced red foxes were located in California varied considerably in type of habitat and degree of urbanization (Appendix 1, Figure 2). The clumping of red fox sightings in some urban areas may represent an affinity for urban environments (Stamps 1990), but may also represent an increased likelihood of being sighted. It is apparent in several large urban areas, including the San Francisco Bay Area and urban Los Angeles and Orange Counties, that the distribution of foxes represent contiguous populations. The ability of radio-collared foxes to disperse across urban Orange County (Table 11, Figures 7 and 8) and the size of individual home ranges (Table 12) strongly support the contention that these populations are contiguous. The red foxes in Santa Barbara probably represent a contiguous population; the same is possible for foxes in the Bakersfield and Fresno areas as well.

Given the present state-wide distribution (Figure 2) and the ability of foxes to disperse considerable distances across urban (Table 11, and Trewhella et al. 1988) and rural (Storm et al. 1976) environments, the introduced red fox population may eventually become contiguous over much of California (although density may vary considerably). Storm et al. (1976:41-42) reported that dispersing rural foxes circumvented cities and lakes, but that highways, streams, and rivers did not present barriers to fox dispersal. Though no evidence suggests that introduced red foxes have colonized northern coastal California (Del Norte, Humboldt, and Mendocino Counties), these areas may be susceptible to introduction of red foxes. It must be noted that these counties contain extensive wetlands (e.g., Humboldt Bay) and red fox introduction at these sites would probably cause considerable environmental damage.

Introduced red foxes were reported from areas where Hall and Kelson (1959) reported the presence of San Joaquin kit foxes (Vulpes macrotis mutica), gray foxes (Urocyon cinereoargenteus), and coyotes (Canis latrans). Consequently, interactions between native canids and introduced red foxes are very likely including competition for food and den sites (Sargeant et al. 1987, Voigt and Earle 1983), predator-prey interactions (Dekker 1983, Voigt and Earle 1983, Harrison et al. 1989, Ralls et al. 1990), interbreeding (Thornton et al. 1971), and disease transmission (Lloyd 1980:248-251, Wandeler 1980, Davidson et al. 1992). The threat to kit foxes by introduced red foxes involving predation (Ralls et. al. 1990), or interbreeding (Thornton et al. 1971) is not well known; however, all interactions between these two species may be detrimental to the endangered San Joaquin kit fox.

The native Sierra Nevada red fox may also suffer from interactions with the introduced red fox. The unknown status and distribution of the Sierra Nevada red fox population, and the lack of a visual means to distinguish these two foxes, make the assessment of potential interactions extremely difficult.

Local Distribution

In urban Orange County, introduced red foxes were locally abundant (Figures 1 and 3). They reside and reproduce in open spaces and corridors found in urban and suburban areas where coyote numbers are reduced (Soule et al. 1988, U. S. Fish and Wildlife Service and U. S. Navy 1990) and supplemental feeding is often available. Consequently, interactions between foxes, urban wildlife (including some endangered species), feral animals, pets and humans, exist in urban areas (U. S. Fish and Wildlife Service and U. S. Navy 1990).

The transmission of diseases including rabies (Lloyd 1980, Macdonald 1980, Wandeler 1980) canine distemper (Lloyd 1980, Davidson et al. 1992), leptospirosis (Lloyd 1980), mange (Olive and Riley 1948, Ross and Fairley 1969, Stone et al. 1972, Storm et al. 1976) and other diseases that infect foxes (Lloyd 1980, Macdonald and Newdick 1982, Davidson et al. 1992), is a realistic biological and management concern. Disease outbreaks and transmission may be more likely in locations like Mile Square Park and Los Alamitos Armed Forces Reserve Center which support multiple fox families, recreational users and their pets, farm workers, and a variety of other wildlife and feral animals. Davidson et al. (1992) reported that 15 gray foxes (covertly purchased from an animal dealer in Indiana) were incubating canine distemper when necropsied. Lloyd (1980:248) described the role of the red fox in rabies transmission to other wildlife, livestock, feral animals, pets, and humans. Red foxes were considered largely responsible for the maintenance and spread of rabies where epizoatics occurred (North America, Europe, and northern Asia), accounting for 60-85% of diagnosed rabies cases (Wandeler 1980). While the control of rabies in wildlife, and rabies vaccinations and treatments have improved, approximately 25,000 people world-wide die of rabies every year (Winkler and Bogel 1992).

Presently the main concern with the introduced red fox in urban Orange County is its impact on populations of endangered species in coastal wetlands (U. S. Fish and Wildlife Service and U. S. Navy 1990). Introduced red foxes reside in or adjacent to most of these sensitive areas (Figure 3). Monitoring of endangered species populations in these sensitive areas has been conducted by CDFG and USFWS. Removal of red foxes by control efforts have coincided with increased counts of light-footed clapper rails at Seal Beach NWR (U. S. Fish and Wildlife Service and U. S. Navy 1990) and increased numbers of active least tern nests at Bolsa Chica Ecological Reserve (E. Burkett, CDFG Biologist, pers. comm.).

Population Characteristics

Density

Other studies have reported variable densities of urban red fox. Harris and Raynor (1986) estimated mean densities of red foxes in several British cities which ranged from 0.19-2.03 fox families per km^2 and reported local densities of up to 5 fox families per km^2. In London, Page (1981) reported minimum densities of 2.06 fox families per km^2, and 2.61 adult foxes per km^2 when including unproductive vixens. Trewhella et al. (1988) reported that population densities of red foxes in London, Oxford, and Bristol, England (largely urban/suburban investigations) ranged from 1.08 to 3.64 families per km^2, while investigations in rural settings found population densities considerably lower (usually < 0.50 fox families per km^2).

In these studies fox families were defined as a litter of pups and associated adults. However, adult numbers may vary considerably due to the presence of nonbreeding adults that may or may not be related to the breeding adults (Macdonald 1979).

Using a conservative estimate of 5 for family size (2 adults and 3 pups), Harris and Raynor (1986) may have described a summer density of approximately to 25 foxes per km^2 in some areas. Mile Square Park supported an estimated density of 17 red foxes per km^2 in November 1991 which was probably similar to sites with high fox densities in England. Such a density may facilitate rapid disease transmission. Los Alamitos Armed Forces Reserve Center supported at least 12 foxes prior to an outbreak of mange (Table 9, Figure 6) which was implicated in the mortalities of at least 7 foxes at this site.

Densities at multiple fox-family sites apparently vary with available space, adequate cover, available food, and history of colonization by red foxes (carrying capacity may not be reached for a number of years after colonization). Communal denning (2 reproductive females share a single den to raise their litters) has been reported for red foxes (Sheldon 1950, Kruuk 1964, Tullar et al. 1976), but was not observed in Orange County. From Mile Square Park only 3 (37.5%) of the radio-collared juveniles dispersed and they were all males (Figures 7 and 8). The proportion of juveniles that disperse from Mile Square Park may be influenced by either the mortality of resident foxes in a population at carrying capacity, or the availability of unoccupied space in a population not yet at carrying capacity.

Areas with multiple fox families may have dynamic carrying capacities due to supplemental feeding fluctuations, potential disease outbreaks, and landscape alteration effects on cover availability. As carrying capacities change, populations with multiple fox families probably serve as a source of or recipient site for dispersing foxes.

Many areas where foxes reside in Orange County did not support the number of foxes that Mile Square Park, Los Alamitos Armed Forces Reserve Center (Figure 6), or Seal Beach NWR (U. S. Fish and Wildlife Service and U. S. Navy 1990) supported in the past. Many locations (Bristol Street, Crescent Avenue, Anaheim Powerline, Orange County Sewage Treatment Plant #2, and others) support single families of red foxes. Because an accumulation of adults has not occurred over time at these single family sites (excepting at the Bristol Street site where a third adult was present) it is assumed that most juveniles disperse from these sites or suffer mortality. The dispersal of the two remaining juveniles (both radio-collared) at the Orange County Sewage Treatment Plant site in 1991 also suggests dispersal from the single family sites is a regular event. It was unknown if spatial, behavioral or food constraints defined the carrying capacity at single family sites.

<u>Dispersal</u>

Although a number of studies have investigated red fox juvenile dispersal in North America (Storm 1965, Phillips et al. 1972, Andrews et al. 1973, Storm et al. 1976, Pils and Martin 1978, Voigt 1987), few have investigated dispersal of urban red foxes. Storm et al. (1976) found that the mean dispersal distance was 31 km (19.4 miles) for juvenile and subadult males, and 11 km (6.7 miles) for juvenile and subadult females in rural Illinois and Iowa. A similar proportion of the population of juvenile red foxes dispersed in both rural and urban settings (Phillips et al. 1972, Storm et al. 1976, Voigt 1987, Harris and Trewhella 1988). Relatively extensive investigations of red fox juvenile dispersal in the urban environment have been conducted in Bristol (Harris and Trewhella 1988, Woollard and Harris 1990), Oxford (Voigt and Macdonald 1984), and London (Page 1981) England and Edinburgh, Scotland (Kolb 1984).

Red foxes in urban areas may be limited to small pockets or patches of habitat. This arrangement of patches of suitable habitat may be similar to habitat distribution in rural areas. However dispersal from one suitable habitat to another may be quite different in the urban environment. In an urban situation, Harris and Trewhella (1988) found mean juvenile dispersal distances were 2.8 km and 1.6 km for males and females, respectively. They also found that 67% of juvenile males and 32% of juvenile females dispersed by the end of their first year, while approximately 30% of adults of both sexes dispersed.

Radio-collared foxes in Orange County dispersed greater distances on average (Table 11) than urban red foxes studied in Europe (Trewhella et al. 1988). However the proportion of dispersers from each population segment was lower than found by Harris and Trewhella (1988). Dispersal characteristics of radio-collared foxes from Orange County must be cautiously compared to other studies due to the small sample examined in Orange County.

In urban Orange County, foxes dispersed from late summer to early winter. Dispersal may also occur very quickly (< 1 week) or may be a prolonged or continual process (Voigt and Macdonald 1984, Macdonald 1987:182).

Numerous urban features facilitate dispersal including flood control channels, culverts, beach strands, railroads, powerline and highway corridors, freeway underpasses, and tunnels. Railway lines were used both for dispersal routes and as home range features in Scotland (Kolb 1984) and in England (Trewhella and Harris 1990). Hunt et al. (1987) reported red foxes using tunnels constructed under railways.

In Orange County, the urban environment was interspersed with a dendritic array of flood control channels that converge and ultimately empty into the Pacific Ocean at several sites. These flood channels passed through or emptied at ecologically sensitive areas including: Seal Beach NWR, Bolsa Chica Ecological Reserve, Upper Newport Bay Ecological Reserve, and the Huntington Beach least tern nesting colony at the mouth of the Santa Ana River (a large flood channel). These flood channels also pass through or adjacent to Mile Square Park, Los Alamitos Armed Forces Reserve Center, the Crescent Avenue site, the Bristol Street site, the Anaheim powerline site, and the Orange County Sewage Treatment Plant #2 site.

Flood channels were used by resident foxes, and they may have facilitated dispersal to sensitive coastal habitats because of their connection between red fox den sites and the coastal sites. The Santa Ana River was adjacent to the Anaheim powerline site, Mile Square Park, and Orange County Sewage Treatment Plant #2. It was suspected that fox #10 used the Santa Ana River to disperse from Mile Square Park to the Anaheim powerline site. He also used the Santa Ana River corridor while he resided at the Anaheim powerline site. Westminster Memorial Park, a cemetery which contained a red fox population, had a direct connection to Seal Beach Naval Weapons Station and Seal Beach NWR via a railroad.

Areas with multiple families, like Mile Square Park and Los Alamitos Armed Forces Reserve Center, are likely to produce more offspring than areas with single fox families, and thus produce more potential dispersers. These dispersers (which may include adults as well) may then travel to sensitive habitats (e.g., coastal wetlands). Because dispersers entering sensitive wildlife habitats may originate from distant sites, all centers of fox activity within 10 km of a management area should be given consideration in the management plan for that area (Table 11). Given the dispersal distances observed by juveniles and adults, and the proximity of resident foxes (at high or low densities) to sensitive coastal habitats, localized red fox control efforts in these habitats may be continually necessary to protect endangered species. Unless it is possible to erect effective barriers to dispersal, new foxes will eventually recolonize these areas.

The effect of dispersal on Sierra Nevada red fox was not studied. However, the mean dispersal distances reported by Storm et. al. (1976) may represent dispersal distances of introduced red foxes in rural locations of California. Given the proximity of introduced red fox sightings to the historical range of the Sierra Nevada red fox (Grinnell et al. 1937), moderate dispersal distances from the locations of a number of sightings (see section on distribution) could allow invasion of the historical range by introduced red foxes.

The variability and versatility in dispersal behaviors exhibited by red foxes makes the likelihood that red foxes will colonize or recolonize sensitive habitats both spatially and temporally unpredictable.

Survival

While disease may periodically cause marked declines in local populations of red foxes (Tullar et al. 1976, Lloyd 1980, Voigt 1987), vehicle collisions appear to be the largest cause of mortality in urban Orange County (Tables 9 and 10). Factors other than vehicle related collisions have accounted for a number of red fox deaths as well (Tables 9 and 10).

Bias can occur in survival estimates when animals are radio-tagged at different times of the year when survival rates differ (Heisy and Fuller 1985). Survival estimates were biased upwards when juveniles, collared after the initiation of a survival interval, were included in the analysis. Juveniles captured later in the year (and therefore later in the survival interval) were older and more experienced than foxes collared earlier in the year and their survival probabilities were therefore greater. This may explain why July-captured juveniles had an empirically lower survival rate than overall juveniles (Table 8). While 100% survival of radio-collared juvenile females (Table 8) may not generally represent the survival rate of this cohort in Orange County in 1991, it may indicate a greater likelihood of survival for females than males.

The proportions of the sexes that disperse may significantly influence survival rates. Juvenile males that dispersed ($n = 4$) suffered the greatest number of mortalities ($n = 3$). The one radio-collared juvenile female that dispersed, fox #23, established a home range and produced $\geq$ 2 pups as a yearling. Because assessing reproductive status is difficult with foxes (especially males) at areas with multiple families it was not possible to determine differential reproductive success among dispersers and non-dispersers. Of those that successfully dispersed, 75% were believed to produce offspring after dispersing, yet not a single non-dispersing juvenile ($n = 6$) was observed with offspring in the spring.

Storm et al. (1976) reported that both females and males breed as yearlings. Three radio-collared juveniles in Orange County were known to have bred and raised pups as yearlings.

Macdonald (1987:144) found that approximately 95% of wild red foxes die before the age of 4; however he knew of wild and captive red foxes that lived to 9 and 14 years of age, respectively. In Orange County 2 radio-collared adults were estimated conservatively at $\geq$ 5 years of age (in 1992), based on comparisons of teeth wear with known-age captive and wild red foxes. An additional fox (recovered by Orange County Animal Control) had more pronounced tooth wear than both of our older radio-collared adults and was assumed $\geq$ 6 years of age. Both radio-collared foxes (adults #1 and #2) reproduced in 3 consecutive years (1990-1992). These foxes have the reproductive potential to reproduce as yearlings, reproduce each year, produce 4-6 pups per year, and live to $\geq$ 5 years of age.

Red Fox Use of Land and Food Resources

Use of Land Resources

Red foxes now inhabit the most expansive geographical range of any wild carnivore and use habitats as varied as arctic tundra, arid deserts, and metropolitan centers (Macdonald 1987:14, Voigt 1987). In Orange County red foxes were observed inhabiting a wide range of areas in an environment previously devoid of this species. As coyote numbers decreased through expansive urbanization, red foxes were able to inhabit patches of habitat within urban areas where they became the largest wild predator (U. S. Fish and Wildlife Service and U. S. Navy 1990). Red foxes may, in fact, seek refuge in (or around) human inhabitances in rural areas as a coyote avoidance mechanism (Dekker 1983).

Red foxes in urban Orange County were found inhabiting most open spaces, often locations with concentrations of human use such as parks, golf courses, airports, and cemeteries. Use of these areas reflects a tolerance for human presence. However these sites were also where foxes were commonly fed or had an abundance of prey (e.g., gophers or waterfowl). In Orange County, foxes were fed by people at every site studied; some feeding was done on a daily basis.

Radio-collared foxes were observed using all the features of the urban environment, including shopping mall and stadium parking lots, commercial and industrial areas, agricultural areas, and residential areas. These features were interspersed with other open areas and were often connected by travel corridors (as traveled by our foxes). However, radio-collared foxes did not limit themselves to such corridors and also moved directly through residential or similarly developed urban areas. Foxes were observed crossing city streets up to 5 lanes in width (observed in the early morning hours when traffic was minimal). There was no evidence that any urban structure was a barrier to their movements.

Home range and land-parcel use by red foxes varied depending on the land-parcel type and the amount of available open space (Figure 9). Mean home range size for urban red foxes was 0.45 km^2 in Bristol (Harris 1980), and Oxford (Voigt and Macdonald 1984), while it was 1.65 km for foxes studied in London (Page 1981). In contrast, mean home ranges for rural foxes (using mostly open space) was estimated at 6.0 km^2 by Murie (1936) to 34 km^2 by Jones and Theberge (1982).

In Orange County individuals varied considerably with regard to home range size and land-parcel use. However, home range size was positively correlated to the amount of open space at each site (open space perhaps being analogous to the rural case). This does not necessarily imply cause and effect because the relationships between open space, natural food availability, and supplemental feeding were unknown. Home ranges of foxes often overlapped. Areas of overlap commonly included areas of special use like the culverts in Mile Square Park that were used for diurnal cover. Every radio-collared fox at Mile Square Park used the culverts, and foxes at other sites commonly used available culverts as well.

Hersteinsson and Macdonald (1982) described typical habitat features of urban red foxes in Oxford, England. Woodlands, pastures, arable lands, and residential habitats (gardens, orchards, scrubland, and houses) were common components of urban fox home ranges, and these were also observed in Orange County. Harris (1977) found 60% of all recovered foxes were associated with residential habitats including gardens, garden sheds, cellars, and houses. The greatest percentage of dens were located at these same locations, with railway and other embankments used frequently as well (Harris 1977). While freeway and railway embankments were used by Orange County foxes for den sites, flat open areas were used most and residential habitats (specifically yards, gardens or buildings) were not observed being used as den sites. A comprehensive den site survey could not be conducted in Orange County and observed den site locations may be biased by likelihood of detection.

In contrast to Harris (1977) it was found that land-parcels including vacant lands, golf courses, parks, and airports were used more often by radio-collared foxes in Orange County than residential habitats. It was likely that supplemental feeding influenced home range sizes and land-parcel use. Locations of special habitat features (e.g., culverts) and supplemental food sources probably concentrated fox use. Supplemental feeding may be more extensive or predictable at highly urbanized sites (e.g., Mile Square Park) when compared to larger open spaces (Los Alamitos Armed Forces Reserve Center, Bolsa Chica Ecological Reserve).

Use of Food Resources

The adaptive nature of the red fox is demonstrated well by its ability to forage on a wide variety of foods. Red fox predation upon invertebrate and vertebrate prey (including domestic and feral animals), and their utilization of carrion, human food offerings, and garbage in urban areas has been widely reported (Harris 1981, Macdonald 1987, Doncaster et al. 1990). In urban Orange County, birds, mammals, seeds, insects, and human food packaging were frequently found in scat samples. Much of the human food remains and food packaging may be attributed to intentional feeding by people, though scavenging and garbage may contribute. Eggs were present in the diet. In Spring and Summer, the increase in egg shell fragments probably results from the consumption of eggs of native avifauna. Domestic chicken eggs provided purposefully or inadvertently by people could explain the year-round use of eggs. However, egg caching could also explain the year-round observation of egg fragments. The frequency of egg shells in the scat may relate only indirectly to the number or size of eggs eaten.

Food item size and characteristics are important when considering frequency of food items in scat samples. Food item frequency does not illustrate the relative importance of food items consumed by foxes (Lockie 1959). It does however indicate seasonal changes and the regularity with which items may be consumed.

Surplus killing and food caching are behaviors reported of red foxes (Kruuk 1972, Macdonald 1976, Macdonald 1987:164,171). Animals that are killed in surplus are sometimes cached to eat later. Conclusions about red fox food habits can not be drawn from cache data alone. Large food items are more persistent in caches than small food items; less preferred food items are also more persistent (Macdonald 1987:43). Conversely, large food items may be less likely to appear in the scat because of a greater proportion of digestible material. In addition, Sargeant et al. (1984) reported that only 5% of adult ducks taken by a red fox family were left above ground at an average den. Consequently both scat and caches are important in examining food habits.

Orange County foxes were observed preying upon and provisioning pups with ducks (common to local parks and golf courses), domestic chickens, and domestic rabbits. Foxes were also observed preying upon killdeer (Charadrius vociferus) and American avocet. Birds were regularly taken and were consistently part of the diet. Harris (1981) found that the diet of juvenile foxes consisted largely of passerines (song birds). In Orange County, passerines were commonly found in scat samples and were present at den and cache sites. Thus the introduced red fox is considered a threat to Belding's Savannah sparrow (designated as endangered by the California Fish and Game Commission in 1974).

Macdonald (1977) found that red foxes preferred voles (Microtus sp.) over other rodents and other potential prey. In scats collected from Orange County, gophers were the most frequently found rodent, but California ground squirrels (Spermophilus beecheyi) and deer mice (Peromyscus sp.) were also present (Table 5). Harris (1981) and Macdonald (1987:180) reported that most instances of domestic cat (Felis domesticus) mortality by foxes involved juvenile cats. We observed several cat carcasses at den sites and cats were detected in scat samples.

The relative importance of supplemental feeding to the Orange County red fox population is poorly understood. However, supplemental feeding of foxes appears to be a widespread phenomenon which contributes large volumes of food to some locations, while only occurring occasionally at (or in small amounts) at others. Supplemental feeding does provide human-fox interactions for members of the public that may not otherwise interact with wildlife. Where food is limiting, supplemental feeding may increase local carrying capacity, and conversely, emigration or a lowering of carrying capacity may occur where supplemental feeding is reduced or ceased. In California ground squirrels, Dobson (1979) found adult and juvenile female immigration to areas with supplemental feeding; however he found that juvenile male dispersal was largely independent of supplemental feeding and population density.

Using the slightly smaller gray fox in captivity as a model, Ball and Golightly (1992) found that 0.133 kg of mice/fox-day served as a weight-maintenance diet. Free-ranging foxes may well consume twice this amount (i.e., 0.27 kg/fox-day) (Golightly 1981). Sargeant (1978) found that the average consumption for adult red foxes under 4 experimental treatments (including 3 treatments with ad libitum food) was 0.320 kg/fox-day for captive red foxes fed natural prey species. Using the range of food consumption of 0.27-0.320 kg/fox-day, Mile Square Park could support 22-27 adult foxes solely on supplemental food (7.12 ± 0.033 kg/day). The estimate of supplemental food quantity was conservative because all sources of supplemental food were not quantified (or known). Supplemental food was provided at Mile Square Park but this did not preclude consumption of prey species by resident foxes. Proportions of birds and mammals in scat samples collected from Mile Square Park were similar to proportions in scat samples from other sites. Apparently foxes at Mile Square Park fed on animal prey despite the availability of supplemental food.

The vulnerability of the California least tern and the light-footed clapper rail to red fox predation has become a management concern (U. S. Fish and Wildlife Service and U. S. Navy 1990). Neither species has evolved in the presence of red foxes and therefore have not developed specific defenses against them. California least tern chicks and eggs are particularly vulnerable when foxes invade colonies on nest islands; much of a colony's reproduction can be decimated in a single night (E. Burkett, CDFG Biologist, pers. comm.). Newly hatched least tern chicks weigh approximately 6.0 g (Massey 1974). In an extreme case, a single red fox would be expected to consume 43-53 newly-hatched least tern chicks in a single night if they were the sole source of energy intake. Surplus killing and caching behaviors have allowed foxes to decimate colonies of nesting gulls (Kruuk 1964). Other endangered species or species of special concern may be vulnerable to introduced red fox predation including the

San Joaquin kit fox (Ralls et al. 1990), the snowy plover (Charadrius alexandrinus), the salt marsh harvest mouse, the burrowing owl (Athene cunicularia), and the California clapper rail (U. S. Fish and Wildlife Service 1990).

SUMMARY

1) Introduced red fox sightings were extensive in California; from Shasta County (northern extent) to San Diego County (southern extent), and from the Pacific coast (western extent) to western Riverside County and the western Sierra Nevada foothills (eastern extents). The population appeared to be contiguous in the San Francisco Bay Area and the urban area of Los Angeles and Orange Counties, but may also be contiguous in other areas of the present range.

2) The diet of the introduced red fox was variable and included birds and bird eggs, mammals, insects, seeds, and human food. Supplemental feeding by people may be an important aspect of food provisioning in these animals.

3) Reproduction can occur every year with litter sizes ranging from 1-9 pups. Young may reproduce in the spring following their birth. Multiple dens were used for single litters, and dens were located in flat open areas, embankments, golf-course sand traps, plantations, and rock or scrap metal piles.

3) Among radio-collared foxes, females had the highest survival rates, 100% for juveniles, and 72% for adults. Males had lower survival rates, 42% and 50% for juveniles and adults respectively. Juvenile dispersers had the lowest survival rate (37%). Two radio-collared red foxes, alive at the end of the project, were estimated at $\geq$ 5 years of age.

4) Causes of mortality in radio-collared foxes included vehicle collisions, attack by dogs, disease (mange), accidents other than vehicle collisions, and unknown causes.

5) Dispersal occurred most often with juvenile males, but adult males and 1 juvenile female dispersed (no adult females dispersed). Dispersal distances range from 0.7-13.8 km. Successful foxes dispersed 9.8 ± 1.85 km. Foxes dispersed from August to January.

6) Radio-collared red foxes used open spaces in the urban environment including: undeveloped land, disturbed land, vacant fields (e.g., airfields), athletic fields, golf courses, parks, flood channels, riparian areas, agricultural land, wetlands, railroad right-of-ways, highway corridors, industrial land, and beaches. They were also found in residential and retail business areas.

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LITERATURE CITED

Andrews, R. D., G. L. Storm, R. L. Phillips, R. A. Bishop. 1973. Survival and movements of transplanted and adopted red fox pups. J. Wildl. Manage. 37:69-72.

Aubry, K. B. 1984. The recent history and present distribution of the red fox in Washington. Northwest Sci. 58:69-79.

Ball, L. C., and R. T. Golightly. 1992. Energy and nutrient assimilation by gray foxes on diets of mice and himalaya berries. J. Mamm. 73:840-846.

Davidson, W. R., M. J. Appel, G. L. Doster, O. E. Baker, and J. F. Brown. 1992. Diseases and parasites of red foxes, gray foxes, and coyotes from commercial sources selling to fox chasing enclosures. J. Wildl. Dis. 28:In Press.

Dekker, D. 1983. Denning and foraging habits of red foxes, Vulpes vulpes, and their interaction with coyotes, Canis latrans, in central Alberta. Can. Field-Nat. 97:303-306.

Dixson, K. R., and J. A. Chapman. 1980. Harmonic mean measure of animal activity areas. Ecology. 61:1040-1044.

Dobson, F. S. 1979. An experimental study of dispersal in the California ground squirrel. Ecology. 60:1103-1109.

Doncaster, C. P., C. R. Dickman, and D. W. Macdonald. 1990. Feeding ecology of red foxes (Vulpes vulpes) in the city of Oxford, England. J. Mamm. 71:188-194.

Fichter, E., and R. Williams. 1967. Distribution and status of the red fox in Idaho. J. Mamm. 48:219-230.

Golightly, R. T. 1981. Comparative energetics of two desert canids: the coyote (Canis latrans) and the kit fox (Vulnes macrotis). Ph.D. Thesis, Arizona State Univ., Tempe, 174 pp.

Gould, G. I. 1980. Status of the red fox in California. Calif. Dept. of Fish and Game, Nongame Wildl. Invest., Job I-8, Progress Report.

Gray, R. L. 1975. Sacramento Valley red fox survey. Calif. Dept. of Fish and Game, Nongame wildl. invest. Progress report. 6 pp.

———. 1977. Extensions of red fox distribution in California. Calif. Fish and Game. 63:58.

Grinnell, J., J. S. Dixson, and J. M. Linsdale. 1937. Furbearing mammals of California. Univ. of Calif. Press, Berkeley. 777 pp.

Hall, E. R., and K. R. Kelson 1959. The mammals of North America. The Ronald Press Co., New York. 1,083 pp.

Harris, S. 1977. Distribution, habitat utilization and age structure of a suburban fox (Vulpes vulpes) population. Mamm. Rev. 7:25-39.

_____ 1978. Age determination in the red fox (Vulpes vulpes) -an evaluation of technique efficiency as applied to a sample of suburban foxes. J. Zool. 184:91-117.

_____ 1980. Home ranges and patterns of distribution of foxes (Vulnes vulues) in an urban area as revealed by radio tracking. Pages 685-690 in C. J. Amlaner and D. W. Macdonald, eds. A handbook on bio-telemetry and radio tracking. Pergamon Press, Oxford.

_____ 1981. On the food of suburban foxes (Vulpes vulpes), with special reference to London. Mamm. Rev. 11:151-168.

_____ and J. M. V. Raynor. 1986. Urban fox (Vulpes vulpes) population estimates and habitat requirements in several British cities. J. Anim. Ecol. 55:575-591.

_____ and W. J. Trewhella. 1988. An analysis of some of the factors affecting dispersal in an urban fox (Vulpes vulpes) population. J. Appl. Ecol. 25:409-422.

Harrison, D. J., J. A. Bissonette, and J. A. Sherburne. 1989. Spatial relationships between coyotes and red foxes in eastern Maine. J. Wildl. Manage. 53:181-185.

Harvey, M. J., and R. W. Barbour. 1965. Home range of Microtus ochragaster as described by a modified minimum area method. J. Mammal. 46:398-402.

Heisy, D. M., and T. K. Fuller. 1985. Evaluation of survival and cause-specific mortality rates using telemetry data. J. Wildl. Manage. 49:668-674.

Hersteinsson, P., and D. W. Macdonald. 1982. Some comparisons between red and arctic foxes, Vulnes vulues and Alopex lagopus, as revealed by radio tracking. Symp. Zool. Soc. London. 49:259-289.

Hunt, A., H. J. Dickens, and R. J. Whelan. 1987. Movement of mammals through tunnels under railway lines. Aust. Zool. 24:89-93.

Ingles, L. G. 1965. Mammals of the Pacific States: California, Oregon, and Washington. Stanford U. Press, Stanford California. 506 pp.

Jones, D. M., and J. B. Theberge. 1982. Summer home range and habitat utilization of the red fox (Vulpes vulpes) in a tundra habitat, northwest British Columbia. Can. J. Zool. 60:807-812.

Kehew, D. E. 1992. 1991-1992 California county fact book. California Counties Foundation Reasearch Division, Sacramento California. 293 pp.

Kolb, H. H. 1984. Factors affecting the movements of dog foxes in Edinburgh. J. Appl. Ecol. 21:161-173.

Kruuk, H. 1964. Predation and anti-predator behavior of the black-headed gull (Larus ridibundis L.). Behav. Suppl. 11:1-130.

_____ 1972. Surplus killing by carnivores. J. Zool. 166:233-244.

Lloyd, H. G. 1980. The red fox. B. T. Batsford Ltd., London, U.K. 320 pp.

Lockie, J. D. 1959. The estimation of the food of foxes. J. Wildl. Manage. 23:224-227.

Macdonald, D. W. 1976. Food caching by red foxes and some other carnivores. Z. Tierpsychol. 42:170-185.

_____ 1977. On food preference in the red fox. Mamm. Rev. 7:7-23.

_____ 1979. 'Helpers' in fox society. Nature, London. 282:69-71.

_____ 1980. Rabies and wildlife: a biologists's perspective. Oxford Univ. Press, New York. 151 pp.

_____ 1987. Running with the fox. Facts on File Publ., New York. 224 pp.

_____ and M. T. Newdick. 1982. The distribution and ecology foxes, (Vulpes vulpes), in urban areas. Pages 123-135 in R. Benjamin, J. A. Lee, and M. R. D. Seward, eds. Urban ecology. Blackwell Sci. Publ., Oxford, U.K.

Massey, B. W. 1974. Breeding biology of the California least tern. Proc. Linn. Soc. New York. 72:1-24.

Murie, A. 1936. Following fox trails. Misc. Publ. Mus. Zool., Univ. Michigan. 32:1-45.

Olive, J. R., and C. V. Riley. 1948. Sarcoptic mange in the red fox in Ohio. J. Mamm. 29:73-74.

Page, R. J. 1981. Dispersal and population density of the red fox (Vulpes vulpes) in an area of London. J. Zool. 194:485-491.

Phillips, R. L., R. D. Andrews, G. L. Storm, and R. A. Bishop. 1972. Dispersal and mortality of red foxes. J. Wildl. Manage. 36:237-248.

Pils, C. M., and M. A. Martin. 1978. Population dynamics, predator-prey relationships and management of the red fox in Wisconsin. Wis. Dep. Nat. Resour., Tech. Bull. # 105, 56 pp.

Ralls, K., P. J. White, J. Cochran, and D. B. Siniff. 1990. Kit fox-coyote relationships in the Carrizo Plain Natural Area. Unpubl. annu. rep., U. S. Fish Wildl. Serv. 27 pp.

Roest, A. I. 1977. Taxonomic status of the red fox in California. Calif. Dept. of Fish and Game, Nongame Wildl. Invest. Final report. 15 pp.

Ross, J. G., and J. S. Fairley. 1969. Studies of disease in the red fox (Vulpes vulpes) in northern Ireland. J. Zool. 157:375-381.

Sargeant, A. B. 1978. Red fox prey demands and implications to prairie duck production. J. Wildl. Manage. 42:520-527.

_____ S. H. Allen, and R. T. Eberhardt. 1984. Red fox predation on breeding ducks in mid continent North America. Wildl. Monogr. 89. 41 pp.

_____ S. H. Allen, and J. O. Hastings. 1987. Spatial relations between sympatric coyotes and red foxes in North Dakota. J. Wildl. Manage. 51:285-293.

Seber, G. A. F. 1973. The estimation of animal abundance and related parameters. Hafner Press, New York. 506 pp.

Sheldon, W. G. 1950. Denning habits and home range of red foxes in New York State. J. Wildl. Manage. 14:33-42.

Sleeper, J. 1987. Bears to Briquets: A history of Irvine Park 1897-1997. Calif. Classics, Trabuco Canyon, Calif.

Soule, M. E., D. T. Bolger, A. C. Alberts, J. Wright, M. Sorice, and S. Hill. 1988. Reconstructed dynamics of rapid extinctions of chapparal-requiring birds in urban habitat islands. Conserv. Biol. 2:75-92.

Stamps, D. 1990. The red fox goes to town. Natl. Wildl. 28:10-13.

Stone, W. B., E. Parks, B. L. Weber, F. J. Parks 1972. Experimental transfer of sarcoptic mange from red foxes and wild canids to cative wildlife and domestic animals. New York Fish and Game J. 19:1-11.

Storm, G. L. 1965. Movements and activities of foxes as determined by radio-tracking. J. Wildl. Manage. 29:1-13.

Storm, G. L., R. D. Andrews, R. L. Phillips, R. A. Bishop, D. B. Siniff, and J. R. Tester. 1976. Morphology, reproduction, dispersal, and mortality of midwestern red fox populations. Wildl. Monogr. No. 49. 82 pp.

Stuwe, M., and C. E. Blohowiak. 1985. Micro-computer program for the analysis of animal locations (Mcpaal), version 1.2. Conser. and Res. Center, Nat. Zool. Pk., Smithsonian Institute, Front Royal, Virginia.

Swanson, L. A., and C. S. Papp. 1972. Common insects of North America. Harper & Row, New York. 750 pp.

Thornton, W. A., G. C. Creel, and R. E. Trimble. 1971. Hybridization in the fox genus Vulpes in west Texas. Southwest. Naturalist. 15:473-484.

Trewhella, W. J., S. Harris, and F. E. McAllister. 1988. Dispersal distance, home range size and population density in the red fox (Vulpes vulpes) : a quantitative analysis. J. Appl. Ecol. 25:423-434.

Trewhella, W. J., and S. Harris. 1990. The effect of railway lines on urban fox (Vulpes vulpes) numbers and dispersal movements. J. Zool. 221:321-326.

Tullar, B. F., L. T. Berchielli, and E. P. Saggese. 1976. Some implications of communal denning and pup adoption among red foxes in New York. New York Fish and Game J. 23:92-95.

U. S. Fish and Wildlife Service and U. S. Navy. 1990. Endangered species management and protection plan, Naval Weapons Station - Seal Beach and Seal Beach National Wildlife Refuge. Final environmental impact statement. Portland, Oregon. 591 pp.

U. S. Fish and Wildlife Service. 1990. Predator management plan and environmental assessment, San Francisco Bay National Wildlife Refuge, Newark, CA. Draft report. 26 pp.

Vail, E. L. 1942. Fox ranching in southern California. Calif. Fish and Game. 28:87-88.

Voigt, D. R. 1987. Red fox. Pages 379-392 in M. Novak, J. A. Baker, M. E. Obbard, and B. Malloch, eds. Wild furbearer management and conservation in North America. Ontario Trappers Assoc., North Bay.

Voigt, D. R., and B. D. Earle. 1983. Avoidance of coyotes by red fox families. J. Wildl. Manage. 47:852-857.

Voigt, D. R., and D. W. Macdonald. 1984. Variation in the spatial and social behavior of the red fox, Vulpes vulpes. Acta Zool. Fenn. 171:261-265.

Wandeler, A. I. 1980. Epidemiology of fox rabies. Pages 237-249 in E. Zimen, ed. The red fox. Biogeographica. Vol. 18. Dr. W. Junk, The Hague, The Netherlands.

Winkler, W. G., and K. Bogel. 1992. Control of rabies in wildlife. Sci. Am. 266:86-92.

Woollard, T. and S. Harris. 1990. A behavioral comparison of dispersing and non-dispersing foxes (Vulpes vulpes) and an evaluation of some dispersal hypotheses. J. Anim. Ecol. 59:709-722.

Zar, J. H. 1974. Biostatistical analysis. Prentice-Hall Inc. Englewood Cliffs, N.J. 620 pp.

Table 1. Number of confirmed red fox locations (319) from telephone surveys in California by county. Data were from telephone surveys conducted June 1990 to January 1993. Counties not listed were not surveyed.

County	Cumulative No. of Locations (year)			Sightings from Gray 1975 presence (+), absence (-) not surveyed (ns)
	<1975	(1985	≤1992	
Alameda	0	2	33	-
Butte	1	3	4	+
Colusa	2	5	9	+
Contra Costa	0	4	9	-
El Dorado	0	0	2	+
Fresno	0	1	16	-
Glenn	3	4	6	+
Humboldt	0	0	0	ns
Imperal	0	0	0	ns
Kern	0	0	14	-
Kings	0	0	2	-
Los Angeles	5	8	17	+[a]
Madera	0	1	1	+
Marin	0	1	7	+
Mendocino	0	0	0	+
Merced	0	0	15	-
Monterey	0	3	23	-
Napa	1	1	1	+
Nevada	0	0	0	ns
Orange	5	7	35	ns
Placer	0	0	1	ns
Riverside	0	0	3	ns
Sacramento	1	1	3	+
San Benito	0	2	16	-
San Bernardino	0	1	2	ns
San Diego	0	1	4	ns
San Francisco	0	0	0	ns
San Joaguin	0	2	6	+
San Luis Obispo	0	4	24	ns
San Mateo	0	1	5	-
Santa Barbara	0	5	14	ns
Santa Clara	0	3	16	-
Santa Cruz	0	0	1	-
Shasta	4	5	6	+
Solano	0	1	4	+
Sonoma	1	1	2	-
Stanislaus	0	0	0	ns
Sutter	2	2	2	+
Tehema	4	4	6	+
Trinity	0	0	0	+
Tulare	0	0	3	-
Ventura	0	1	3	ns
Yolo	0	2	4	+
Yuba	0	0	0	+
total	29	76	319	

[a]Los Angeles County was not formally surveyed but sightings of red foxes at El Dorado Nature Center in Long Beach were included.

Table 2. Red fox trapping and scat collection sites in Orange County, California, June 1990 - March 1992.

Site	Location	Scat Collections
Bristol Street	At Jct. with Route 55 in Costa Mesa, CA	7
Costa Mesa High School	Costa Mesa, CA	1
Crescent Ave.	At Dad Miller Golf Course in Anaheim, CA	13
Mile Square Park	Fountain Valley, CA	17
Orange Co. Sewage Treatment Plant #2	At Jct. of Brookhurst St. and Pacific Coast Highway in Huntington Beach, CA	0
Los Alamitos Armed Forces Reserve Center	Los Alamitos, CA	12
Bolsa Chica State Ecological Reserve	Huntington Beach, Orange Co., CA	3
Seal Beach National Wildlife Refuge[a]	Seal Beach, CA	1
Anaheim Powerline[a]	At Jct. of Cerritos Ave. and State College Ave. in Anaheim, CA	4
Edison Power Plant	On Pacific Coast Highway, between Newland Street and Magnolia Avenue, in Huntington Beach, CA	2

[a]No trapping conducted at these sites.

Table 3. Percent occurrence[a] of major food types in red fox fecal samples by season in Orange County, California, 1990-1991.

Food Type	Winter (n=124)	Spring (n=58)	Summer (n=114)	Fall (n=125)
Mammals	74	84	60	51
Aves	56	76	81	66
Egg Shell	2	2	10	6
Invertebrates	84	90	97	99
Seeds	60	69	77	84
Human Food and Food Packaging	86	41	59	60

[a]Percent occurrence of food types equals the number of fecal samples containing the food type within a specific season, divided by the total number of fecal samples analyzed from that season.

Table 4. Percent occurrence[a] of avian prey items in red fox fecal samples by season in Orange County, California, 1990-1991.

Prey Item	Winter (n=69)	Spring (n=44)	Summer (n=92)	Fall (n=83)
Strigidae (owl family)	4	0	1	0
Anatidae (duck family)	1	5	41	32
Euphagus cyanocephalus (Brewer's blackbird)	0	0	1	0
Columba livia (pigeon)	0	2	5	2
Falco sp. (falcon family)	0	0	11	1
Sturnus vulgaris (starling)	0	0	8	0
Unidentified passerine (songbirds)	20	5	53	50
Gallus domesticus (domestic chicken)	0	0	2	1
Phasianidae (pheasant family)	0	0	1	1
Unidentified bird	81	87	[b]	[b]

[a]Percent occurrence of prey items is the number of fecal samples containing the prey item divided by the number of samples containing avian prey (e.g., 69 samples in Winter contained avian prey items).
[b]Awaiting final analysis.

Table 5. Percent occurrence[a] of mammalian prey items in red fox fecal samples by season in Orange County, California, 1990-1991.

Food Item	Winter (n=92)	Spring (n=49)	Summer (n=68)	Fall (n=64)
Geomyidae (gopher family)	44	31	40	42
Peromyscus sp. (deer mice)	1	2	3	6
Spermophilus beecheyi (Calif. ground squirrel)	3	0	16	3
Didelphis virginianus (opossum)	1	0	3	0
Felis domesticus (domestic cat)	1	0	0	6
Sylvilagus auduboni (cottontail rabbit)	4	0	0	2
Unidentified mammal	57	73	38	41

[a]Percent occurrence of prey items is the number of fecal samples containing the prey item divided by the number of samples containing mammalian prey.

Table 6. Food items[a] identified at red fox dens and cache sites in Orange County, California, June 1990 - July 1992.

Food item[b]	Number Recovered
Larus sp. (gulls)	9
Anatidae (duck family)	7
Spermophilus beecheyi (Calif. ground squirrel)	5
Gallus domesticus (domestic chicken)	3
Columba livia (pigeon)	3
Sylvilagus auduboni (cottontail rabbit)	2
Domestic rabbit	2
Felis domesticus (domestic cat)	2
Didelphis virginianus (oppossum)	2
Geomyidae (pocket gopher family)	1
Limosa fedoa (marbled godwit)	1
Passer domesticus (house sparrow)	1
Zenaida macroura (mourning dove)	1
Corvus sp. (crows)	1
Phalacrorax sp. (cormorants)	1

[a]Food items other than human food offerings and food packaging. Charadrius vociferus (killdeer) and Recurvirostra americana (American avocet) predation by a radio-collared red fox were observed. A cormorant Phalacrorax sp). was entangled in fishing line and was either scavenged or killed by foxes.
[b]Anatidae include ducks with typical mallard (Anas platyrhynchos) coloration and white domestic ducks, both commonly seen in parks and golf courses.

Table 7. Trap-nighs and trap success for red fox captures in Orange County, California.

Site[a]	Pre-bait nights[b]	Trap-nights	No. of Captures	No. of Recaptures	Trap Success[c] (%)
I) June 1990 - January 1991					
Crescent	NA	116	2	8	1.72
Bristol	NA	94	1	0	1.06
MSP	NA	34	4	1	11.76
STP	NA	114	0	0	0.00
LAAFRC	NA	42	5	0	11.90
BCER	NA	14	2	0	14.29
Total	--	444	14	9	3.38
II) June 1991 - March 1992					
Cresent	11	12	0	2	0.00
LAAFRC	123	18	0	2	0.00
ACP	5	0	0	0	0.00
SCEP	20	18	2	4	11.11
BCER	77	0	0	0	0.00
CMHS	82	2	0	0	0.00
OCSTP	23	17	1	0	5.88
Total	341	67	3	8	4.48

[a]Crescent is Crescent Ave. site, Bristol is Bristol St. site, CMHS is Costa Mesa High School,-MSP is Mile Square Park, OCSTP is Orange Co. sewage treatment plant #2, LAAFRC is Los Alamitos Armed Forces Reserve Center, BCER is Bolsa Chica State Ecological Reserve, ACP is the Associated Concrete Products Inc. on McArthur Blvd., SCEP is the Huntington Beach Southern California Edison Plant.
[b]NA = Not Available
[c]Trap success = captures/trap nights

Table 8. Survival[a] of radio-collared red foxes in Orange County, California, 1990-1992.

Population segment	Survival rate estimate	95% CI[b]
Juveniles[c]		
Captured in July (n = 7)	0.54	0.31-1.00
Known dispersers (n = 5, 4M:lF) (all captured in July)	0.37	0.16-1.00
Males (n = 9)	0.42	0.21-0.98
Females (n = 6)	1.00	1.00-1.00
Overall (n = 15)	0.65	0.42-0.99
Adults[d]		
Known 1-yr olds (n = 6, 4M:2F)	0.64	0.38-1.00
Males (n = 8)	0.50	0.28-0.99
Females (n = 4)	0.72	0.43-1.00
Overall (n = 12)	0.58	0.38-0.94

[a]Survival was estimated using the Micromort computer program (Heisy and Fuller 1985).
[b]Confidence interval
[c]Juvenile survival rates were based on a 250-day interval (9 Aug.- 15 Mar.). The 1990 and 1991 cohorts were combined in the analysis.
[d]Adult survival rates were based on a 365-day interval (15 Mar 1991 - 14 Mar. 1992)

Table 9. Mortalities of radio-collared red foxes in Orange County, California, 1990-1992.

Fox	Age	Sex	Date	Cause of death
#7	ad	F	1 Oct. 1990	suffocation in tar pit[a]
#19	juv	M	23 Oct. 1990	killed by dogs
#10	juv	M	28 Nov. 1990	hit by vehicle
#5	ad	M	7 Mar. 1991	unknown
#20	juv	M	20 Apr. 1991	euthanization[b]
#21	juv	F	23 Apr. 1991	euthanization[b]
#17	juv	F	25 Jul. 1991	missing[c]
#22	juv	M	25 Aug. 1991	hit by vehicle
#9	juv	M	3 Sep. 1991	hit by vehicle
#18	juv	M	12 Sep. 1991	unknown[d]
#4	ad	M	28 Sep. 1991	unknown[d]
#3	ad	M	7 Nov. 1991	hit by vehicle
#8	ad	F	11 Feb. 1992	unknown

[a]Tar pit was a man-made pit containing tar and was labeled a "Hazardous Sustance Lagoon."
[b]Foxes were trapped and euthanized at Bolsa Chica Ecological Reserve through a red fox control program.
[c]Fox was not found since 25 July 1991 and was considered missing.
[d]Fox had severe sarcoptic mange at time of death.

Table 10. Cause-specific mortality rates for radio-collared red foxes in Orange County, California, 1990-1992.

Population segment	Mortality Rate Estimates[a] Vehicle collisions (n) (95% CI)	Other (n) (95% CI)	Unknown (n) (95% CI)
Juveniles[b]			
Males (n = 9)	0.27 (2) (0.00-0.59)	0.14 (1) (0.00-0.38)	0.14 (1) (0.00-0.38)
Females (n = 6)	0.00	0.00	0.00
Known dispersers (n = 5,4M:1F)	0.38 (2) (0.00-0.80)	0.00	0.19 (1) (0.00-0.53)
Overall (n = 15)	0.18 (2) (0.00-0.40)	0.09 (1) (0.00-0.25)	0.09 (1) (0.00-0.25)
Adults[c]			
Males (n = 8)	0.24 (2) (0.00-0.52)	0.00	0.24 (2) (0.00-0.52)
Females (n = 4)	0.00	0.25 (1) (0.00-0.66)	0.00
Known 1-yr olds (n = 6, 4M:2F)	0.17 (1) (0.00-0.46)	0.00	0.17 (1) (0.00-0.46)
Overall (n = 12)	0.16 (3) (0.00-0.36)	0.08 (1) (0.00-0.23)	0.16 (3) (0.00-0.36)

[a]Mortality rate estimates as determined using Micromort computer software (Heisey and Fuller 1985). "Unknown" mortalities are suspected to include additional vehicle collision deaths and disease (mange) related deaths. "Other" mortalities include one dog attack (fox #16) and one suffocation, in a tar pit (fox #7).
[b]Juvenile mortality estimates were based on a 250 day survival interval (9 Jul. - 14 Mar. for both 1990 and 1991 combined).
[c]Adult mortality rate estimates were based on a 365 day interval from 15 Mar. 1991 - 14 Mar. 1992.

Table 11. Dispersal data for radio-collared red foxes in Orange County, California, 1990-1992.

Fox	Date	Age	Sex	Direction (in degrees)	Distance[a] (km)
Successful Dispersers[b]					
#9	15 Dec. 1990	juv	M	NNE (27)	10.8
#3	15 Dec. 1990	ad	M	WSW (245)	13.8
#23	--	juv	F	NW (301)	4.9
#1	24 Nov. 1991	ad	M	WSW (255)	9.8
Unsuccessful Dispersers[c]					
#10	28 Nov. 1990	juv	M	ENE (75)	0.7
#22	12 Aug. 1991	juv	M	NW (310)	10.8
#15	3 Jan. 1992	juv	M	NW (303)	10.5
#15	5 Jan. 1992	juv	M	SSW (211)	1.7

[a]From natal den site or mean UTM coordinate of home range to a subsequent home range center or whelping den, or location of mortality during dispersal.
[b]Successful dispersers were foxes that survived dispersal to establish (or initiate) a home range. Fox #3 was considered a successful disperser due to length of time (325 days) between dispersal initiation and subsequent road-kill mortality. Fox #23's dispersal consisted of a series of exploratory movements between 22 Aug. and 27 Nov. 1991.
[c]Unsuccessful dispersers were foxes that died during dispersal. On 3 Jan. 1992 fox #15 made an exploratory foray from Mile Square Park to Seal Beach Naval Weapons Station and back to Mile Square Park (a 21 km straight-line movement). On 13 Jan. 1992 fox #15 dispersed south from Mile Square Park and presumably died. The radio collar signal was located in an inaccessable location and did not move for four months.

Table 12. Home range estimates using Minimum Convex Polygon (MCP) and Harmonic Mean Transformation (HMT) methods for radio-collared foxes in Orange County, Calif., Jun. 1990 - Dec. 1991.

Fox	Sex	Site[a]	No. Locations	Range Estimate (km^2) MCP	Range Estimate (km^2) HMT[b]
Adults[c,d]					
1 (PRE-DISP)	M	Bristol	106	16.04	12.34
(POST-DISP)		Huntington	78	8.66	7.25
2	F	Crescent	90	0.49	0.56
3	M	Crescent	38	0.40	0.61
4	M	LAAFRC	46	2.90	3.39
5	M	LAAFRC	48	2.91	3.46
6	M	MSP	140	0.56	0.48
7	F	OCSTP	13	1.72	1.02
8	F	SCEP	40	3.70	4.75
9 (POST-DISP	M	APL	58	1.77	1.63
11	M	MSP	166	0.54	0.45
12	F	MSP	121	0.78	0.69
13	F	MSP	89	0.93	0.59
14	M	MSP	161	0.86	0.83
17	M	LAAFRC	69	3.31	2.26
18	F	LAAFRC	82	2.23	1.63
20	M	BCER	90	9.92	9.06
21	F	BCER	94	10.12	10.35
23	F	SCEP	163	12.21	11.24
Mean			67	4.26	3.82
Standard error			13	1.07	0.94
Juveniles					
9 (PRE-DISP)	M	MSP	31	0.71	0.97
10	M	MSP	27	0.98	1.13
11	M	MSP	50	0.48	0.35
12	F	MSP	46	0.55	0.44
13	F	MSP	53	0.60	0.83
14	M	MSP	50	0.48	0.35
15	M	MSP	55	0.62	0.63
16	F	MSP	66	0.33	0.31
17	M	LAAFRC	45	3.02	1.02
18	F	LAAFRC	56	2.23	1.79
19	M	LAAFRC	17	0.77	0.69
20	M	BCER	70	9.60	9.19
21	F	BCER	94	10.11	9.00
22	M	OCSTP	17	2.80	1.42
23	F	SCEP	123	12.18	21.80
Mean			53	3.03	3.33
Standard error			7	1.05	1.52

[a]Cresent Ave. site, Bristol is Bristol St. site, MSP is Mile Square Park, LAAFRC is Los Alamitos Armed Forces Reserve Center, OCSTP is Orange Co. sewage treatment plant #2, APL is Anaheim powerline site, BCER is Bolsa Chica State Ecological Reserve, SCEP is the Southern California Edison Plant.
[b]HMT estimates for 15 grid division and 95% of the locations.
[c]Pre-disp referes to data collected before dispersal. Post-disp refers to data collected after dispersal.
[d]Includes animals initially captured as juveniles and matured with radio collar intact.

Table 13. Land parcel types used by radio-collared red foxes in Orange County, California.

Land Parcel Types	Percent of Home Ranges With Type
Undeveloped land, vacant fields, disturbed land	100
Athletic fields, parks, golf courses	96
Flood control channels, riparian	68
Residential tracts, retail business	37
Agriculture land (includes fallow land)	29
Wetlands, estuaries	21
Railroad tracks, major highways	21
Industrial land	21
Beaches	12

[a]Number of home ranges that incorporated a land parcel type divided by the number of home ranges (n = 24) examined.

Table 14. Descriptions of movements from continuous relocations of radio-collared red foxes in Orange County, California. Means between different following episodes are followed by ± standard error.

Fox	n[a]	Travel rate (km/hr)	Street crossings per hour[b]	Number of land parcel types used per hour[c]
#1	6	3.30 ± 0.46	4.30 ± 1.40	3.8 ± 1.4
#4	2	0.76 ± 0.33	--	1.7 ± 0.96
#8	4	1.10 ± 0.33	1.10 ± 0.62	2.5 ± 0.67
#9	1	2.30	0.00	4.4
#15	1	0.58	--	1.1
#17	1	1.70	0.26	1.5
#18	1	1.80	0.00	1.5
#23	4	1.80 ± 0.54	2.00 ± 0.82	4.9 ± 0.42
Mean		1.66 ± 0.33	1.30 ± 0.52	2.7 ± 0.43

[a]n=number of independent following episodes.
[b]Foxes #4 and #15 do not have streets within their home ranges.
[c]Land parcel types include: beaches, parks, golf courses, fairgrounds, residential areas, powerline right-of-ways, high schools, pasture, industrial lands, disturbed fields, eucalyptus groves; vegetated dunes, railroad right-of-ways, airfields, and agricultural lands.

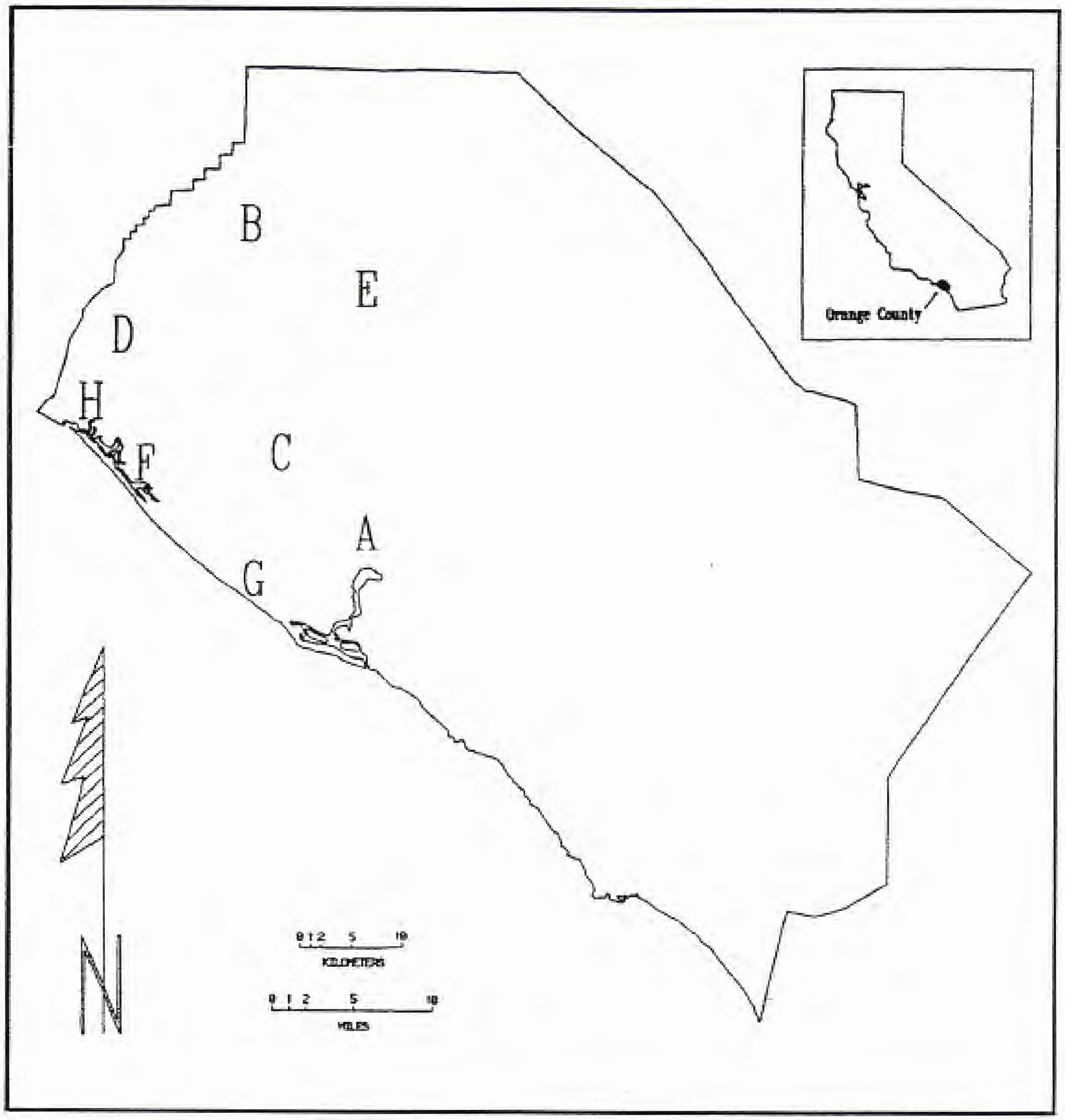

Figure 1. Study area for northwestern Orange County, California. A = Bristol Street site, B = Crescent Avenue Site, C = Mile Square Park Site, D = Los Alamitos Armed Forces Reserve Center site, E = Anaheim Powerline site, F = Bolsa Chica Ecological Reserve site, G = Huntington Beach site, H = Seal Beach NWR and NWS.

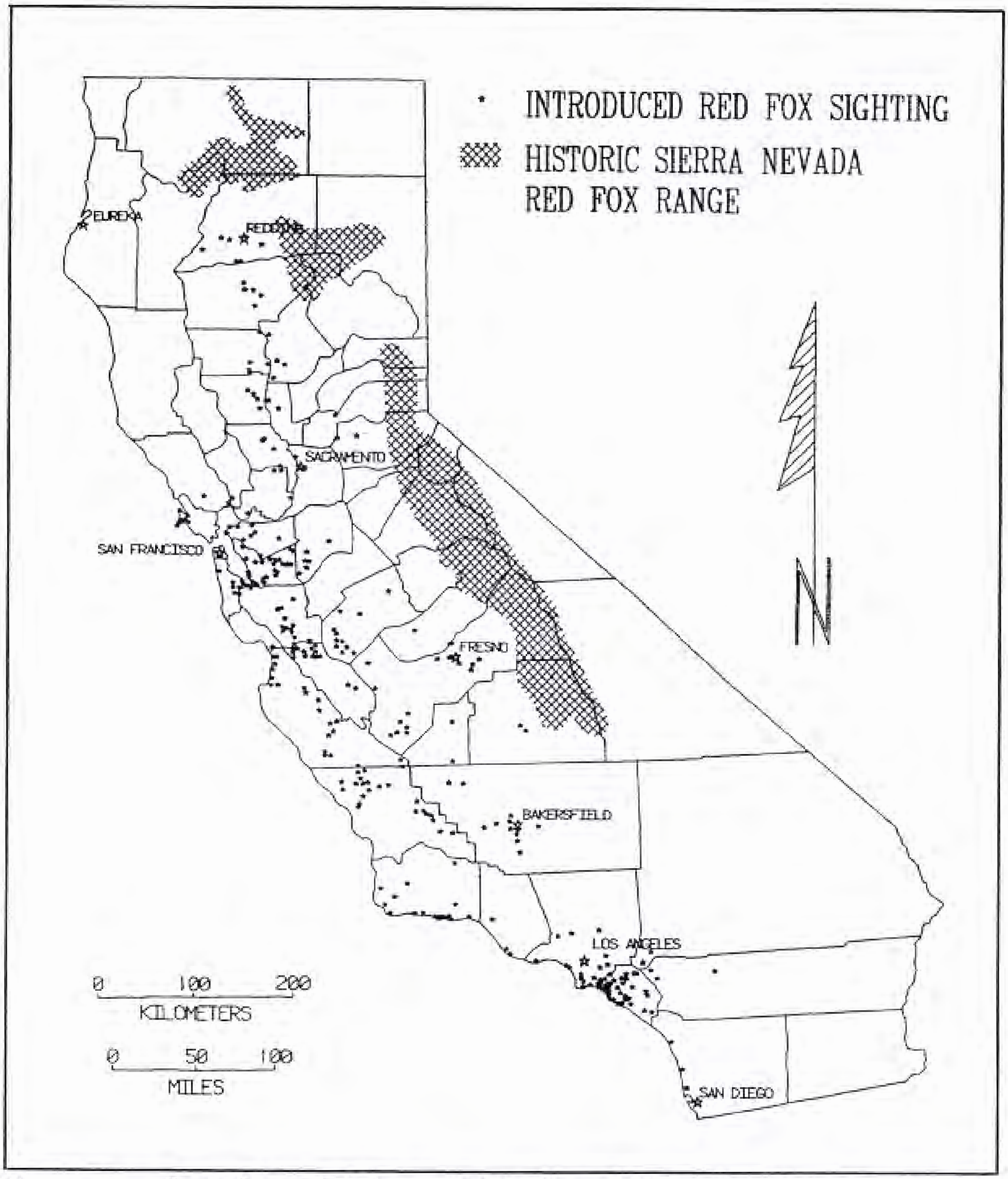

Figure 2. Red fox sightings (319) for California acquired from telephone interviews. Each solid black star represents one or more sightings at a site (sightings > 1.6 km apart are considered independent); open stars indicate cities. The range of Sierra Nevada red fox was summarized from Grinnell et. al. (1937).

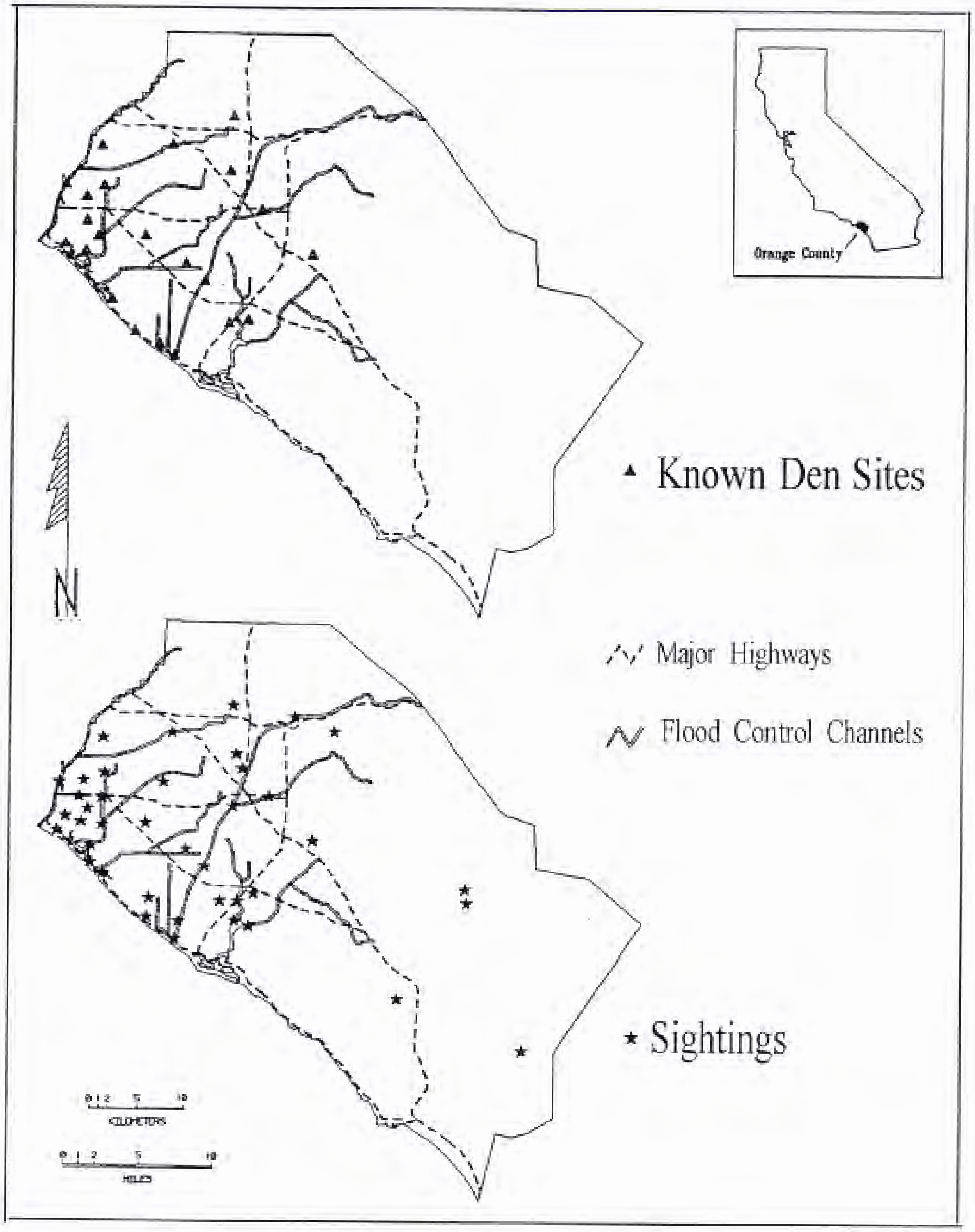

Figure 3. Known den sites (22) and sightings (39) in Orange county, California from 1992 and earlier. Den sites (triangles) on the map represent one or more den locations. Sightings (stars) represent one or more observations of foxes at a location. Den site and sighting locations > 1.6 km (1 mile) apart are considered independent.

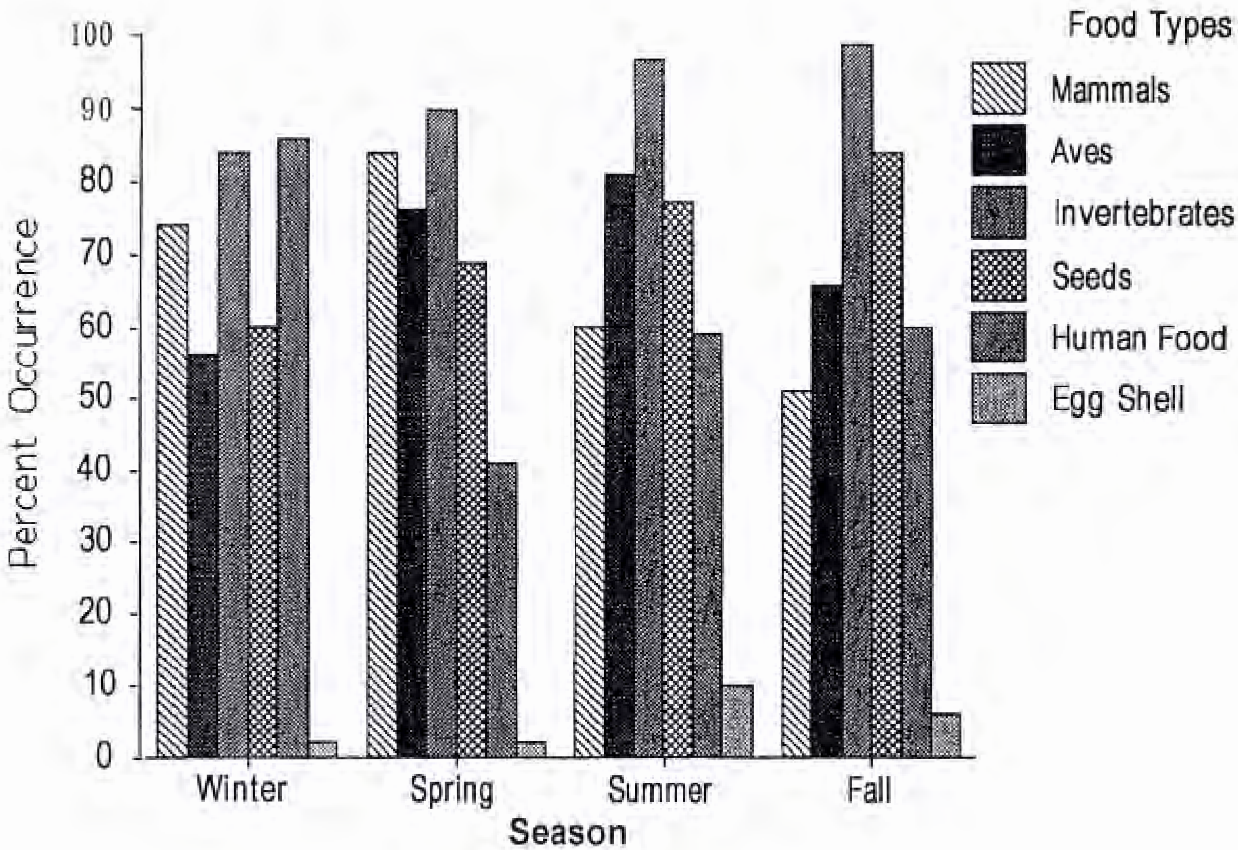

Figure 4. Percent occurrence of major food types found seasonally in scat samples collected in Orange County, California 1990-1991.

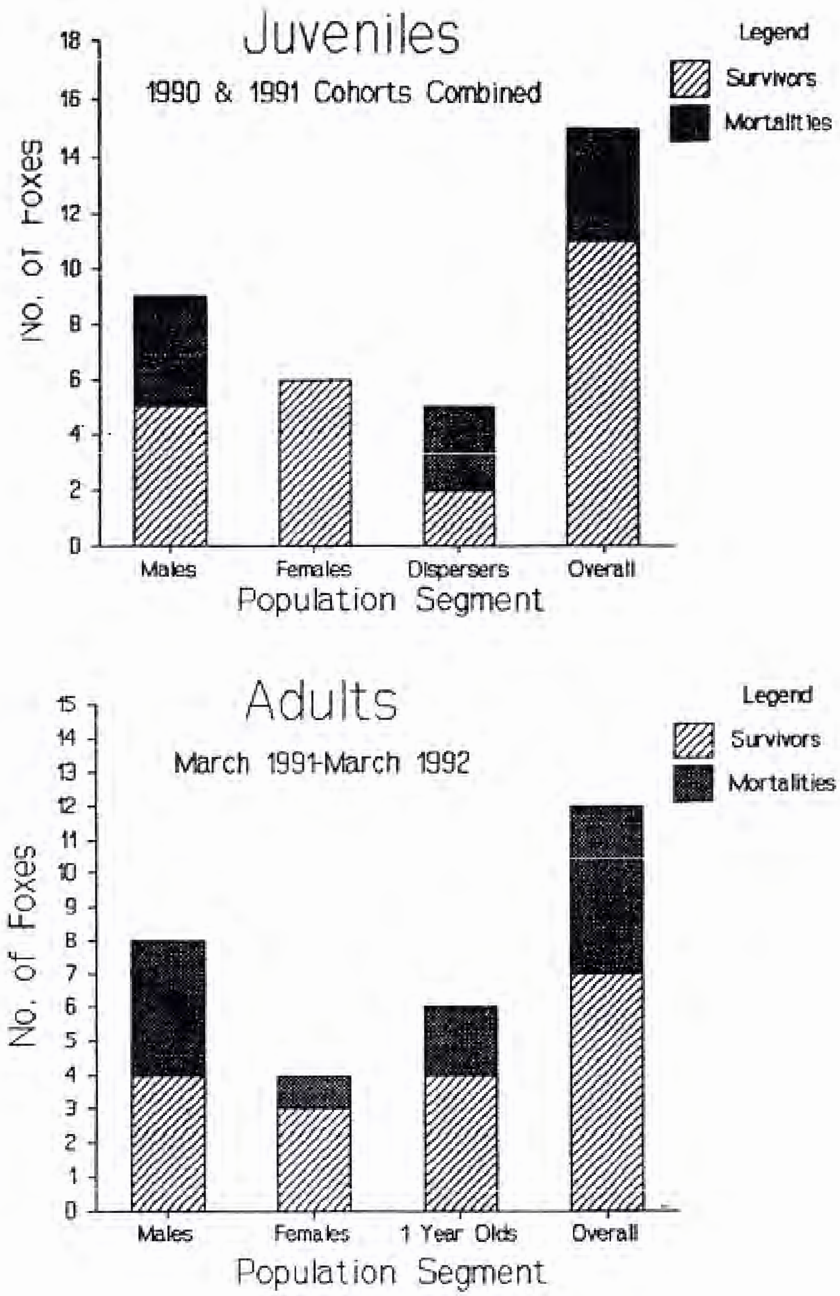

Figure 5. Survival and mortality of radio-collared foxes in Orange County, California, 1990-1992. Juvenile dispersers included 3 males and 1 female. One-year-old adults included 4 males and 2 females.

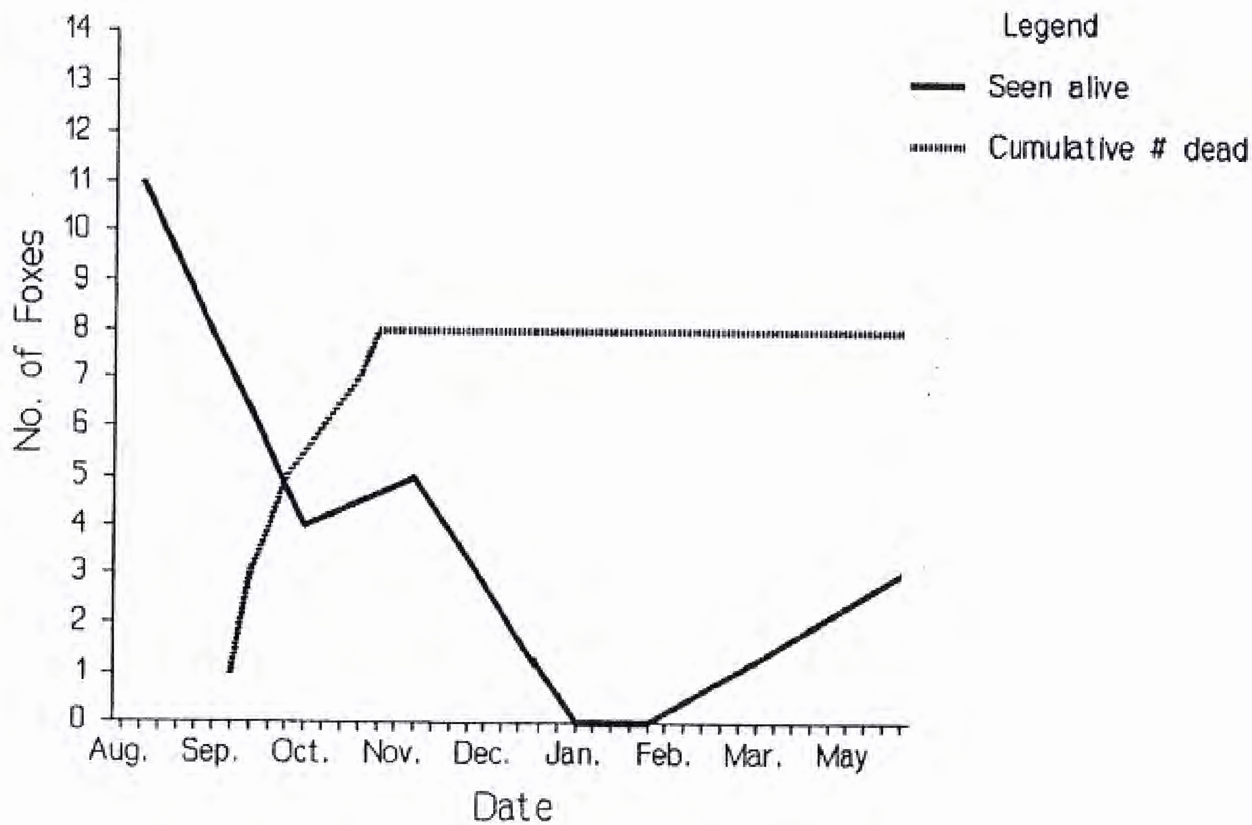

Figure 6. Relationship between the number of live foxes seen and the cumulative number of dead foxes retrieved at Los Alamitos Armed Forces Reserve Center.

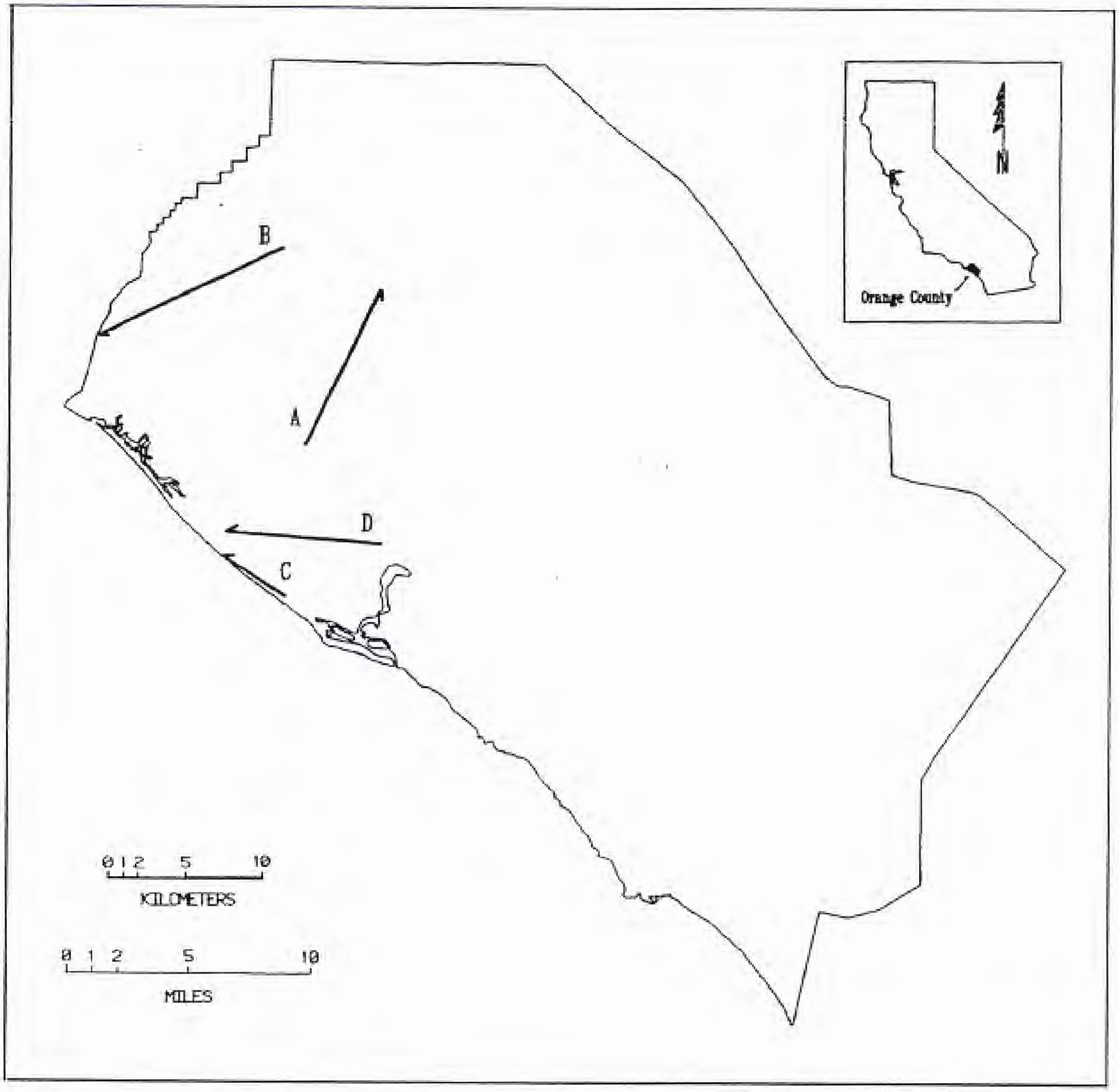

Figure 7. Straight-line dispersal distances of radio-collared red foxes that established home ranges after dispersal in Orange County, California, 1990-1992. **A** = fox #10's (juv. male) dispersal from Mile Square Park in Fountain Valley to Anaheim. B = fox #3's (ad. male) dispersal from Crescent Avenue. site in Anaheim to Rossmoor. C = fox #23's (juv. female) dispersal from Orange County Sewage Treatment Plant #2 to Huntington Beach. D = fox #1's (ad. male) dispersal from Bristol Street site in Costa Mesa to Huntington Beach.

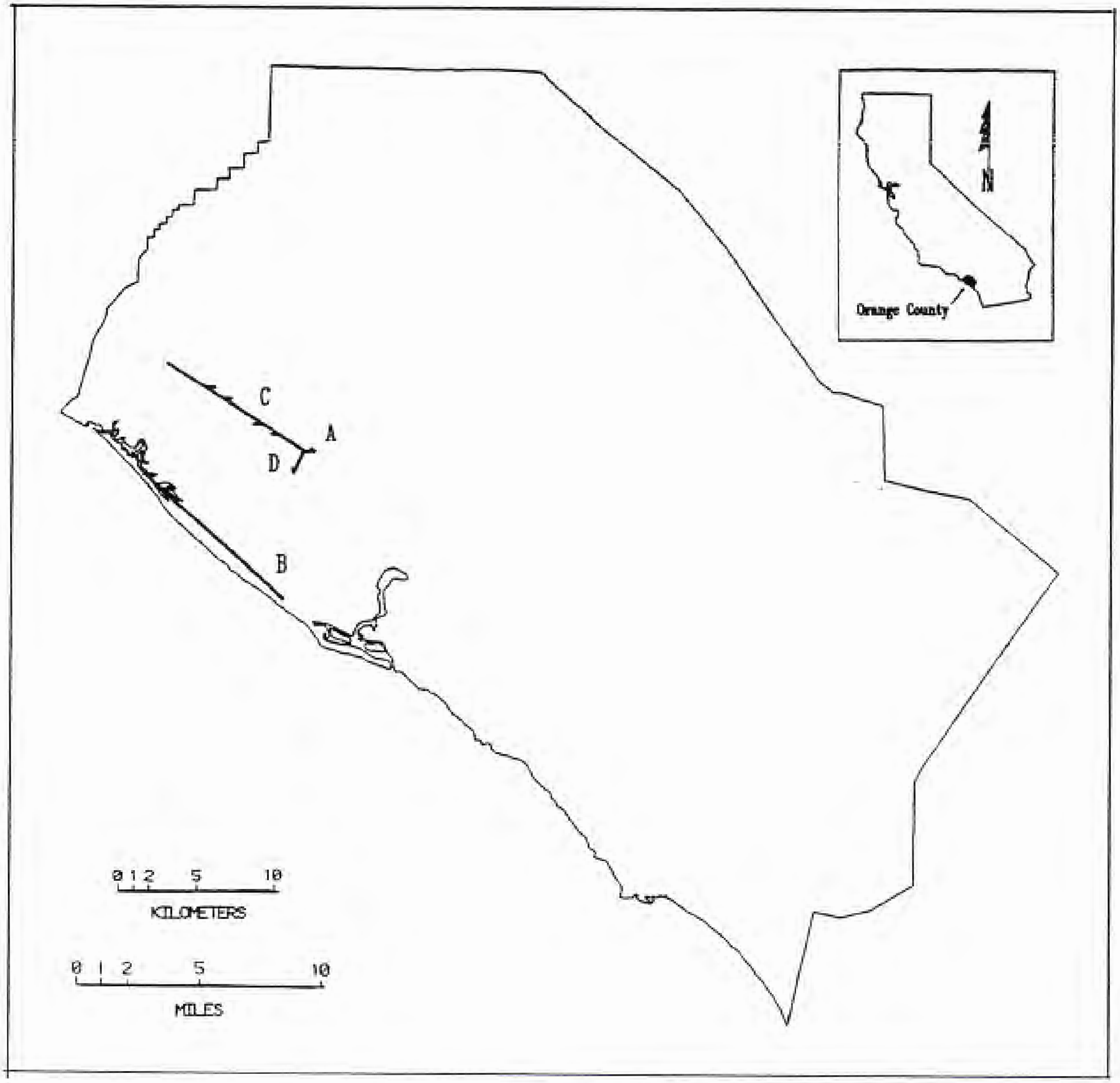

Figure 8. Straight-line dispersal distances of radio-collared red foxes that died during dispersal in Orange County, California, 1990-1992. A = fox #11's (juv. male) dispersal from Mile Square Park to Euclid Ave., Mile Square Park's eastern boundary. B = fox #22's (juv. male) dispersal from Orange County Sewage Treatment Plant #2 to the jct. of Warner Ave. and Pacific Coast Highway in Sunset Beach. C = fox #15's (juv. male) 21 km round-trip exploratory movement to Seal Beach Naval Weapons Station and back to Mile Square Park. D = fox #15's (juv. male) dispersal from Mile Square Park to the jct. of Alameda Ave. and Brookhurst St. in Fountain Valley.

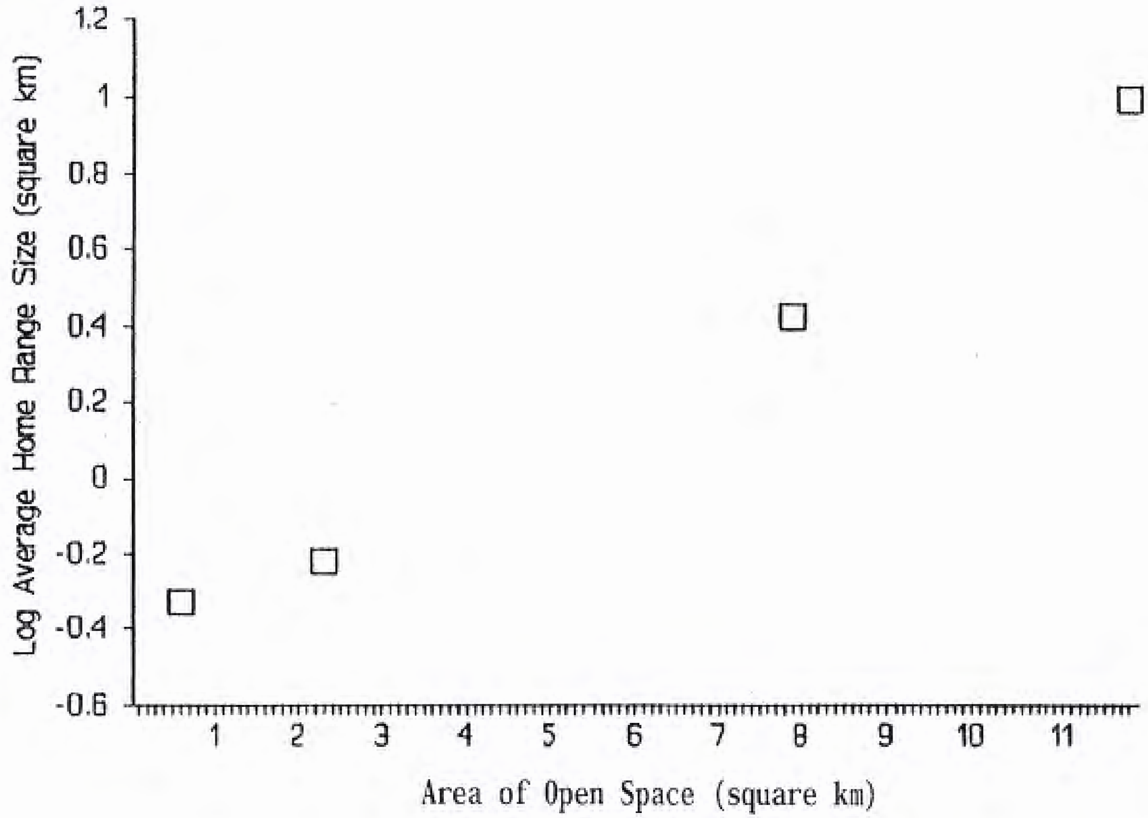

Figure 9. Relationship of $\log_{10}$ home range size (HMT) and the area of available continual open space (at 4 sites). The correlation coefficient is statistically significant (r=84, $p<0.05$).

Appendix 1. Sighting data for state-wide distribution of introduced red foxes in California for 1992 and earlier.

Observer	Affiliation[a]	Sighting Dates[b]	UTM X	UTM Y	Elevation (m)	Habitat[c,d]	Reliability
Alameda County							
C. Machado	-	01/01/79 - 01/01/91	5894	41737	200-300	GR,OW,R	good
S. Orloff	BI	01/01/83	6258	41792	50-150	GR	excellent
T. Palmisano	CDFG	01/01/87	5960	41759	100-150	GR,R	excellent
T. Palmisano	CDFG	11/01/89	6098	41732	150-200	GR,R	excellent
T. Palmisano	CDFG	01/01/89	6060	41660	150-200	GR,OS	excellent
S. Orloff	BS	01/01/89	6039	41747	150-200	GR	excellent
P. Lacy	ADC	01/01/89 - 01/01/92	6090	41633	300-400	OW,SB	excellent
P. Lacy	ADC	01/01/89 - 01/01/92	5992	41520	650-750	OW,SB	excellent
B. Stafford	CSC	04/01/89	6246	41744	200-250	GR	excellent
J. Didonato	EBRPD	01/23/90	5763	41652	0-10	TSM	excellent
T. Palmisano	CDFG	04/01/90	5762	41605	0-10	TSM	excellent
L. Briden	CDFG	03/01/90	6163	41731	200-250	GR	excellent
J. Didonato	EBRPD	08/09/90	5750	41679	0-10	TSM,R	excellent
J. DiDonato	EBRPD	10/16/90	5838	41719	50-100	OW,PW	excellent
S. Orloff	BI	01/01/91	6146	41722	150-200	GR	excellent
P. Lacy	ADC	01/01/91	6083	41592	200-250	GR,OW	excellent
B. Stafford	CSC	04/01/91	6245	41801	50-100	GR	excellent
K. Bates	PI	04/15/91 - 05/01/91	6120	41730	0-10	NA	excellent
K. Bates	PI	04/25/91	5980	41680	90-100	U	excellent
C. Pelles	USFS	12/01/91	5750	41637	0-10	TSM,GR	excellent
J. DiDonato	EBRPD	12/23/91	5678	41910	200-400	NA	excellent
E. Harding-Smith	USFWS	01/01/92 - 02/01/92	5794	41461	0-10	TSM,GR	excellent
E. Harding-Smith	USFWS	01/01/92 - 02/01/92	5733	41503	0-10	TSM,GR	excellent
P. Lacy	ADC	01/02/92	5962	41567	150-250	OW,SB	excellent
E. Harding-Smith	USFWS	01/05/92	5704	41536	0-10	TSM	excellent
P. Lacy	ADC	01/08/92	5977	41582	100-150	OW,SB	excellent
E. Harding-Smith	USFWS	02/01/92 - 06/01/92	5795	41515	0-10	TSM,SP	excellent
E. Harding-Smith	USFWS	03/01/92	5848	41510	0-10	SP	excellent
E. Harding-Smith	USFWS	03/01/92 - 06/01/92	5891	41485	0-10	TSM,SP	excellent
E. Harding-Smith	USFWS	03/12/92	5827	41427	0-10	GR,SM	excellent
C. Rosen	PI	07/29/92	5907	41797[*]	200-250	SU	excellent
E. Harding-Smith	USFWS	06/10/92	5820	41510	0-10	TSM,SP	excellent
E. Harding-Smith	USFWS	06/19/92 - 06/24/92	5783	41551	0-10	TSM,SP	excellent
Butte County							
D. Johnson	CDFG	01/01/78	6170	43668	30-40	R	excellent
J. Snowden	CDFG	01/01/80 - 01/01/85	6071	43680	25-30	AG,R	excellent
J. Snowden	CDFG	01/01/81	5895	44015	40-50	AG	excellent
M. Garrette	PI	11/01/91	5982	43530	20-25	W,GR	excellent
Colusa County							
J. Parriott	ADC	01/01/63 - 01/01/87	5640	43305	40-50	R,GR,SB	excellent
J. Parriott	ADC	01/01/63 - 01/01/87	5661	43580	30-40	R,GR,SB	excellent
G. Trapp	CSU	11/27/76	5773	43435	10-20	W	excellent
J. Parriott	ADC	01/01/78 - 01/01/92	5725	43547	20-30	AG,R	excellent
J. Parriott	ADC	01/01/80 - 12/01/88	5860	43340	10-20	R,AG	excellent
G. Mensik	CDFG	01/01/85 - 01/01/91	5826	43281	10-20	GR,R	excellent
G. Mensik	CDFG	01/01/89	5699	43458	20-30	AG	excellent
P. Hoffman	CDFG	01/01/89	5775	43436	10-20	R,W,GR	excellent
P. Hoffman	CDFG	03/21/89	5849	43294	10-20	AG,GR,R	excellent

Appendix 1. Continued.

Observer	Affiliation[a]	Sighting Dates[b]	UTM X	UTM Y	Elevation (m)	Habitat[c,d]	Reliability
Contra Costa County							
M. Flynn	UCS	01/01/75	5748	41982	250-350	PW,R,SB	excellent
M. Flynn	UCS	01/01/75	5833	42029	0-10	R,SU	excellent
S. Orloff	BI	01/01/83	6148	41923	30-60	GR	excellent
P. Duda	CH	01/01/84 - 03/21/92	5639	42068	0-50	R	excellent
J. DiDonato	EBRPD	01/01/89 - 01/01/91	5561	42063	0-20	TSM,EW	excellent
P. Duda	EBRPD	01/01/89 - 03/21/92	5520	41985	0-10	TSM,R	excellent
J. DiDonato	EBRPD	05/17/90	5775	41958	200-300	NA	excellent
T. Palmisano	CDFG	07/01/90	5815	42111	0-10	TSM,R	excellent
J. DiDonato	EBRPD	04/18/91	5685	41927	350-450	OW	excellent
El Dorado County							
M. Van Herin	ASRE	01/01/89	6678	42965	250-300	NA	excellent
C. Pelles	USFS	03/01/90	7023	42798	500-600	GR,OS	good
Fresno County							
D. McFadden	FAC	01/01/79	2790	40667	100-150	R,GR	excellent
D. McFadden	FAC	01/01/81	2811	40688	100-150	R,GR	excellent
D. McFadden	FAC	01/01/85	2562	40740	100-150	GR	excellent
D. McFadden	FAC	01/01/86	2533	40899	50-100	R,AG	excellent
R. Jones	UCS	01/01/88	7455	40036	160-180	R,SB	excellent
R. Jones	UCS	05/01/88	7365	40011	210-220	AG,SB,W	excellent
R. Jones	UCS	09/01/88	7109	40481	400-450	GR,OPW	excellent
R. Jones	UCS	01/01/89	7039	40724	100-150	AG,GR	excellent
G. Gerstenberg	CDFG	07/01/89	3105	40703	750-800	CH,OW	excellent
R. Jones	UCS	07/01/89	7451	40205	140-150	GR,SB,AG	excellent
R. Rempel	CDFG	09/01/89	2622	40688	100-110	AG	excellent
D. McFadden	FAC	12/01/89 - 06/07/92	2879	40697	250-300	AG,GR,OS	excellent
D. Williams	CSU	03/01/90	7420	40110	230-250	GR	excellent
D. Williams	CSU	04/01/90	7316	36971	250-300	OS,GR,AG	excellent
R. Jones	UCS	07/01/90	7458	39988	190-200	AG,SB,R	excellent
D. McFadden	FAC	05/01/91	2460	40763	50-100	NA	excellent
Glenn County							
G. Trapp	CSU	05/27/52	5719	43624	30-40	U	excellent
D. Hinz	CDFG	01/01/55 - 01/01/75	5679	43883	50-60	AG,GR,R	excellent
J. Parriott	ADC	01/01/63 - 01/01/87	5602	43655	60-100	AG,R,GR	excellent
B. Holtz	CDFG	01/01/76	5829	44038	40-50	AG,R	excellent
P. Hoffman	CDFG	03/21/90	5672	43585	20-30	AG,GR,R	excellent
P. Hoffman	CDFG	01/01/90	5967	43677	20-30	GR,R,AG	excellent
Kern County							
L. Spiegel	CEC	01/01/86	2626	39506	60-80	GR	excellent
B. Asserson	CDFG	03/21/89	3130	39200	120-140	AG,GR,U	excellent
J. Bennett	ADC	03/01/89	3155	39046	100-110	AG,SU	excellent
J. Bennett	ADC	06/01/89	3170	38990	90-110	AG	excellent
S. Tabor	BI	11/01/89	3160	39080	100-120	AG	excellent
B. Asserson	CDFG	06/21/90	3123	39065	100-120	AG,U	good
J. Bennett	ADC	08/01/90	3120	39240	140-160	AG,SU	excellent
B. Asserson	CDFG	09/21/90	3073	39102	100-120	AG,U	good
J. Bennett	ADC	10/01/90	3075	39171	110-120	SU	excellent
R. van de Hoek	BLM	11/01/91	3186	38878	70-80	AG	good
S. Fitton	BLM	02/17/92	2800	38977	160-180	SB,AG,U	excellent
S. Fitton	BLM	03/09/92	2954	39056	90-110	AG,GR	excellent
S. Fitton	BLM	09/23/92	3360	39113	250-260	AG	excellent
M. Bradbury	CDWR	07/22/92	2513	39509	90-110	AG	excellent
Kings County							
J. Shelton	CDWR	01/01/86	2598	40105	60-70	AG,GR	excellent
J. Shelton	CDWR	01/01/87	2554	39670	50-70	R,SB	excellent
Los Angeles County							
P. McMonagle	CSUS	01/01/59	4058	37564	50-70	U	good
J. Nishidia	CSU	11/17/68	3602	37843	220-230	NA	good
V. Bleich	CDFG	01/01/70	3802	37302	0-40	AG,U	excellent

Appendix 1. Continued.

Observer	Affiliation[a]	Sighting Dates[b]	UTM X	UTM Y	Elevation (m)	Habitat[c,d]	Reliability
Los Angeles County, cont.							
V. Bleich	CDFG	01/01/70	3996	37418	0-10	U	excellent
R. Golightly	PI	01/01/73	3762	37408	40-60	U	excellent
D. Zembal	USFWS	01/01/75 - 12/31/75	3937	37359	0-10	U	excellent
L. Heitz	CDFG	01/01/80	3934	37423	0-10	U	excellent
R. Mattoni	AI	01/01/84	3679	37570	60-80	U	excellent
V. Bleich	CDFG	09/15/86	3774	37382	80-120	U	excellent
P. Rose	NPS	09/21/89	3332	37635	60-70	SB,SU	excellent
J. Lewis	CSUS	05/01/90	3761	37409	20-40	U	excellent
--	AAC	08/20/90	3328	37638	0-50	SU	excellent
E. Burdett	PI	09/21/90	3982	37535	20-40	U	excellent
D. Creeth	PI	09/21/90	3932	37907	900-1000	CH,SB	good
R. Jillson	PI	04/01/91	4029	37657	60-70	R,U	excellent
D. Creeth	PI	09/01/88 - 01/01/91	3675	37593	0-10	TSM,W	excellent
W. Wright	MNP	01/01/92	3758	37435	20-30	TSM,U	excellent
Madera County							
D. Williams	CSU	07/01/84	7467	41099	50-100	AG	excellent
Marin County							
G. Fellers	NPS	01/01/83 - 10/01/85	5035	42281	50-150	GR	excellent
R. Henton	NPS	01/01/86 - 01/01/90	5027	42047	0-50	GR	excellent
R. Henton	NPS	01/01/90	4985	42051	100-150	GR	excellent
R. Henton	NPS	01/01/86 - 01/01/91	5032	42099	50-60	GR	excellent
G. Fellers	NPS	06/05/86	5119	42118	50-100	SB	excellent
R. Henton	NPS	01/01/90	5011	42078	50-60	GR	excellent
C. Dickie	CCW	01/12/91	5288	43250	50-100	GR,R	excellent
Merced County							
S. Melanson	USFWS	03/20/86	6897	41211	0-25	W,GR	excellent
S. Melanson	USFWS	02/26/87	6900	41282	0-25	GR,R	excellent
J. Beam	CDFG	03/21/87	6769	41033	70-90	GR	excellent
F. Warnette	CDFG	01/01/87	6842	40962	100-150	GR	excellent
F. Warnette	CDFG	06/21/87	6818	40875	200-300	GR	excellent
R. Rempel	CDFG	06/01/88	7244	41353	50-60	AG,U	excellent
D. Williams	CSU	06/01/89	6757	41083	40-60	AG	excellent
J. Single	HA	11/01/89 - 04/01/90	6787	41008	100-150	GR,AG	excellent
D. Williams	CSU	01/01/90	6757	41037	70-90	GR,EW	excellent
G. Gerstenberg	CDFG	06/01/90	6750	41032	50-70	GR,W	excellent
G. Gerstenberg	CDFG	08/01/90	6833	40990	50-100	GR,AG	excellent
J. Shelton	CDWR	11/01/90	6708	41240	40-60	GR,AG	excellent
J. Shelton	CDWR	03/19/91	6960	40840	110-130	GR,AG	excellent
G. Gerstenberg	CDFG	04/01/91	6992	41043	25-50	AG	excellent
G. Gerstenberg	CDFG	05/20/91	6886	41077	20-40	AG	excellent
Monterey County							
D. Pine	CDFG	12/01/78	6741	40055	50-150	GR	excellent
K. Moore	CDFG	09/01/80	6124	40747	0-50	GR,OS,OW	excellent
D. Pine	CDFG	05/01/84	6659	40168	50-150	AG,GR	excellent
D. Pine	CDFG	06/01/85	6613	40138	130-150	AG,R	excellent
D. Pine	CDFG	05/01/86	6635	40116	50-150	GR,AG	excellent
B. Elliot	CDFG	01/01/87	6102	40763	0-50	TSM,GR	excellent
D. Pine	CDFG	08/01/87	6730	39735	270-290	OS,SB	excellent
D. Pine	CDFG	10/01/87	6400	40400	40-60	AG,R	excellent
F. Scaroni	MAC	01/01/88	7423	39720	450-550	GR	excellent
S. Orloff	BI	01/01/88	6793	40017	150-200	GR	excellent
F. Scaroni	MAC	04-01/88	7457	39665	450-550	GR	excellent
B. Berry	DOD	07/01/89	7037	39631	200-250	OS,U	excellent
S. Kempel	CDFG	01/01/90 - 05/01/91	6125	40760	0-50	GR,OS,TSM	excellent
F. Scaroni	MAC	05/01/90	6596	40218	70-80	SU,GR	excellent
R. Parker	ADC	06/21/90	6747	39765	250-300	GR,OS,CH	excellent
M. Littlefield	DOD	09/01/90	6697	39787	250-300	GR,OS	excellent
M. Littlefield	DOD	09/21/90	6140	40568	0-50	OW,GR	excellent
M. Littlefield	DOD	04/01/91	6037	40541	0-50	D,CH	excellent
M. Littlefield	DOD	04/01/91	6062	40596	0-50	CH,D	excellent

Appendix 1. Continued.

Observer	Affiliation[a]	Sighting Dates[b]	UTM X	UTM Y	Elevation (m)	Habitat[c,d]	Reliability
Monterey County, cont.							
D. Renshaw	PC	06/01/91	6678	40032	130-150	GR,OS,OW	excellent
M. Casey	MAC	06/01/91	6551	40312	50-150	GR,AG	excellent
M. Casey	MAC	06/01/91	6420	40432	50-150	AG,GR	excellent
M. Flynn	UCS	11/16/91	6086	40865	0-50	AG	excellent
Napa County							
J. Swanson	CDFG	10/10/70 - 01/01/92	5602	42272	0-10	TSM,GR,U	excellent
Orange County							
C. Carisoza	PI	01/01/42 - 01/01/89	4421	37281	250-350	GR,OW,SB	excellent
C. Carisoza	PI	01/01/65 - 06/21/92	4142	37296	0-20	U	excellent
D. Proud	PI	01/01/70	4173	37473	50-70	AG,U	excellent
M. Bereki	OC	03/01/72	4124	37319	0-10	U	excellent
R. Landry	PI	01/01/74 - 01/01/75	4031	37354	0-10	AG,U	excellent
K. Novick	CDFG	04/01/80	4046	37277	0-10	TSM	excellent
J. Beruman	PI	01/01/82	4080	37345	10-20	AG,U	excellent
G. Campbell	PI	01/01/85 - 01/01/86	4195	37264	10-30	U	excellent
G. Gerstenberg	CDFG	01/01/87	4214	37375	40-60	R,U	excellent
D. Proud	PI	01/01/88	4171	37419	40-60	U	excellent
G. Gerstenberg	CDFG	06/21/88	4237	37464	50-100	R,U	excellent
S. Haggadorn	OC	09/01/88	4489	37103	120-140	OW,SB	excellent
L. Fiorillo	CDFG	01/01/89	4025	37439	20-40	U	excellent
J. Anderson	OC	01/01/89	4258	37334	0-50	R,U	excellent
C. Knight	ADC	06/01/89	4002	37345	0-10	TSM,U	excellent
E. Burkett	CDFG	06/01/89	4175	37365	20-40	U	excellent
J. Lewis	CSUS	01/01/90	4034	37397	0-10	U	excellent
J. Lewis	CSUS	01/01/90	4026	37391	0-10	U	excellent
M. Kinney	USFWS	01/01/90	4351	37154	50-150	R,SU	excellent
S. Linsmeier	OC	03/21/90 - 03/01/92	4281	37444	150-200	GR	good
E. Burkett	CDFG	05/01/90	4095	37392	10-30	U	excellent
J. Lewis	CSUS	06/01/90 - 05/15/92	4177	37256	0-50	AG,U	excellent
J. Lewis	CSUS	06/01/90 - 03/01/92	4110	37445	25-50	R,U	excellent
J. Lewis	CSUS	09/01/90 - 01/15/92	4112	37219	0-10	R,U	excellent
B. Cahill	LAAC	12/01/90	4437	37247	300-400	OW,SU	good
C. Knight	ADC	03/01/91	4014	37365	0-10	GR	excellent
L. Dawes	PI	03/01/91	4192	37230	0-50	TSM,U	good
J. Kapus	PI	06/01/91 - 05/01/92	4161	37260	10-20	AG,U	excellent
S. Huebner	OC	06/27/91	4084	37260	0-10	U	excellent
M. Faulhaber	PI	08/25/91	4019	37300	0-10	U	excellent
L. August	PI	10/22/91	4022	37317	0-10	U	excellent
J. Evans	PI	11/07/91	3990	37386	0-10	U	excellent
--	OC	11/25/91	4117	37237	0-10	U	excellent
F. Selby	PI	02/01/92	4177	37237	10-20	U	excellent
C. Knight	ADC	03/01/92	4007	37322	0-10	U,TSM	excellent
Placer County							
B. Sanderson	PI	11/01/92	6730	43200	500-550	OW,SB	good
Riverside County							
L. Armstrong	PI	10/01/87	5112	37484	900-1100	CH	excellent
G. Bell	NC	01/01/88	4532	37405	250-300	GR,R,SB	excellent
K. Pope	PI	06/01/91 - 07/01/92	4470	37490	180-220	U	excellent
Sacramento County							
E. Koford	PC	01/01/65 - 01/01/89	6496	42743	30-40	GR,SB	excellent
L. Manger	ADC	03/01/89	6273	42760	0-50	R	excellent
L. Manger	ADC	03/01/89	6415	42670	0-50	OU,W	excellent
San Benito County							
D. Pine	CDFG	09/01/78	6494	40732	150-200	GR	excellent
R. Hopkins	CDFG	01/01/82 - 01/01/83	6268	40807	100-150	GR,OS	excellent
D. Pine	CDFG	09/01/84	6941	40489	350-450	GR,AG	excellent
D. Pine	CDFG	10/01/85	6425	40772	50-100	GR,SU	excellent
D. Renshaw	PC	12/01/85	6383	40802	50-100	GR,R	excellent

Appendix 1. Continued.

Observer	Affiliation[a]	Sighting Dates[b]	UTM X	UTM Y	Elevation (m)	Habitat[c,d]	Reliability
San Benito County, cont.							
D. Renshaw	PC	12/01/85	6481	40831	100-150	GR,SU,R	excellent
D. Pine	PC	07/01/86	6942	40483	350-450	GR,AG	excellent
S. Orloff	BI	01/01/88	6458	40770	100-150	GR	excellent
M. Schauss	PC	01/01/88 - 01/01/90	6320	40889	40-50	GR,AG	excellent
D. Pine	CDFG	03/01/88	6581	40728	300-400	GR,R	excellent
D. Pine	CDFG	07/01/88	6382	40775	50-100	GR,R	excellent
J. Beam	CDFG	07/01/89	6900	40529	400-450	GR,AG	good
D. Renshaw	PC	10/01/90	6416	40821	50-100	GR,SU	excellent
M. Schauss	PC	02/01/91	6373	40868	50-100	AG,GR	excellent
D. Renshaw	PC	03/01/91	6476	40732	100-200	GR,R,SU	excellent
M. Schauss	PC	04/01/91	6296	40848	150-200	GR	excellent
San Bernardino County							
J. Shows	ADC	01/01/75	4507	37707	250-300	SU	excellent
J. Shows	ADC	01/01/89 - 02/01/90	4449	37689	250-300	AG,U	excellent
San Diego County							
B. Kristan	CSUS	01/01/79	4749	36490	0-50	TSM,U	excellent
M. Small	ADC	04/01/89	4620	36772	0-50	AG,TSM	excellent
R. Patton	SDC	09/01/90	4782	36508	50-100	SB,EW	excellent
M. Small	ADC	04/01/91	4801	36275	0-50	NA	excellent
San Joaquin County							
T. Kidder	PI	01/01/84	6412	41822	0-10	AG,R	good
S. Orloff	BI	01/01/83	6351	41690	50-150	GR	excellent
D. Williams	CSU	06/01/90	6522	41843	0-10	AG,W	excellent
S. Orloff	BI	01/01/91	6288	41675	100-200	GR	excellent
L. Feeney	PC	09/08/91	6392	41776	10-20	AG,SU	excellent
D. Mcgeein	PI	10/19/91	6348	41778	10-20	AG	excellent
San Luis Obispo County							
J. Lidberg	CDFG	09/21/83	7145	39492	200-300	GR,OS,AG	excellent
J. Lidberg	CDFG	01/01/84 - 01/01/86	2277	39110	550-650	GR	excellent
J. Lidberg	CDFG	01/01/84 - 01/01/86	7706	39150	600-650	GR,AG	excellent
J. Lidberg	CDFG	06/21/84	6891	39350	300-350	GR,OW	excellent
B. Berry	DOD	08/01/87	7047	39598	200-250	OS	excellent
B. Berry	DOD	01/01/89	7355	39484	300-350	AG,GR,R	excellent
D. Williams	CSU	03/21/89	2528	38987	700-750	SB,GR	excellent
J. Cochran	SI	06/01/89	7670	39180	600-650	AG	excellent
R. Parker	ADC	06/01/89	7645	39287	650-700	GR	excellent
C. Warner	NC	10/01/89	2402	38985	550-600	GR,SB	excellent
B. Berry	DOD	01/01/90	7087	39343	200-250	R,AG	excellent
M. Small	ADC	01/01/90	2278	39120	550-650	AG	excellent
B. Berry	DOD	01/01/90	7045	39521	200-250	OW,R	excellent
B. Vanherweg	BI	06/01/90	7151	39455	200-250	R	excellent
R. Parker	ADC	08/01/90	7257	39464	300-350	GR,OS	excellent
B. Vanherweg	BI	09/01/90	7149	39507	200-250	AG,R,OS	excellent
J. Lidberg	CDFG	10/01/90	6936	39437	450-550	GR,AG,OW	excellent
R. Parker	ADC	11/01/90	7598	39169	400-450	CH,R,OW	excellent
B. Berry	DOD	12/01/90	7052	39562	250-300	OW,AG	excellent
D. Cappelli	ADC	04/01/91	7089	39413	200-250	OW,OS,AG	excellent
B. Berry	DOD	05/01/91	7067	39612	150-200	OS,AG	excellent
B. Berry	DOD	05/17/91 - 05/30/91	7084	39526	200-250	OS	excellent
D. Cappelli	ADC	06/01/91	7059	39267	400-500	CH,OS	good
R. van de Hoek	BLM	01/21/92	7690	39175	600-650	AG	excellent
San Mateo County							
P. White	UCS	01/01/77	5445	41595	0-50	SB,SU	excellent
B. Boeddiker	ADC	01/01/86	5678	41450	30-40	U	excellent
B. Boeddiker	ADC	01/01/87	5662	41424	100-150	RF,SU	excellent
B. Boeddiker	ADC	01/01/87	5702	41365	150-200	RF,SU	excellent
B. Boeddiker	ADC	10/01/91	5525	41615	30-50	SU	excellent

Appendix 1. Continued.

Observer	Affiliation[a]	Sighting Dates[b]	UTM X	UTM Y	Elevation (m)	Habitat[c,d]	Reliability
Santa Barbara County							
S. Sweet	UC	01/01/78 - 01/01/79	2374	38133	0-50	GR,W	excellent
W. Robertson	ADC	02/01/80	7297	38211	0-40	GR,SB	excellent
W. Robertson	ADC	01/01/81	7412	38339	40-80	AG,GR	excellent
P. Collins	SBNHM	03/22/82	2401	38122	0-10	B,GR	excellent
P. Collins	SBNHM	01/26/84	2469	38147	0-50	NA	excellent
C. Morris	DOD	01/01/85	7240	38383	0-40	CH,GR	questionable
S. Sweet	UC	01/01/85 - 01/01/88	7713	38172	0-40	GR,SB	excellent
P. Collins	SBNHM	05/20/87	2332	38134	0-20	U	excellent
P. Collins	SBNHM	01/06/87	2481	38127	40-50	U	excellent
S. Sweet	UC	09/01/88	7613	38182	0-40	CH,SB	excellent
W. Ferren	UC	01/01/89	2661	38100	0-50	TSM,SU,OW	excellent
P. Collins	SBNHM	10/18/89	2507	38729	0-50	NA	excellent
S. Sweet	UC	04/01/90 - 08/04/91	2350	38122	0-50	GR,R,EW	excellent
W. Robertson	ADC	12/01/90	7340	38143	0-40	GR,SB	excellent
Santa Clara County							
M. Schauss	PC	01/01/80 - 01/01/84	5737	41434	20-30	AG,GR,OS	excellent
M. Schauss	PC	01/01/80 - 01/01/84	5740	41370	100-150	GR	excellent
C. Pelles	USFS	01/01/84	6110	41289	150-200	GR	excellent
J. Beam	CDFG	03/21/87	6425	40921	100-150	GR,OS	excellent
D. Pine	CDFG	08/01/87	6153	41152	80-100	GR,R	excellent
M. Schauss	PC	01/01/88	6229	41000	90-110	OS,SU	excellent
D. Renshaw	PC	10/01/88	6171	41105	150-200	GR,AG,SU	excellent
D. Renshaw	PC	10/01/88	6195	41089	100-150	GR,SU	excellent
D. Renshaw	PC	10/01/88	6211	41095	100-110	GR,SU	excellent
R. Hopkins	HA	01/01/89	6171	41174	200-300	AG,GR,R	excellent
M. Schauss	PC	05/01/89	6295	40906	40-50	GR,AG	excellent
M. Schauss	PC	11/01/89	6257	41106	300-350	GR	excellent
M. Schauss	PC	01/01/90	6245	41077	90-100	SU	excellent
M. Schauss	PC	01/01/90	6246	40957	80-100	GR	excellent
R. Hopkins	HA	02/01/90 - 03/01/91	6056	41288	40-50	GR,R,SU	excellent
B. Elliot	CDFG	04/01/91	6213	41301	750-800	OS,CH	excellent
Santa Cruz County							
M. Flynn	UCS	10/01/90	6102	40700	0-50	AG	excellent
Shasta County							
V. Bisnett	ADC	01/01/45 - 01/01/85	5225	44830	650-750	OW,SB	excellent
V. Bisnett	ADC	01/01/50 - 01/01/85	5945	45292	900-1000	PW,SB	excellent
V. Bisnett	ADC	01/01/50 - 06/01/91	5527	44737	190-210	SB	excellent
V. Bisnett	ADC	01/01/50 - 06/01/91	5572	44730	190-210	OW,SB	excellent
V. Bisnett	ADC	01/01/76 - 01/01/85	5397	44907	250-400	OW,SB	excellent
T. Stone	CDFG	01/01/82	5773	44190	150-250	OW,GR	excellent
Solano County							
B. Berry	DOD	09/21/80	6036	42645	0-50	R,AG	excellent
K. Leverich	PI	01/01/87 - 01/01/89	6163	42386	0-10	AG	excellent
D. Becker	CDFG	01/01/90	5786	42152	0-10	W,GR	excellent
R. Jones	UCS	04/01/91	6052	42643	0-50	R,AG	excellent
Sonoma County							
J. Swanson	CDFG	01/01/70 - 01/01/92	5552	42302	0-10	AG,GR,W	excellent
H. Eedsneed	PAC	11/12/91	5291	42349	0-50	GR	questionable
Sutter County							
E. Kammerer	CDFG	01/01/70 - 01/01/75	6082	43267	0-100	R,AG	excellent
E. Kammerer	CDFG	01/01/70 - .01/01/75	5974	43361	0-100	R,GR	excellent
Tehema County							
J. Bendinger	PI	01/01/68 - 01/01/92	5652	44386	200-300	GR,R	excellent
T. Stone	CDFG	01/01/74	5850	44341	125-175	R	excellent
T. Stone	CDFG	05/01/74	5752	44388	60-80	R	excellent
T. Stone	CDFG	09/21/74	5772	44190	50-60	R	excellent

Appendix 1. Continued.

Observer	Affiliation[a]	Sighting Dates[b]	UTM X	UTM Y	Elevation (m)	Habitat[c,d]	Reliability
Tehema County, cont.							
H. Hill	TAC	10/01/91 - 01/14/92	5765	44400	50-100	GR,AG	excellent
H. Hill	TAC	01/01/92	5642	44495	50-150	SU,OS	excellent
Tulare County							
R. Hansen	PI	05/01/88	3126	39954	130-150	AG	excellent
J. Hawkins	PI	01/01/89	3295	40332	400-500	GR,OW	excellent
J. Crew	CDFG	03/01/91	3196	39915	130-150	AG,U	excellent
Ventura County							
R. Dow	DOD	01/01/81	3052	37753	0-50	TSM,SB	excellent
M. Bouke	CDFG	10/01/90	2886	38092	140-160	SB,R,AG	excellent
D. Ledig	USFWS	12/01/90	3009	37775	0-10	TSM,AG	excellent
Yolo County							
R. Cole	UC	01/01/75 - 01/01/92	6065	42756	0-100	AG,R	excellent
G. Trapp	CSU	02/26/76	5961	42848	100-200	NA	excellent
R. Scoonover	CDFG	01/01/88 - 01/01/91	5877	42926	200-300	GR	excellent
R. Scoonover	CDFG	01/01/91	5906	42930	100-200	GR	excellent

[a]AAC = Agoura Animal Control, ADC = USDA Animal Damage Control, AI = Agresearch Inc., ASRE = Auburn State Recreational Area, BI = Biosystems Analysis, BLM = Bureau of Land Management, CCW = California Center for Wildlife, CDFG = California Department of Fish and Game, CDWR = California Department of Water Resources, CEC = California Energy Commission, CSC = Computer Systems Corporation, CSU = California State University, CSUS = California State University student, DOD = U.S. Department of Defense (includes all military personel), EBRPD = East Bay Regional Park District, FAC = Fresno Agricultural Commission, HA = Harvey and Associates, LANHM = Los Angeles County Natural History Museum, MAC = Monterey County Animal Control, NC = Nature Conservancy, MNP = Madron Nature Preserve, NPS = USDI National Park Service, OC = Orange County, PAC = Petaluma Animal Control, PC = private consultant, PI = private individual, RF = Redwood Forest, SAC = Shasta County Animal Control, SB = Sacramento Bee, SBNHM = Santa Barbara County Natural History Museum, SDC = San Diego County, SI = Smithsonian Institute, TAC = Tehama County Animal Control, UC = University of California, UCS = University of California student, USFS = U.S. Forest Service, USFWS = U.S. Fish and Wildlife Service.

[b]The sighting dates are rounded off to the first of the month when only the month was known and to the first of the year when only the year was known. When only the season was given the following dates were used: Winter = 12/21, Spring = 03/21, Summer = 06/21, and Fall = 09/21

[c]AG = agricultural, B = beach, CH = chapparal, D = dunes, EW = Eucalyptus woodland, GR = grasslands, NA = information not available, OPW = oak-pine woodland, OS = oak savana, OW = oak woodland, PW = pine woodland, QU = gravel quarry, R = riparian, RF = redwood forest, SB = scrub, SM = salt marsh, SP = salt ponds, SU = suburban, TS = tidal slough, TSM = tidal salt marsh, U = urban, W = freshwater wetlands.

[d]Habitat types are listed in the approximate order of dominance at the red fox sighting location.

[e]Approximate location within 1 km of true location.

Appendix 2. Sighting data for Orange County, California, distribution of introduced red foxes in California for 1992 and earlier.

Observer	Affiliation[a]	Sighting Dates[b]	UTM X	UTM Y	Elevation (m)	Habitat[cd]	Reliability
Orange County							
C. Carisoza	PI	01/01/42 - 01/01/89	4421	37281	250-350	GR,OW,SB	excellent
C. Carisoza	PI	01/01/65 - 06/15/92	4142	37296	0-20	U	excellent
D. Proud	PI	01/01/70	4173	37473	50-70	AG,U	excellent
M. Bereki	OC	03/01/72	4124	37319	0-10	U	excellent
R. Landry	PI	01/01/74 - 01/01/75	4031	37354	0-10	AG,U	excellent
K. Novick	CDFG	04/01/80	4046	37277	0-10	TSM	excellent
J. Beruman	PI	01/01/82	4080	37345	10-20	AG,U	excellent
G. Campbell	PI	01/01/85 - 01/01/86	4195	37264	10-30	U	excellent
USFWS	EIS	01/01/86	3988	37335	0-10	AG	excellent
USFWS	EIS	01/01/86	4032	37371	0-10	AG	excellent
USFWS	EIS	01/01/86	4010	37372	0-10	AG	excellent
USFWS	EIS	01/01/86	4022	37358	0-10	AG	excellent
USFWS	EIS	01/01/86	4012	37344	0-10	AG,TSM	excellent
USFWS	EIS	01/01/86	3997	37350	0-10	AG	excellent
USFWS	EIS	01/01/86	4006	37327	0-10	TSM	excellent
G. Gerstenberg	CDFG	01/01/87	4214	37375	60-70	R,U	excellent
D. Proud	PI	01/01/88	4171	37419	40-60	U	excellent
G. Gerstenberg	CDFG	07/01/88	4237	37464	50-100	R,U	excellent
S. Haggadorn	OC	09/01/88	4489	37103	120-140	OW,SB	excellent
L. Fiorillo	CDFG	01/01/89	4025	37439	20-40	U	excellent
J. Anderson	OC	03/01/89	4258	37334	0-50	R,U	excellent
E. Burkett	CDFG	06/01/89	4175	37365	20-40	U	excellent
J. Lewis	CSUS	01/01/90	4034	37397	0-10	U	excellent
J. Lewis	CSUS	01/01/90	4026	37391	0-10	U	excellent
M. Kinney	USFWS	01/01/90	4351	37154	50-150	R,U	excellent
S. Linsmore	OC	04/01/90 - 03/01/92	4281	37444	150-200	GR	excellent
E. Burkett	CDFG	05/01/90	4095	37392	10-30	U	excellent
J. Lewis	CSUS	06/01/90 - 05/15/92	4177	37256	0-50	AG,U	excellent
J. Lewis	CSUS	06/01/90 - 03/01/92	4110	37445	25-50	R,U	excellent
J. Lewis	CSUS	09/01/90 - 01/15/92	4112	37219	0-10	R,U	excellent
B. Cahill	LAAC	12/01/90	4437	37247	300-400	OW,SU	good
L. Dawes	PI	03/01/91	4192	37230	0-50	TSM,U	good
J. Kapus	PI	06/01/91 - 06/01/92	4161	37260	10-20	AG,U	excellent
S. Huebner	OC	06/26/91	4084	37260	0-10	U	excellent
M. Faulhaber	PI	08/25/91	4019	37300	0-10	U	excellent
L. August	PI	10/22/91	4022	37317	0-10	U	excellent
J. Evans	PI	11/07/91	3990	37386	0-10	U	excellent
--	OC	11/25/91	4117	37237	0-10	U	excellent
F. Selby	PI	02/01/92	4177	37237	10-20	U	excellent

[a]ADC = USDA Animal Damage Control, CDFG = California Department of Fish and Game, CSUS = California State University student, EIS = Seal Beach Env. Impact Statement (U. S. Fish and Wildlife Service and U. S. Navy 1990) LAAC = Los Angeles Animal Control, OC = Orange County, PC = Private Consultant, PI = Private Individual.
[b]The sighting dates are rounded off to the first of the month when only the month was known and to the first of the year when only the year was known. When only the season was given the following dates were used: Winter = 12/21, Spring = 03/21, Summer = 06/21, and Fall = 09/21
[c]AG = agricultural, GR = grasslands, OW = oak woodland, R = riparian, SB = scrub, TSM = tidal salt marsh, U = urban.
[d]Habitat types are listed in the approximate order of dominance at the red fox sighting location.

Appendix 3. Percent occurrence[a] of invertebrate prey items in red fox scat samples by season in Orange County, California, 1990-1991.

Prey Item	Winter (n=104)	Spring (n=52)	Summer (n=111)	Fall (n=124)
Coleoptera	51	15	79	b
Orthoptera	28	12	48	49
Lepidoptera	3	6	18	14
Hymenoptera	4	4	9	8
Dermaptera	10	0	17	8
Scorpiones	11	0	7	26
Arachnida/Siphonaptera	0	0	1	SA
Cocoon	3	0	2	SA
Crustacea	6	8	0	6
Molluska	10	15	0	2

[a]Percentage occurrence was calculated by dividing the number of samples containing an invertebrate prey item by the number of samples containing invertebrates. Sample sizes (eg. Winter, n=104) included only samples that contained invertebrates.
[b]Awaiting final analysis.

Appendix 4. Percent occurrence[a] of seeds in red fox scat samples by season in Orange County, California, 1990-1991.

Seed Family:Genera	Winter (n=74)	Spring (n=40)	Summer (n=89)	Fall (n=131)
Aizoaceae				
Mesembryanthemum sp.	0	3	0	0
Apaceae	0	0	1	0
Arecaceae				
Phoenix sp.	0	0	15	10
Washingtonia sp.	12	5	0	27
Unid. Arecaceae	4	0	0	0
Asteraceae				
Carthamus sp.	0	5	0	0
Centaurea sp.	0	3	0	0
Unid. Asteraceae	0	0	0	1
Brassicaceae	0	3	2	0
Cataceae	0	3	0	0
Chenopodiaceae				
Atriplex sp.	0	0	2	0
Unid. Chenopodiaceae	0	0	1	0
Compositae	0	0	0	1
Convolvulaceae				
Cressa sp.	0	3	0	0
Corporalaceae	0	0	1	0
Cucurbitaceae				
Citrullus sp.	0	0	0	1
Cyperaceae	0	3	2	0
Euphorbiaceae				
Euphorbia sp.	0	0	0	1
Fabaceae				
Acacia sp.	1	0	1	0
Caesalpinia sp.	0	0	3	2
Medicago sp.	0	0	8	3
Phaseolus sp.	0	0	2	0
Unid. Fabaceae	1	0	0	2
Geraniaceae				
Geranium sp.	5	13	10	4
Hordeae	3	0	3	1
Malvaceae	0	0	0	1
Moraceae				
Ficus sp.	22	10	46	61
Myoporaceae				
Myoporum sp.	28	18	0	0
Myrtaceae				
Eucalyptus sp.	0	0	1	0
Pinaceae	1	0	4	2

Appendix 4. Continued.

Poaceae				
Agrostis sp.	0	0	0	1
Avena sp.	0	0	11	5
Bromus sp.	0	5	23	1
Cenchrus sp.	0	0	0	1
Panicum sp.	0	10	0	0
Paspalum sp.	0	0	4	0
Phalaris sp.	0	5	0	0
Sorghum sp.	0	3	2	0
Unid. Poaceae	7	8	2	1
Polygonaceae				
Polygonurn sp.	0	0	4	0
Rumex sp.	1	3	3	3
Rosaceae				
Frageria sp.	3	5	0	0
Malus sp.	0	0	10	3
Pyrus sp.	0	0	1	1
Rubiaceae	0	0	1	0
Solanaceae				
Solanum sp.	0	0	0	2
Unid. Solanaceae	0	0	0	1
Taxaceae				
Taxus sp.	0	0	1	0
Vitaceae				
Vitis sp.	1	5	1	1
Other Genera				
Koelreuteria sp.	0	0	1	0
Copsicum sp.	0	0	3	0
Caryopsis sp.	0	3	1	0
Carum sp.	0	0	1	0
Siverse sp.	0	0	1	0

[a]Percent occurrence was calculated by dividing the number of samples containing a specific seed type by the number of samples containing seeds.

Appendix 5. Capture data on radio-collared and ear-tagged red foxes in Orange County, California, June 1990 - January 1991.

Age	Sex	Capture Date	Site[a]	Ear-tags (color and #) Right, Left	Radio-collars colors, frequency
Ad	F	6/29/90	Crescent	red #7, blue #18	orange-R/white-L, 148.800
		8/24/91	Crescent (recapture)		orange-R/white-L
Ad	M	6/29/90	Bristol	white #19, yellow #15	yellow-R/white-L, 148.601
		4/10/91	Bristol (recapture)		green-R/blue-L, 148.700
Juv	M	7/16/90	MSP	yellow #21, green #12	yellow-R/blue-L, 148.551
		10/09/90	MSP (recapture)		white-R/green-L, 148.551
Juv	F	07/19/90	MSP	red #14, orange #17	red-R/blue-L, 148.750
		02/20/91	MSP (recapture)		yellow-R/orange-L, 148.950
Juv	M	07/20/90	MSP	yellow #22, green #36	orange-R/yellow-L, 148.650
Juv	M	07/25/90	MSP	blue #6, white #10	orange-R/blue-L, 148.701
		02/22/91	MSP (recapture)		yellow-R/blue-L, 148.650
Ad	M	08/06/90	Crescent	green #37, red #13	green-R/red-L, 148.951
Juv	F	09/22/90	LAAFRC	orange #39, yellow #38	yellow-R/green-L, 148.650

Appendix 5. Continued.

Juv	M	09/23/90	LAAFRC	blue #32, orange #34	blue-R/white-L, 148.800
Ad	F	10/01/90	OCSTP	red #43, green #40	green-R/yellow-L, 148.950
Ad	M	10/01/90	LAAFRC	green #41, red #42	red-R/orange-L, 148.600
Juv	F	10/09/90	MSP	yellow #44, white #33	white-R/red-L, 148.501
Juv	M	10/09/90	MSP	white #47, red #46	red-R/yellow-L, 148.851
		02/22/91	MSP (recapture)		red-R/yellow-L, 148.851
Ad	M	10/09/90	MSP	orange #50, blue #52	blue-R/yellow-L, 148.901
		11/11/91	MSP	orange #50, blue #52	blue-R/orange-L, 14
Ad	M	10/13/90	LAAFRC	blue #49, green #48	white-R/blue-L, 148.501
		09/05/91	LAAFRC (recapture)		orange-R/green-L 12
Juv	M	10/14/90	LAAFRC	yellow #35, blue #45	green-R/orange-L, 148.751
Juv	M	01/01/91	BCER	white #55, blue #54	blue-R/white-L, 148.800
Juv	F	01/06/91	BCER	yellow #53, red #51	green-R/white-L, 148.850
Ad	F	02/22/91	MSP	red #07, yellow #31	
Ad	M	02/22/91	MSP	yellow #30, red #25	
Juv	M	02/22/91	MSP	yellow #28, red #01	

Appendix 5. Continued.

Ad	F	02/22/91	MSP	red #06, yellow #29	
Ad	M	02/22/91	MSP	yellow #63, red #08	
		11/11/91	MSP	red #63 yellow #65	(recapture)
Ad	F	02/22/91	MSP	red #09, yellow #64	
Juv	M	07/09/91	OCSTP	red #26 red #27	orange-R/red-L, 148.850
		07/20/91	SCEP (recapture)		orange-R/red-L, 148.850
Juv	F	07/13/91	SCEP	Blue #56 White #57	Blue-R/White-L 148.800
		11/21/91	OCAS (recapture)		Blue-R/White-L 148.800
Juv	M	07/21/91	MSP	White #58 Blue #59	Yellow-R/White-L 11
Ad	F	07/28/91	SCEP	Orange #24 Blue #23	red-R/green-L 15
Juv	F	11/11/91	MSP	Green #17 Red #18	orange-R/green-L 12
Ad	M	11/11/91	MSP	yellow #63 yellow #8	
Juv	F	11/11/91	MSP	yellow #69	
Juv	F	11/11/91	MSP	yellow #20	
Ad	F	11/11/91	MSP	yellow #66	

[a]Bristol is Bristol St. site, Crescent is Crescent Ave. site, MSP is Mile Square Park, LAAFRC is Los Alamitos Armed Forces Reserve Center, OCSTP is Orange County sewage treatment plant #2, BCER is Bolsa Chica State Ecological Reserve, SCEP is the Southern California Edison Plant between Newland and Magnolia Ave. OCAS is the Orange County Animal Shelter.

Introduction and Range Expansion of Nonnative Red Foxes (Vulpes vulpes) in California

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Introduction and Range Expansion of Nonnative Red Foxes (Vulpes vulpes) in California

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ABSTRACT.—Predation on endangered species by nonnative red foxes (*Vulpes vulpes*) and the resulting controversy over red fox control efforts in California prompted our investigation of the introduction and range expansion of the red fox in California. Since the late-1800s, nonnative red foxes have been introduced into California by escaping from fur farms and fox hunters, through intentional releases by pet owners and fur-farm owners and translocations of previously introduced foxes. From 1990–1993 we conducted telephone interviews of wildlife professionals to obtain observations of nonnative red foxes outside the historical range of the native Sierra Nevada red fox (*V. v. necator*). Nonnative red foxes now occur throughout lowland areas of California including the Sacramento and San Joaquin valleys, San Francisco Bay-Delta area, the southern California Coast Range and Coastal Plain and most major urban areas. Their range expansion over the last 100 y was the result of population growth from numerous points of introduction and exhibited by the exponential growth typical of invading species. Fox predation on endangered species and opposition to red fox management have been the two largest management issues associated with this range expansion.

INTRODUCTION

The red fox (*Vulpes vulpes*) occupies one of the widest geographic ranges among carnivores (Lloyd, 1980). Introduction of red foxes by humans into previously unoccupied geographic regions (*e.g.*, Australia in the mid 1800s; Saunders *et al.*, 1995; Dickman, 1996) has been a major contributor to the expansion of its range. In the United States introductions of nonnative red foxes have occurred in the Eastern Seaboard (Presnall, 1958; Churcher, 1959), the Southeast (Lee *et al.*, 1993), Alaska (Bailey, 1993), California (Grinnell *et al.*, 1937), Idaho (Fichter and Williams, 1967), Oklahoma (Hatcher and Wigtil, 1985) and Oregon and Washington (Aubry, 1983). Fur farming and fox hunting in many of these areas resulted in the escape and release of foxes, and the establishment of nonnative red fox populations.

In California the native Sierra Nevada red fox (*Vulpes v. necator*) occurred in high-elevation habitats of the Sierra Nevada and southern Cascade Range (Grinnell *et al.*, 1937). Since the late-1800s however, nonnative red foxes have been found in areas of California outside the historical range of the Sierra Nevada red fox (Grinnell, 1933; Grinnell *et al.*, 1937; Gray, 1975). Additional populations of nonnative red foxes were identified by wildlife managers in the early- to mid-1980s as a result of their predation upon the California clapper rail (*Rallus longirostris obsoletus*) in the San Francisco Bay Area, and upon the light-footed clapper rail (*R. l. levipes*) and the California least tern (*Sterna antillarum browni*) in coastal southern California (U.S. Fish and Wildlife Service and U.S. Navy, 1990; U.S. Fish and Wildlife Service, 1990; Zembal, 1992). These endangered birds use ground nests, are restricted to coastal habitats and are particularly vulnerable to red fox predation (U.S. Fish

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and Wildlife Service and U.S. Navy, 1990; U.S. Fish and Wildlife Service, 1990; Zembal, 1992; Golightly *et al.*, 1994).

Since nonnative red foxes pose a threat to several sensitive species, current information on their distribution and range expansion is critical to assess the magnitude of this threat and develop management recommendations to minimize impacts to native species. Our goal was to assess the distribution of nonnative red foxes in California and determine how this distribution may be changing. Our specific objectives were to: (1) summarize the history of introductions of nonnative red foxes in California, (2) describe the resulting range expansion, (3) identify factors that likely contributed to this expansion, (4) discuss the implications for native fauna and nonnative red fox management and (5) describe management options for nonnative red foxes.

METHODS

We summarized the history of introductions of nonnative red foxes into California by reviewing literature, assessing fox farm records maintained by the California Department of Fish and Game (CDFG) and recording anecdotal reports during interviews with wildlife professionals. We used only historical information that could be dated, including photos, newspaper articles, memos and first-hand observations by the person interviewed.

To determine the recent distribution of nonnative red foxes in California we conducted telephone interviews of wildlife professionals from June 1990 to January 1993. Wildlife professionals included CDFG biologists; municipal, county, and federal animal damage control specialists; park, reserve and refuge biologists and naturalists; museum biologists; federal wildlife biologists; private consulting biologists; university research biologists; and commercial trappers located throughout the state (*see* Lewis *et al.*, 1993 for a comprehensive list). We used only red fox observations which occurred outside the historical range of the Sierra Nevada red fox (Grinnell *et al.*, 1937) because no technique has been devised to reliably make visual distinctions between Sierra Nevada red foxes and nonnative red foxes. Grinnell *et al.* (1937) reported Sierra Nevada red foxes at elevations ≥ 1370 m. Consequently, we excluded red fox observations from the Sierra Nevada and Cascade range above 1066 m elevation. Observations included only red foxes seen by the person being interviewed. We also used locations and dates obtained from museum specimens and photographs from agency or personal files to complete our analysis of the distribution.

During interviews we determined the date, location and the reliability of an observation of a red fox. We also asked for suggestions of additional people to interview. The reliability of an observation was assessed by considering the observer's experience with red foxes, the accuracy of their description of the reported animal and the circumstances of their observation. Red foxes have unique pelage colors and patterns that distinguish them from gray foxes (*Urocyon cinereoargenteus*), kit foxes (*Vulpes macrotis*) and coyotes (*Canis latrans*) (Ingles, 1965); these colors and patterns allow a specific description of the animal by the interviewed observer. In our final analysis we included only unambiguous observations. The elevation of each observation was estimated from its location on a 1:100,000, U.S. Geological Survey topographic map. For efficiency, new observations were mapped only if they were at least 1.6 km (1 mile) from the nearest previously reported observation; consequently, a single mapped location may have represented more than one fox observation.

We investigated the range expansion by comparing the distributions reported by Grinnell *et al.* (1937) and Gray (1975) to the recent distribution (completed in 1993). We used the minimum convex polygon method (Mohr, 1947) to estimate the area of each distribution. Methodologies differed among the three studies; Grinnell *et al.* (1937:40–41, 381–386) used locations of reported captures, collected specimens and published accounts, Gray (1975) used trapper questionnaires and CDFG sighting reports and we used telephone interviews of wildlife professionals. However, each study described the statewide distribution at a distinct time.

RESULTS

Nonnative red fox introduction.—The first known introductions of nonnative red foxes occurred in the upper Sacramento Valley of California before 1890 (Grinnell, 1933; Grinnell *et al.*, 1937; Hanson, 1944). Roest (1977) suggested that these foxes may have been transported from the Midwest to California via the Transcontinental Railroad, which was completed in 1869. Sleeper (1987) reported the importation, captive breeding and release of nonnative red foxes in Orange County in southern California from 1905 to 1919, specifically for fox hunting. Presumably the same was true for northern California where red foxes were hunted as early as the 1880s (Grinnell *et al.*, 1937; Hanson, 1944).

Raising red foxes to provide pelts for garments (*i.e.*, fox farming) probably accounted for most introductions of nonnative red foxes in California. Red fox breeding stock and pelts (predominantly the silver phase) sold for thousands of dollars in the early 1900s, prompting the spread of the industry throughout North America (Jones, 1913). Commercial fox farms began operating in California around 1920 (U.S. Department of Agriculture, 1922; Ashbrook, 1923; Anon.,1926). By 1930 there were at least 58 fox farms in California (Anon., 1930), and approximately 125 by 1942 (Vail, 1942). These farms were widely distributed in California from the 1920s to the 1940s (Fig. 1). Although some fox farms had elaborate facilities to prevent the escape or theft of foxes (Dearborn, 1915; Ashbrook, 1923), escapes and releases from fox farms were not uncommon (Bassett, 1939; Aubry, 1984). Farm foxes have also been reported to escape while being transported by vehicle (Whitlow and Hall, 1933). Fox farming peaked as an industry in California in the 1950s and declined thereafter; it apparently ceased in California in the 1980s (R. Jurek, Calif. Dept. of Fish and Game, pers. comm.).

Red foxes are kept as pets, and some are released by owners (Leslie, 1970) or escape captivity. Introductions of nonnative red foxes by animal control officials, wildlife rehabilitators and disenchanted pet owners may account for the majority of recent fox introductions in California (Lewis *et al.*, 1998). For example, wildlife rehabilitators in Southern California released two nonnative red foxes into Sequoia National Park (Estrada, 1989) within the historical range of the native Sierra Nevada red fox.

Range expansion.—Grinnell *et al.* (1937) described the distribution of nonnative red foxes from seven observations in five counties in the upper Sacramento Valley (Fig. 2A). These seven observations occurred from southern Tehama County (northernmost latitude, 40°00′) south to southern Sutter County (southernmost latitude, 38°47′). Gray (1975) described the distribution from 168 observations in 17 counties (Fig. 2B). These 168 observations occurred in the Sacramento Valley (northernmost latitude, 40°51′), the San Francisco Bay-Delta area and the northernmost portion of the San Joaquin Valley (southernmost latitude, 37°40′) (Fig. 2B). Gray also reported a small satellite population in southern Los Angeles County (latitude 33°48′; Fig. 2B). The distribution described by Gray (1975) encompassed the distribution described by Grinnell *et al.* (1937).

When assessing the recent distribution we interviewed 199 individuals; 124 (62%) of them reported observations of red foxes. Three-hundred-eleven reliable red fox observations were reported in 36 counties (Fig. 2C); six of these by the authors. Mean elevation of nonnative red fox observations was 139 ± 10 m ($\bar{x}$ ± SE, range = 0 to 1000 m). The recent distribution encompasses the distributions described by Grinnell *et al.* (1937) and Gray (1975) with the exception of a small area in the northern and northwestern edge of Gray's distribution.

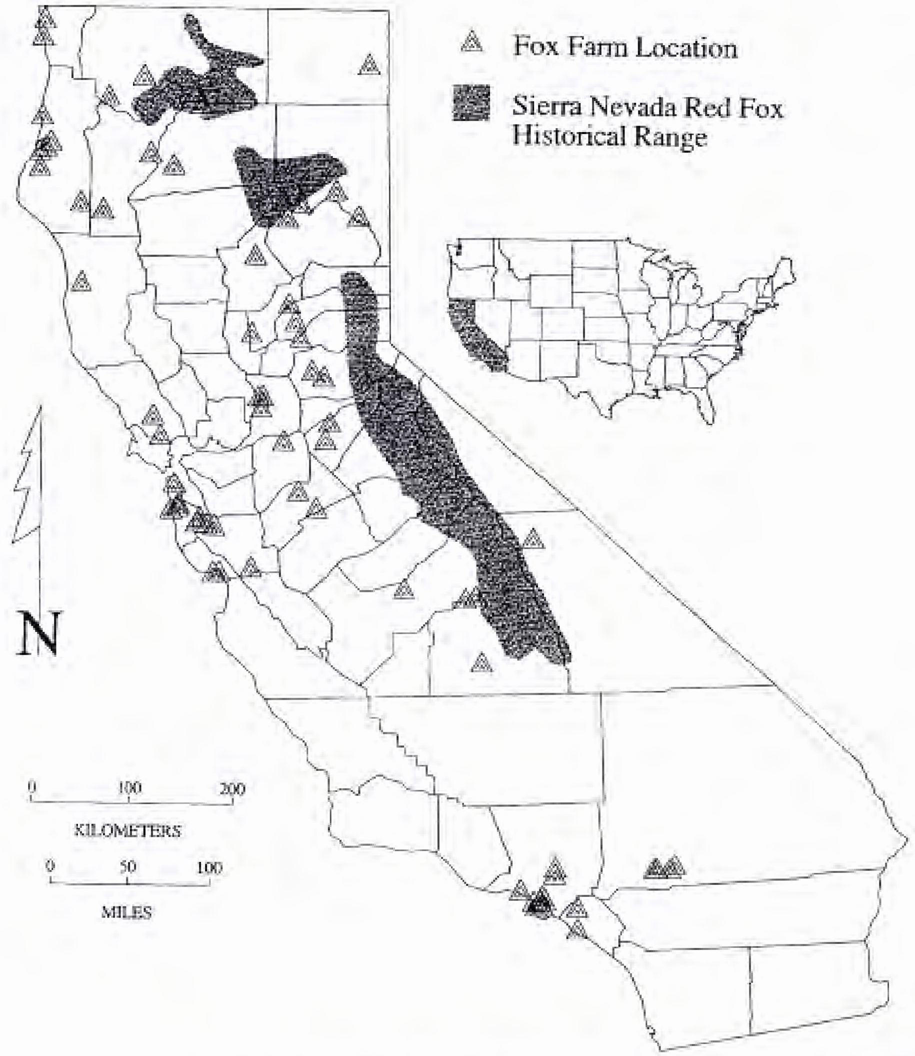

FIG. 1.—Locations of known fox farms in California from the 1920s to 1940s ($n = 69$). A few locations may represent the farmer's home address rather than the fox farm location (from Lewis *et al.*, 1995)

The recent distribution includes much of the southern and central coastal areas from Mission Bay in San Diego County (southernmost latitude, 32°48′) north to Point Reyes National Seashore in Marin County (Fig. 2C). Red foxes were observed throughout the San Joaquin and Sacramento valleys in an area extending from Bakersfield northward to Redding in Shasta County (northernmost latitude, 40°36′). Observations were also reported as far east as western Riverside County and the western Sierra Nevada foothills. Other observations

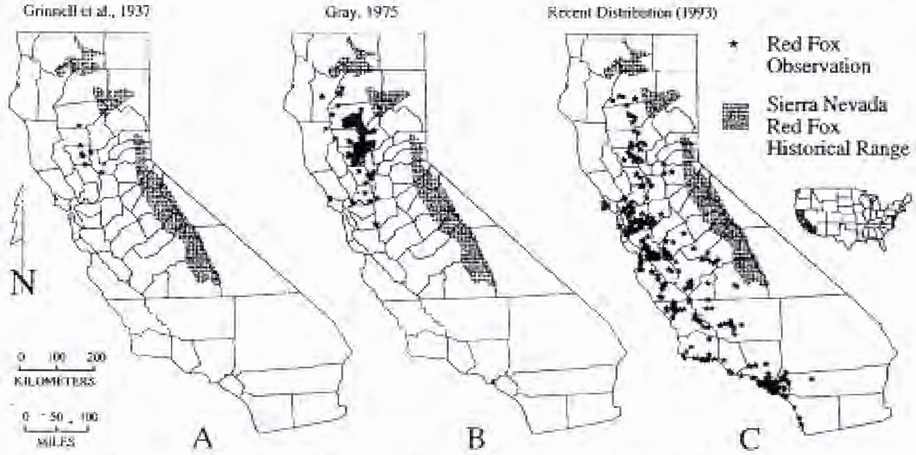

FIG. 2.—The range expansion of the nonnative red fox in California from A) Grinnell *et al.* (1937), B) Gray (1975) and C) the recent distribution (1993). The star in the southern portion of the Gray (1975) distribution represents a small satellite population of foxes in the City of Long Beach in Los Angeles County. The historical range of the Sierra Nevada red fox was described by Grinnell *et al.* (1937).

were reported in the Salinas River Valley, the Carrizo Plain and the San Francisco Bay-Delta area. No observations were reported from the Mojave Desert in southeastern California, the northern coastal plain, the northern Coast range or east of the Sierra Nevada and Cascade range.

Red foxes were commonly observed in rural areas, but were also observed in urban and suburban areas of Los Angeles and Orange counties, the San Francisco Bay area, Bakersfield, Fresno and Santa Barbara. Area estimates for the three distributions indicate an exponential expansion of the nonnative red fox range since its initial introduction ($r^2 = 0.947$; Fig. 3).

DISCUSSION

Based on the wide distribution of fox farms (Fig. 1), known releases and escapes and the distribution described by Gray (1975) (Fig. 2B), we concluded that the range expansion of nonnative foxes was the result of introductions from numerous geographic locations, times and sources. This expansion exhibited the exponential growth typical of invading species (Hengeveld, 1989), but may not have occurred without continued human introductions and transplantations over the last 100 y.

Captures of nonnative red foxes in Sonoma, Marin and Solano Counties in 1996 and 1997 (J. Steuber, USDA Wildlife Services, Sacramento, California, pers. comm.) indicate that foxes may be expanding their range north of the San Francisco Bay area. We expect the range to continue to expand as a result of population growth, dispersal and additional introductions and translocations. The recent illegal transportation of nonnative foxes for hunting purposes elsewhere in the U.S. (Poten, 1991; Davidson *et al.*, 1992) and recent illegal liberations of farm foxes by animal rights activists indicate that new introductions continue to occur in North America. Although little or no fox farming takes place in California at present, an increased demand for pelts could encourage the practice in the future.

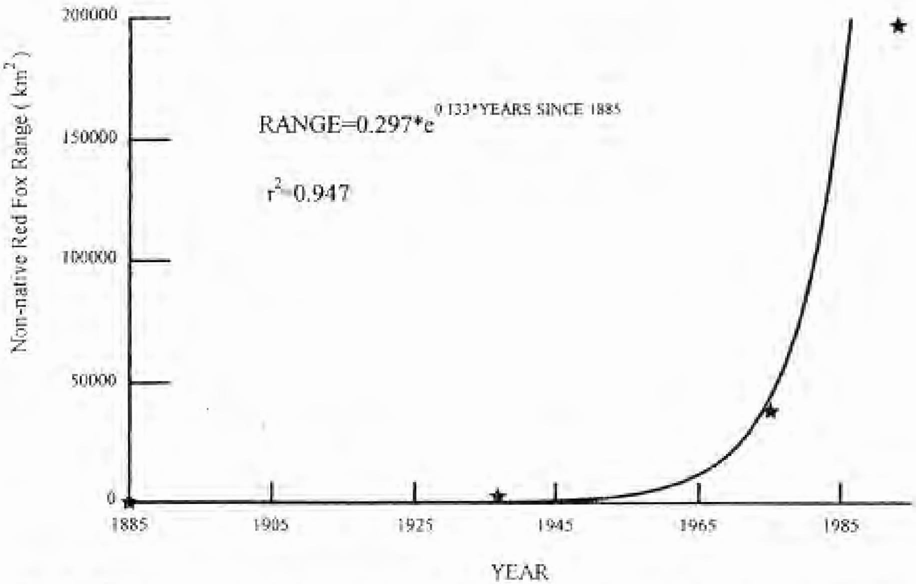

FIG. 3.—Range expansion of the nonnative red fox in California, 1885–1993, based on minimum convex polygon estimates of range sizes for the three distributions. The four plotted points refer to the first introduction (~1885; Grinnell, 1933; Hanson, 1944), the distribution in ~1937 (Grinnell *et al.*, 1937), the distribution in ~1975 (Gray, 1975) and the recent distribution (in 1993). The small satellite population identified in Los Angeles County in southern California (Fig. 2B) was excluded when estimating range size for the Gray (1975) distribution

The mere presence of fox farms in an area, however, does not necessarily result in the introduction and occurrence of nonnative red foxes, as evidenced in the northern California coastal plain. Introduction can be difficult to document because evidence of colonization or the establishment of a population of red foxes may not occur for some time after an introduction. The number of foxes introduced and the ability of individuals to adapt to local ecological conditions could affect the establishment of a local population and the opportunity to detect their presence. The people who release red foxes dictate where foxes are introduced and can be instrumental in fox colonization of some habitats. The lack of observations in the Mojave Desert suggests that ecological conditions there may not be suitable for red fox colonization, or that no introductions occurred in this ecosystem. However, colonization of the Mojave Desert may be possible, as red foxes occur in desert ecosystems elsewhere (Lloyd, 1980).

The invasion and colonization of nonnative species are often associated with the presence of disturbed ecosystems (Culotta, 1991), but may also reflect the availability of an unexploited niche, repeated introductions, lack of predators or other favorable conditions (Adams *et al.*, 1993). The conversion of much of California's lowlands to agriculture and expansive urban/suburban development represents considerable disturbance. In urban areas of Orange County in southern California, nonnative red foxes were locally abundant (Lewis *et al.*, 1993; Lewis, 1994). Foxes in Orange County were commonly observed in open spaces and corridors in urban and suburban areas where they were fed by people (Golightly *et al.*,

1994) and where coyotes, which are predators and competitors of red foxes, were uncommon (U.S. Fish and Wildlife Service and U.S. Navy, 1990). We suspect that recent increases in fox sightings in urban Orange County were linked to increasing urbanization which reduced suitable habitat for coyotes while creating patches of open spaces (*e.g.*, golf courses, cemeteries, airports, parks, wildlife refuges) suitable for red foxes within the urban matrix (Lewis *et al.*, 1993). These observations are consistent with the "mesopredator release" hypothesis presented by Soulé *et al.* (1988) where urban sprawl reduces or eliminates suitable habitat for top carnivores [*e.g.*, coyotes and mountain lions (*Felis concolor*)] such that lower-tier "mesopredators" [*e.g.*, red foxes, opossums (*Didelphis virginianus*), feral cats (*Felis catus*), striped skunks (*Mephitis mephitis*)] may become unusually abundant.

The red fox is a generalist predator and in much of California it is an exotic predator. Consequently, nonnative red foxes are a threat to native fauna, including a number of threatened and endangered species (Table 1). Disease transmission (Lloyd, 1980; Davidson *et al.*, 1992; Lee *et al.*, 1993), resource competition (*see* review in Johnson *et al.*, 1996) and interbreeding (Thornton *et al.*, 1971) are other threats nonnative red foxes pose to native species. Red foxes also present a threat to humans and their pets through disease transmission (particularly rabies; Wandeler, 1980; Winkler and Bögel, 1992), especially in urban areas where foxes can become abundant and interactions between foxes and humans are common (Lewis *et al.*, 1993; Golightly *et al.*, 1994).

The rapid expansion and wide-spread distribution of the nonnative red fox has resulted in two major issues: fox predation on threatened and endangered species and opposition by animal rights groups to red fox control (*see* review in Lewis *et al.*, 1998). While large-scale management efforts may be required to effectively protect threatened and endangered species from red foxes, limited management funding and opposition by animal rights groups have prevented efforts of this size. Consequently, agency efforts have focused on critical localized problems (*e.g.*, fox predation on endangered species at a refuge) with the understanding that control may be required on a long-term basis because foxes may regularly disperse into the problem area (Lewis, 1994). Management of nonnative red foxes has typically involved capture (using padded leg-hold traps) and euthanasia (U.S. Fish and Wildlife Service and U.S. Navy, 1990). In California opposition to the lethal control of foxes resulted in legal action against the U.S. Fish and Wildlife Service; the expenditure of agency resources to produce National Environmental Policy Act (NEPA) compliance documents (U.S. Fish and Wildlife Service and U.S. Navy, 1990; U.S. Fish and Wildlife Service, 1990); inaction on a 1996 proposal for a trapping and hunting season for nonnative red foxes (R. Aiton, Calif. Trapper's Assoc., pers. comm.) and the passing of an initiative on the 1998 California State ballot that bans the use of all body-gripping traps for recreational and commercial trapping and limits their use for endangered-species protection efforts.

Given the political climate and biological realities, new, proactive management strategies for nonnative red foxes are needed that include: (1) preventing introductions and translocations; (2) identifying needs for protecting native species where the nonnative red fox range is expanding and for species particularly vulnerable to fox predation; (3) developing management strategies at larger scales such as the regional or state-wide level; (4) developing alternatives to the use of body-gripping traps to control predators as part of endangered-species protection efforts; (5) regularly assessing fox distributions and densities, especially in urban areas; (6) developing plans for preventing or managing fox-transmitted disease epidemics and (7) improving communications with the public about fox management issues. Proactive measures are also needed to prevent or limit the introduction of other deleterious exotic species (*see* Atkinson, 1996). Management of anthropogenic issues and improved communication with an increasingly urban/suburban constituency may re-

TABLE 1.—Threatened or endangered species of California that are vulnerable to nonnative red fox predation based on documentation (as footnoted), or potentially vulnerable to fox predation based on weight[a]. Species listed co-occur with nonnative red foxes in at least one geographic area as delineated by the 7.5 minute U.S. Geological Survey topoquad maps of California

Species	Latin name	Status[b]
BIRDS		
Bank swallow	*Riparia riparia*	CT
Belding's savannah sparrow	*Passerculus sandwichensis beldingii*	CE
California black rail	*Laterallus jamaicensis coturniculus*	CT
California clapper rail[c]	*Rallus longirostris obsoletus*	FE, CE
California gnatcatcher	*Polioptila californica*	FT
California least tern[d]	*Sterna antillarum browni*	FE, CE
Least Bell's vireo	*Vireo bellii pusillus*	FE, CE
Light-footed clapper rail[d]	*Rallus longirostris levipes*	FE, CE
Western snowy plover[e]	*Charadrius alexandrinus nivosus*	FT
Western yellow-billed cuckoo	*Coccyzus americanus occidentalis*	CE
Willow flycatcher	*Empidonax traillii*	CE
MAMMALS		
Giant kangaroo rat	*Dipodomys ingens*	FE, CE
Salt marsh harvest mouse	*Reithrodontomys raviventris*	FE, CE
San Joaquin antelope squirrel	*Ammospermophilus nelsoni*	CT
San Joaquin kit fox[f]	*Vulpes macrotis mutica*	FE, CT
Stephen's kangaroo rat	*Dipodomys stephensi*	FE, CT
Tipton kangaroo rat	*Dipodomys nitratoides nitratoides*	FE, CE
REPTILES		
Alameda whipsnake	*Masticophus lateralis euryxanthus*	CT
Blunt-nosed leopard lizard	*Gambelia silus*	FE, CE
Giant garter snake	*Thamnophis gigas*	FT, CT
San Francisco garter snake	*Thamnophis sirtalis tetrataenia*	FE, CE
AMPHIBIANS		
Arroyo southwestern toad	*Bufo microscaphus californicus*	FE
California red-legged frog	*Rana aurora draytonii*	FT
Santa Cruz long-toed salamander	*Ambystoma macrodactylum croceum*	FE, CE

[a] Weight designation was given to potential prey species that weight ≤ 3 kg, following Lloyd (1975)
[b] Statuses include: CE = California endangered, CT = California threatened, FE = federally endangered, FT = federally threatened
[c] Predation documented by U.S. Fish and Wildlife Service (1990)
[d] Predation documented by U.S. Fish and Wildlife Service and U.S. Navy (1990)
[e] Predation documented by U.S. Fish and Wildlife Service (1990, 1993)
[f] Predation documented by Ralls and White (1995)

quire a concerted long-term effort but may be the most beneficial approach to managing nonnative species. Site-specific management is valuable and may continue to receive most of the attention, however it is unlikely that site-specific management will provide a long-term solution.

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LITERATURE CITED

ADAMS, K. D., C. M. KING AND W. H. KOHLER. 1993. Potential ecological effects of escaped transgenic animals: lessons from past biological invasions, p. 153–173. *In:* K. Wohrmann and J. Tomiuk (eds.). Transgenic Organisms. Birkhauser Verlag Basel/Switzerland.

ANONYMOUS. 1926. A unique fox ranch. *Am. Game,* 15(3):58.

——— 1930. Agricultural news—northern California. *Calif. Cultivator* p. 396. April 5, 1930.

ASHBROOK, F. G. 1923. Silver fox farming. *U.S. Dep. Agric., Dep. Bull.* No. 1151. 59 p.

ATKINSON, I. A. E. 1996. Introductions of wildlife as a cause of species extinctions. *Wildl. Biol.,* 2:135–141.

AUBRY, K. B. 1983. The Cascade red fox: distribution, morphology, zoogeography and ecology. Ph.D. Dissertation, Univ. Washington, Seattle. 151 p.

———. 1984. The recent history and present distribution of the red fox in Washington. *Northwest Sci.,* 58:69–79.

BAILEY, E. P. 1993. Fox introductions on Alaskan islands—history, impacts on avifauna, and eradication. *U.S. Fish and Wildl. Serv. Resour. Publ.* 193. 54 p.

BASSETT, C. F. 1939. An efficient trap for the fox ranch. *U.S. Dep. Agric., Bur. Biol. Surv. Wildl. Res. Manage. Leaflet* BS-127. 5 p.

CHURCHER, C. S. 1959. The specific status of the New World red fox. *J. Mammal.,* 40:513–520.

CULOTTA, E. 1991. Biological immigrants under fire. *Science,* 254:1444–1447.

DAVIDSON, W. R., M. J. APPEL, G. L. DOSTER, O. E. BAKER AND J. F. BROWN. 1992. Diseases and parasites of red foxes, gray foxes, and coyotes from commercial sources selling to fox-chasing enclosures. *J. Wildl. Dis.,* 8:581–589.

DEARBORN, N. 1915. Silver fox farming in eastern North America. *U.S. Dep. Agric., Dep. Bull.* No. 301. 35 p.

DICKMAN, C. R. 1996. Impact of exotic generalist predators on the native fauna of Australia. *Wildl. Biol.,* 2:185–195.

ESTRADA, J. 1989. Raising baby raccoons just comes with the job. *Temple City Times,* Temple City, California. October 15, 1989.

FICHTER, E. AND R. WILLIAMS. 1967. Distribution and status of the red fox in Idaho. *J. Mammal.,* 48: 219–230.

GOLIGHTLY, R. T., M. R. FAULHABER, K. L. SALLEE AND J. C. LEWIS. 1994. Food habits and management of introduced red fox in southern California. *Proc. Vertebr. Pest Conf.,* 16:15–20.

GRAY, R. L. 1975. Sacramento Valley red fox survey. Calif. Dept. of Fish and Game, Nongame wildl. invest. Progress report. 6 p.

GRINNELL, J. 1933. Review of recent mammal fauna of California. *Univ. Calif. Publ. Zool.,* 40:71–234.

———, J. S. DIXON, AND J. M. LINSDALE. 1937. Furbearing mammals of California. Univ. of Calif. Press, Berkeley. 777 p.

HANSON, N. W. 1944. As I remember. Broyles and Camper, Chico, California. 191 p.

HATCHER, R. T. AND G. W. WIGTIL. 1985. Fates of red foxes released into southeastern Oklahoma. *Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies,* 39:321–325.

HENGEVELD, R. 1989. Dynamics of biological invasions. Chapman & Hall, New York. 160 p.

INGLES, L. G. 1965. Mammals of the Pacific States: California, Oregon, Washington. Stanford Univ. Press, Stanford, California. 506 p.

JOHNSON, W. E., T. K. FULLER AND W. L. FRANKLIN. 1996. Sympatry in canids: a review and assessment, p. 189–218. *In:* J. L. Gittleman (ed.). Carnivore behavior, ecology, and evolution, Vol. 2. Cornell University Press, Ithaca, New York.

JONES, J. W. 1913. Fur-farming in Canada. Commission of Conservation, Canada, Ottawa. 166 p.

LEE, G. W., K. A. LEE AND W. R. DAVIDSON. 1993. Evaluation of fox-chasing enclosures as sites of potential introduction and establishment of *Echinococcus multilocularis*. *J. Wildl. Dis.*, 29:498–501.

LESLIE, R. F. 1970. Wild pets. Crown Publ. Inc., New York. 240 p.

LEWIS, J. C. 1994. Dispersal of introduced red foxes in urban Southern California. M.S. Thesis, Humboldt St. Univ., Arcata, California. 57 p.

———, K. L. SALLEE AND R. T. GOLIGHTLY. 1993. Introduced red fox in California. Calif. Dept. Fish and Game, Sacramento. Non-game Bird and Mammal Sect. Rep. 93-10. 70 p.

———, R. T. GOLIGHTLY AND R. M. JUREK. 1995. Introduction of non-native red foxes in California: implications for the Sierra Nevada red fox. *Trans. West. Sect. Wildl. Soc.*, 31:29–32.

———, K. L. SALLEE, R. T. GOLIGHTLY, JR. AND R. M. JUREK. 1998. Social and biological aspects of non-native red fox management in California. *Proc. Vertebr. Pest Conf.*, 18:150–155.

LLOYD, H. G. 1975. The red fox in Britain, p. 207–215. *In*: M. W. Fox (ed.). The wild canids. Van Nostrand Reinhold Co., New York.

———. 1980. The red fox. B. T. Batsford Ltd., London, U.K. 320 p.

MOHR, C. O. 1947. Table of equivalent populations of North American small mammals. *Am. Midl. Nat.*, 37:223–249.

PRESNALL, C. C. 1958. The present status of exotic mammals in the United States. *J. Wildl. Manage.*, 22:45–50.

POTEN, C. J. 1991. A shameful harvest: America's illegal wildlife trade. *Nat. Geogr.*, 180:106–132.

RALLS, K. AND P. J. WHITE. 1995. Predation on San Joaquin kit foxes by larger canids. *J. Mammal.*, 76:723–729.

ROEST, A. I. 1977. Taxonomic status of the red fox in California. Calif. Dept. of Fish and Game, Nongame Wildl. Invest. Final report. 15 p.

SAUNDERS, G., B. COMAN, J. KINNEAR AND M. BRAYSHER. 1995. Managing vertebrate pests: foxes. Australian Gov. Publ. Serv., Canberra. 141 p.

SLEEPER, J. 1987. Bears to briquets: A history of Irvine Park 1897–1997. Calif. Classics, Trabuco Canyon, California. 32 p.

SOULÉ, M. E., D. T. BOLGER, A. C. ALBERTS, J. WRIGHT, M. SORICE AND S. HILL. 1988. Reconstructed dynamics of rapid extinctions of chaparral-requiring birds in urban habitat islands. *Conserv. Biol.*, 2:75–92.

THORNTON, W. A., G. C. CREEL AND R. E. TRIMBLE. 1971. Hybridization in the fox genus *Vulpes* in west Texas. *Southwest. Nat.*, 25:423–434.

U.S. DEPARTMENT OF AGRICULTURE. 1922. Report of the Chief of the Bureau of Biological Survey. U.S. Gov. Printing Office, Washington, D.C. 40 p.

U.S. FISH AND WILDLIFE SERVICE AND U.S. NAVY. 1990. Endangered species management and protection plan, Naval Weapons Station—Seal Beach and Seal Beach National Wildlife Refuge. Final environmental impact statement. Portland, Oregon. 591 p.

———. 1990. Predator management plan and environmental assessment, San Francisco Bay National Wildlife Refuge, Newark, California. Draft rep. 26 p.

———. 1993. Endangered and threatened wildlife and plants; determination of threatened status for the Pacific Coast population of the western snowy plover. *Fed. Register*, 58:12864–12874.

VAIL, E. L. 1942. Fox ranching in southern California. *Calif. Fish and Game*, 28:87–88.

WANDELER, A. I. 1980. Epidemiology of fox rabies, p. 237–249. *In*: E. Zimen (ed.). The red fox. *Biogeographica*, Vol. 18. Dr. W. Junk, The Hague, The Netherlands.

WHITLOW, W. B. AND E. R. HALL. 1933. Mammals of the Pocatello region of southeastern Idaho. *Univ. Calif. Publ. Zool.*, 40:235–276.

WINKLER, W. G. AND K. BOGEL. 1992. Control of rabies in wildlife. *Sci. Am.*, 266:86–92.

ZEMBAL, R. 1992. Status and management of light-footed clapper rails in coastal southern California. *Trans. West. Sect. Wildl. Soc.*, 28:1–5.

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Effect of Mammalian Predator Management on Snowy Plover Breeding Success

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Abstract.—The reproductive success of the Snowy Plover (*Charadrius alexandrinus*) nesting on beaches in central Monterey Bay, California, was monitored before (1984 to 1990) and during (1991 to 1999) predator management. From 1984 to 1990, hatching success of the Snowy Plover declined from 66% to 26% and most nest loss was attributed to Red Fox (*Vulpes vulpes*) predation. From 1991 to 1999, exclosures were used to protect some nests and after 1993, mammalian nest predators were removed. Predator management increased hatching success and the number of chicks hatched per male, but not fledging success or the number of chicks fledged per male. Predation of chicks by avian predators probably limited fledging success. The number of breeding adults did not increase and incubating adults were subject to greater mortality when nesting in exclosures. Our results indicate that exclosures are useful for increasing hatching success, but we caution that widespread use of exclosures may increase adult mortality rates and contribute to a decline in breeding numbers. *Received 28 November 2003, accepted 24 February 2004.*

Key words.—*Charadrius alexandrinus*, exclosure, predator management, Red Fox, Snowy Plover, *Vulpes vulpes*.

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Historically, removal of native predators has been conducted to increase post-breeding numbers of waterfowl and other game birds (Balser *et al.* 1968; Duebbert and Lokemoen 1980; Côté and Sutherland 1997). In recent years, predator control programs have been initiated to protect native avifauna that has been heavily impacted by introduced mammalian predators (Moors and Atkinson 1984; Burger and Gochfeld 1994; Dowding and Murphy 2001). For example, numbers of the California Clapper Rail (*Rallus longirostris*) in San Francisco Bay increased when Red Foxes (*Vulpes vulpes*) were removed (Harding *et al.* 2001). Similarly, in Australia, endangered Malleefowl (*Leipoa ocellata*) that were captively reared and released survived longer in areas where introduced Red Foxes were removed (Priddel and Wheeler 1997).

Exclusion of predators from shorebird nests has been accomplished with individual nest exclosures (Vaske *et al.* 1994; Estelle *et al.* 1996; Mabee and Estelle 2000; Murphy *et al.* 2003a) and with electrified or barrier fencing of nesting areas (Mayer and Ryan 1991). On the U.S. Atlantic coast, Piping Plover (*Charadrius melodus*) hatching and fledging rates increased when predator exclosures were placed around individual nests (Rimmer and Deblinger 1990; Melvin *et al.* 1992). In North Dakota, Piping Plover reproductive rates increased within areas protected by electrified fencing (Mayer and Ryan 1991). In Scotland, shorebird nesting success increased in areas where Hedgehogs (*Erinaceus europa*) were excluded with barrier fencing (Jackson 2001).

In Monterey Bay, on the central California coast, predation by Red Foxes has been identified as a major factor limiting reproductive success of the threatened Snowy Plover (Parker and Takekawa 1993). The Red Fox was identified as the major cause of nest loss, and because in California it preys on adult shorebirds (Lewis *et al.* 1993), it was suspected that foxes also were predators of chick and adult plovers at Monterey Bay. The Red Fox was introduced into California from fur farms in the Sacramento Valley in the late 1800s and early 1900s, and has become established in the Central Valley, San Francisco Bay, Monterey Bay, and southern coastal regions of California (Harvey *et al.* 1992; Jurek 1992; Lewis *et al.* 1993).

We began documenting the fate of Snowy Plover nests in central Monterey Bay in 1984. In 1991, the U.S. Fish and Wildlife Service (USFWS) began experimentally protecting individual Snowy Plover nests with anti-predator exclosures. In 1993, the USFWS developed a predator management plan to remove the Red Fox and other mammalian nest predators in addition to continued use of exclosures (Parker and Takekawa 1993).

From 1984 through 1999, management of predators in Snowy Plover habitat in Monterey Bay transitioned from no management to the active exclusion and removal of mammalian nest predators. Throughout this period, we monitored nesting plovers to determine if predator exclosures and Red Fox removal increased plover reproductive success. In this study, we compared reproductive success of the Snowy Plover before (1984 to 1990) and during (1991 to 1999) predator management, expecting that management should result in increased reproductive success and increased numbers of breeding adults.

METHODS

We monitored Snowy Plover nesting along 18 km of sandy beaches in central Monterey Bay, a large area composed of 50 km of contiguous sandy shoreline on the central California coast. The shoreline was backed by low sparsely vegetated foredunes and a moderate to extensive dune system, and bisected at its center by the Salinas River. The Snowy Plover primarily nested above the mean high tide line on beaches and foredunes sparsely vegetated with Sea Rocket (*Cakile maritima*), Beach Pea (*Lathyrus littoralis*), Beach Bur (*Ambrosia chamissonis*), and American Beach Grass (*Leymus mollis*), and at seasonal sand spits at the mouth of the Salinas River. In some years, plovers also nested on sandy, emergent islands in the Salinas River, approximately 500 m upstream of the mouth. Though there was some variability in beach width among years, the amount of available nesting habitat for plover nesting was approximately equivalent between the pre-management and management phases. Weather during the 16-year period of this study did not vary substantially between the two management phases. Temperature from March to September averaged 14.8° C (±0.26 SD) in the pre-management phase, and 14.9° C (±0.92 SD) in the management phase. Rainfall from March to September averaged 16.3 mm (±5.8 SD) in the pre-management phase, and 23.3 mm (±12.8 SD) in the management phase.

The northern two-thirds of the study area was managed by public resource protection agencies (the California Department of Parks and Recreation and the USFWS); the southern third was privately owned. Human use of the shoreline was probably lower during the pre-management phase and increased through time as a function of increasing human population density within the California coastal zone. However, during the pre-management phase, human use was not restricted in plover nesting areas, whereas in the management phase extensive plover habitat areas, such as sand spits, were closed to the public with cable fencing (see below).

From 1991 to 1999, the California Department of Parks and Recreation and the USFWS used exclosures to protect some plover nests. Exclosure design was based on a method developed by Rimmer and Deblinger (1990) for protecting Piping Plover nests. Triangular exclosures were constructed of 5 × 10 cm wire-mesh. Each panel was 7.6 m long and 1.5 m high. Panels were attached to stakes with metal clips and then buried to a depth of 20 cm. The top of each panel was bent outward at about 45° to discourage predators from climbing into the exclosure. Exclosures did not have barrier material across the top. Average exclosure construction time by three people was approximately 30 minutes. Nests receiving exclosures were in areas with more predator activity (based on tracks and predator sightings). Fences constructed of coated wire cable strung between metal rods were used to mark some of the larger nesting areas and some individual nests. These "symbolic fences" did not exclude predators, but were intended to exclude most human activity. Both exclosures and symbolic fences were posted with signs in English and Spanish. The Wildlife Services Division (WSD) of the US Department of Agriculture, conducted predator removal through a cooperative agreement with USFWS. From 1993 to 1999, mammalian nest predators were removed, primarily Red Fox and feral cats (Table 1). The majority (93%, N = 153) of non-target predators were released unharmed. Trapping effort was consistent among years after 1993, when trapping occurred only in the central third of the study area.

An attempt was made to locate every nest within the study area by visiting as frequently as necessary to monitor the activities of every breeding pair (usually three to

Table 1. Number of Red Fox and feral cats removed from Snowy Plover nesting areas in central Monterey Bay, California.

Year	Red Fox	Feral cat
1993	30	2
1994	39	12
1995	7	15
1996	2	18
1997	8	11
1998	13	26
1999	19	11
Total	118	95

four times per week, but at some locations as infrequently as once a week or as frequently as daily). A nesting attempt was defined as a clutch of eggs that was incubated until it either hatched successfully, was lost to predators, human activities or environmental factors, or was abandoned. Infertile clutches were counted as nesting attempts but one-egg "clutches" that were never incubated were not. Hatch dates were estimated from egg-laying dates or from floating eggs found after clutch completion (Hays and Lecroy 1971). Once a nest was located it was checked from afar for the presence of an incubating adult. If an adult was absent, the nest was approached to visually check nest contents. As the estimated hatch date approached, the precise hatch date was determined by examining eggs for signs of imminent hatching. Newly hatched chicks were banded with a unique three- or four-color leg band combination. Broods were monitored by directly observing chicks or adult behavior throughout the chick-rearing period until fledging. Most (> 80%) plovers nesting in the study area had been previously color-banded as chicks. Unbanded adults that recruited into the study area were trapped and banded. One or both adults were banded at 93% of nests, with both adults banded at over 75% of nests.

Four measures of Snowy Plover breeding success were examined: hatching rate, number of chicks hatched per breeding male, fledging rate, and number of chicks fledged per breeding male. We also determined the number of breeding male and female plovers. Breeding adults that nested multiple times in the same area were counted once. Hatching rate was defined as the proportion of clutches in which at least one egg hatched. Fledging rate was defined as the proportion of hatched chicks surviving to 28 days or more (Page *et al.* 1995). Hatching and fledging percentages were converted to ratios of chicks per male rather than chicks per pair because Snowy Plovers are serially polygamous; the male rears the chicks while the female renests and the male is more faithful to his breeding site than the female (Warriner *et al.* 1986).

Causes of most nest losses were determined from evidence at the nest scrape such as predator tracks, eggshell fragments, and partially depredated chicks or adults, but causes of chick or adult mortality were rarely identified. Predation was categorized as canine predation (Red Fox; Gray Fox (*Urocyon cinereoargenteus*); domestic dog; and unknown canid), and non-canine predation. Non-canine predation included Striped Skunk (*Mephitis mephitis*), destruction by gulls (*Larus* spp.) or Brown Pelicans (*Pelecanus occidentalis*), predation of hatching eggs by American Kestrel (*Falco sparverius*) and Loggerhead Shrike (*Lanius ludovicianus*), and unknown predators. Other causes of nest loss included environmental factors (wind and tide), losses attributable to human activities (crushing of eggs by pedestrians, equestrians, and vehicles; deliberate vandalism of nests; and collection of eggs by researchers), nest abandonment, and non-viability of eggs in clutches. Because most nesting adults were banded, nest abandonment accompanied by the disappearance and presumed death of one nesting adult was detectable and was categorized separately from nest abandonment without evidence of adult loss.

Average reproductive measures during pre-management (1984-1990) and management phases (1991-1999) were compared. Mean hatching rate, fledging rate, number of chicks hatched per breeding male, and number of chicks fledged per breeding male were compared between phases using Student's t-tests. Mean numbers of breeding male and female plovers were compared between phases but data from 1991 was excluded because no management occurred in 1990 that could have increased the number of breeding adults the following year. To determine the effectiveness of exclosure use and predator removal, mean percentage of nests lost to canines and percentage lost to all predators were compared between phases using one-tailed Student's t-tests. Reproductive rates for exclosed and unexclosed nests during the management phase were not compared because nests that were selected for protection were most vulnerable to predators (e.g., located in an area with obvious predator activity).

RESULTS

In the pre-management phase, 728 plover nests were monitored and 682 were monitored in the management phase of this study. Hatching rate of Snowy Plovers declined from 66% to 26% during the pre-management phase (Table 2). During the management phase, 49% (N = 333) of nests were protected with exclosures and selected nest predators were removed (Table 1). From the pre-management to management phase, mean hatching rate increased from 43% (SD ± 12%, N = 7 yrs.) to 68% (SD ± 12%, N = 9 yrs.; t_{14} = 3.95, $P < 0.001$) but mean fledging rate decreased from 42% (SD ± 6%, N = 7 yrs.) to 30% (SD ± 12%, N = 9 yrs.; t_{14} = 2.53, $P < 0.02$; Table 2). The mean number of chicks hatched per breeding male increased from 2.0 (SD ± 0.49, N = 7 yrs.) in the pre-management phase to 2.7 (SD ± 0.34, N = 9 yrs.; t_{14} = 3.55, $P < 0.01$; Table 2) in the management phase. The mean number of chicks fledged per male did not change significantly, averaging 0.86 (SD ± 0.28, N = 7 yrs.) during the pre-management phase and 0.81 (SD ± 0.29, N = 9 yrs.; t_{14} = 0.40, n.s.; Table 2) during the management phase. From the pre-management to management phase, the mean number of breeding males decreased slightly, but not significantly, from 55.4 (SD ± 12.5, N = 7 yrs.) to 47.7 (SD ± 8.8, N = 8 yrs.; Table 2). The mean number of females also decreased slightly, but not significantly, from 57.7 (SD ± 11.8, N = 7 yrs.) to 49.0 (SD ± 12.0, N = 8 yrs.; Table 2) between the two phases.

Predators were responsible for a greater proportion of nest losses during the pre-management than the management phase

Table 2. Reproductive success[1] and number[2] of breeding Snowy Plovers before (1984-1990) and during (1991-1999) predator management in central Monterey Bay, California.

Year	Hatching rate (%)	Chicks hatched per male	Fledging rate (%)	Chicks fledged per male	Adult females	Adult males
1984	66	2.91	42	1.23	49	44
1985	47	2.17	54	1.17	65	64
1986	45	2.32	43	1.00	68	65
1987	41	1.69	35	0.59	75	75
1988	38	1.75	39	0.68	45	44
1989	36	1.78	45	0.80	56	51
1990	26	1.49	37	0.56	46	45
Pre-management mean ± SD	43 ± 12	2.00 ± 0.49	42 ± 6	0.86 ± 0.28	55 ± 13	58 ± 12
1991	40	2.11	31	0.66	40	38
1992	77	2.98	22	0.65	50	49
1993	70	2.79	30	0.84	43	43
1994	64	2.91	42	1.23	47	43
1995	58	2.38	49	1.16	57	55
1996	70	3.00	31	0.93	59	57
1997	73	3.18	18	0.57	71	61
1998	82	2.61	34	0.88	42	49
1999	72	2.74	12	0.32	32	34
Management mean ± SD	68 ± 12	2.70 ± 0.34	30 ± 12	0.81 ± 0.29	48 ± 9	49 ± 12

[1]Percentages are rounded to the nearest whole percent.

[2]Numbers of adult plovers are rounded to the nearest whole number. Mean number of adults during the management phase excludes 1991.

(Table 3). The mean percentage of failed nests attributed to predators declined from 52% (SD ± 9%, N = 7 yrs.) in the pre-management phase to 36% (SD ± 17%, N = 9 yrs.; one-tailed t_{14} = 2.35, P < 0.02) during the management phase. The mean percentage of predator losses attributed to canines decreased from 73% (SD ± 27%, N = 7 yrs.) during the pre-management phase to 32% (SD ± 35%, N = 9 yrs.; one-tailed t_{14} = 2.52, P < 0.02) during the management phase. Other identified causes of nest loss included humans, environmental factors, nest abandonment, and non-viable clutches.

From the pre-management to the management phase, the mean percentage of nests lost to nest abandonment increased significantly, from 4% (SD ± 2%, N = 7 yrs.) to 8% (SD ± 5%, N = 9 yrs.), during the management phase (one-tailed t_{14} = 2.07, P < 0.05; Table 3). The mean percentage of nests lost to nest abandonment and accompanied by the mortality of an adult also increased significantly, from 1% (SD ± 1%, N = 7 yrs.) to 4% (SD ± 4%, N = 9 yrs.; one-tailed t_{14} = 2.04, P < 0.05; Table 3). During the management phase, less than half of all nests were exclosed but 76% of the 25 adult plovers that disappeared during incubation and were presumed dead (i.e., were never seen again) were nesting in exclosures. Thus, the number of instances of adult mortality in exclosures was greater than would be expected by chance (χ^2_1 with Haber correction = 7.0, P < 0.01). In most years, the cause of mortality of adults nesting in exclosures was unknown, but during a twelve-day period in April 1997, a Merlin (*Falco columbarius*) was observed predating one adult and suspected of predating eight other adults nesting in exclosures. Although exclosures were not randomly assigned to nests, they were used in areas where egg predators (e.g., canines, skunks, gulls) were active, rather than in areas with a greater abundance of all types predators. We believe, therefore, that assignment of exclosures relative to potential predators of adult plovers was unbiased.

Table 3. Causes of failure of Snowy Plover nests before (1984-1990) and during (1991-1999) predator management in central Monterey Bay, California.

				Causes of nest loss (%)[1]									
				Predators[2]						Abandonment[3]			
Year	Nests (N)	Ex-closed (%)	Failed (N)	Total	Canine	Other	Envi-ron-mental	Hu-mans	Non-viable	Total	Death	No death	Un-known
1984	77	0	25	60	27	73	4	16	0	16	25	75	4
1985	118	0	59	47	43	57	2	12	2	12	0	100	25
1986	129	0	72	56	85	15	1	24	0	4	100	0	15
1987	119	0	69	52	86	14	6	7	0	7	20	80	28
1988	80	0	49	51	76	24	4	4	0	6	33	67	35
1989	106	0	67	39	96	4	0	9	0	3	0	100	49
1990	99	0	74	61	96	4	7	8	0	4	0	100	20
Pre-management mean ± SD				52 ± 8	73 ± 27	27 ± 27	3 ± 2	11 ± 7	0 ± 1	7 ± 5	25 ± 36	75 ± 36	25 ± 14
1991	77	22	45	67	97	3	7	9	0	4	50	50	13
1992	73	90	21	38	50	50	24	5	0	33	43	57	0
1993	66	85	21	19	75	25	24	0	0	48	60	40	10
1994	74	68	29	17	0	100	34	28	7	10	33	67	3
1995	86	55	37	22	13	88	22	11	5	32	33	67	8
1996	94	37	29	52	13	87	24	0	3	17	0	100	3
1997	100	52	27	33	11	89	11	4	4	44	100	0	4
1998	65	14	12	50	0	100	33	0	0	8	100	0	8
1999	47	2	13	23	33	67	31	0	23	23	33	67	0
Management mean ± SD				36 ± 17	32 ± 35	68 ± 35	23 ± 9	6 ± 9	5 ± 7	25 ± 16	50 ± 33	50 ± 33	6 ± 5

[1]Percentages are rounded to the nearest whole percent.

[2]Canine and Other are expressed as percentages of total predator losses.

[3]Abandonment was subdivided into two categories; adults that were resighted and known to be alive (No death) and adults that were resighted and presumed dead (Death). Death and No death are expressed as percentages of total abandonment.

DISCUSSION

Protecting shorebird nests with exclosures at other locations has reduced the probability of nest predation (Deblinger *et al.* 1992; Melvin *et al.* 1992; Estelle *et al.* 1996; Johnson and Oring 2002; Murphy *et al.* 2003a). In this study, exclosures prevented the Red Fox and other nest predators from predating Snowy Plover eggs. Before exclosures were used, hatching rate of plover clutches in Monterey Bay was lower than after 1991, the first year of exclosure use. When nest predators were removed and exclosures subsequently phased out, hatching rate remained high, and a significant shift in the primary cause of nest loss occurred. Predators, particularly canines, caused the majority of nest losses before predator removal, but after removal efforts, nest losses primarily were attributed to other factors. Maintenance of a high hatching rate and reduced nest predation by canines indicates that abundance of egg predators in the study area was significantly reduced during the management phase. An alternative explanation, that predators avoided traps and were still abundant in the study area, is not supported by the increased hatching rate.

After predator removal began, hatching and fledging success were probably affected by different factors. Average fledging rate before management was comparable with rates reported by Warriner *et al.* (1986) and Page *et al.* (1995), but average fledging rate during the management phase was markedly lower. Before predator removal began, use of exclosures in 1991 and 1992 allowed large numbers of chicks to hatch into an environment where the Red Fox was probably abundant. Relatively low fledging rates during these two years may indicate that the Red

Fox was the primary cause of chick mortality that occurred when chicks left the protection of exclosures. Further evidence is provided by the increased fledging rate for each of the three years after mammalian predator removal began in 1993 (Table 2). After 1996, numbers of foxes were reduced, yet fledging rate decreased. In the later years of our study, predation of plover chicks by avian predators was identified as a likely factor affecting fledging success at one or more beach areas. In 1996, a shrike was seen taking a newly hatched chick from an exclosure. In 1998 and 1999, low fledging success at one area corresponded with the presence of hunting American Kestrels. In 1998 and 1999, a pair of Northern Harrier (*Circus cyaneus*) that nested within the central part of the study area were seen hunting over dunes where broods subsequently disappeared. Mammalian predator removal allowed more plover chicks to successfully hatch and avian predators were probably attracted to beach and foredune areas to forage by the presence of increased numbers of plover chicks.

Reproductive success is widely acknowledged to be a key component of population health but demographic models for the Piping Plover and the Snowy Plover are most sensitive to changes in adult survival rates (Plissner and Haig 2000; USFWS 2001). Thus, management techniques that may reduce adult survival rates should be carefully evaluated (Johnson and Oring 2000). In this study, adult plovers that nested in exclosures apparently were subject to greater mortality rates than adults nesting outside of exclosures, probably because avian predators were able to locate incubating Snowy Plovers within exclosures. Other studies have demonstrated that exclosures attract mammalian and avian predators to plover nest sites and cause mortality of incubating plovers (Nol and Brooks 1982; Johnson and Oring 2002; Murphy *et al.* 2003b). Moreover, we believe that some nest abandonment previously reported in exclosure studies may have been caused by adult mortality associated with exclosures (see Melvin *et al.* 1992; Vaske *et al.* 1994; Mabee and Estelle 2000). Larson *et al.* (2002) recommended the expanded use of exclosures for Piping Plovers but Murphy *et al.* (2003b) cautioned that the benefit of increased reproductive output should be carefully weighed against increased adult mortality rates resulting from use of exclosures.

In this study, exclosures and predator removal increased hatching, but not fledging success. Furthermore, the number of chicks fledged per male during the phase of intensive management was below 1.0, suggested for population stability (USFWS 2001). In addition, widespread use of exclosures may increase mortality rates of plovers nesting within exclosures. Although use of exclosures may significantly improve hatching success, exclosures should be used temporarily, sparingly, in combination with adaptive predator management and never without ongoing monitoring and evaluation. Predator management for threatened and endangered plovers must consider the full suite of species that impact both the eggs and chicks, and be adaptive to changes in the predator composition of an area. Monitoring only hatching rates may give a false impression of the effectiveness of management because techniques that increase hatching success may have no effect on fledging success. Monitoring programs for threatened and endangered plovers should include measures of hatching and fledging success, and survival rates of adults, so that the effect of predator management on all life stages can be fully assessed.

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LITERATURE CITED

Balser, D. S., H. H. Dill and H. K. Nelson. 1968. Effect of predator reduction on waterfowl nesting success. Journal of Wildlife Management 32: 669-682.

Burger, J. and M. Gochfield. 1994. Predation and effects of humans on island-nesting seabirds. Pages 39-67 *in* D. Nettleship, J. Burger, M. Gochfield (Eds.), Seabirds on Islands: Threats, Case-studies, and Action Plans. Birdlife International, Cambridge, England.

Côté, I. M. and W. J. Sutherland. 1997. The effectiveness of removing predators to protect bird populations. Conservation Biology 11: 395-405.

Deblinger, R. D., J. J. Vaske and D. W. Rimmer. 1992. An evaluation of different predator exclosures used to protect Atlantic coast piping plover nests. Wildlife Society Bulletin 20: 274-279.

Dowding J. E. and E. C. Murphy. 2001. The impact of predation by introduced mammals on endemic shorebirds in New Zealand: a conservation perspective. Biological Conservation 99: 47-64.

Duebbert, H. F. and J. T. Lokemoen. 1980. High duck nesting success in a predator-reduced environment. Journal of Wildlife Management 44: 428-437.

Estelle, V. B., T. J. Mabee and A. H. Farmer. 1996. Effectiveness of predator exclosures for pectoral sandpiper nests in Alaska. Journal of Field Ornithology 67: 447-452.

Harding, E. K., D. F. Doak and J. Albertson. 2001. Evaluating the effectiveness of predator control: the non-native red fox as a case study. Conservation Biology 15: 1114-1122.

Harvey, T. E., K. J. Miller, R. L. Hothem, M. J. Rauzon, G. W. Page and R. A. Keck. 1992. Status and trends report on wildlife of the San Francisco Estuary. San Francisco Estuary Project/USFWS, Sacramento, CA.

Hays, H. and M. LeCroy. 1971. Field criteria for determining incubation stage of the Common Tern. Wilson Bulletin 83: 425-429.

Jackson, D. B. 2001. Experimental removal of introduced hedgehogs improves wader nest success in the Western Isles, Scotland. Journal of Applied Ecology 38: 802-812.

Johnson, M. and L. W. Oring. 2002. Are nest exclosures an effective tool in plover conservation? Waterbirds 25: 184-190.

Jurek, R. M. 1992. Nonnative red foxes in California. Nongame Bird and Mammal Section Report 92-04. California Department of Fish and Game, Sacramento.

Larson, M. A., M. R. Ryan, and R. K. Murphy. 2002. Population viability of piping plovers: effects of predator exclosures. Journal of Wildlife Management 66: 361-371.

Lewis, J. C., K. L. Salee, and R. T. Golightly. 1993. Introduced red fox in California. Nongame Bird and Mammal Section Report 93-10. California Department of Fish and Game, Sacramento.

Mabee, T. J. and V. B. Estelle. 2000. Assessing the effectiveness of predator exclosures for plovers. Wilson Bulletin 112: 14-20.

Mayer, P. M. and M. R. Ryan. 1991. Electric fences reduce mammalian predation on nests and chicks. Wildlife Society Bulletin 19: 59-63.

Melvin, S. M., L. H. MacIvor and C. R. Griffin. 1992. Predator exclosures: a technique to reduce predation at piping plover nests. Wildlife Society Bulletin 20: 143-148.

Moors, P. J. and I. A. Atkinson. 1984. Predation on seabirds by introduced animals, and factors affecting its severity. International Council for Bird Preservation Technical Publication No. 2: 667-690.

Murphy, R. K., R. J. Greenwood, J. S. Ivan and K. A. Smith. 2003a. Predator exclusion methods for managing endangered shorebirds: are two barriers better than one? Waterbirds 26: 156-159.

Murphy, R. K., I. M. G. Michaud, D. R. C. Prescott, J. S. Ivan, B. J. Anderson and M. L. French-Pombier. 2003b. Predation on adult piping plovers at predator exclosure cages. Waterbirds 26: 150-155.

Nol, E. and R. J. Brooks. 1982. Effects of predator exclosures on nesting success of killdeer. Journal of Field Ornithology 53: 263-268.

Page, G. W., J. S. Warriner, J. C. Warriner and P. W. Paton. 1995. Snowy Plover (*Charadrius alexandrinus*). No. 154 *in* A. Poole and F. Gill (Eds.), The Birds of North America. The Academy of Natural Sciences, Philadelphia, and the American Ornithologists Union, Washington, D.C.

Parker, M. W. and J. E. Takekawa. 1993. Salinas River National Wildlife Refuge Predator Management Plan and Final Environmental Assessment. Unpublished Report, USFWS, Newark, CA.

Plissner, J. H. and S. M. Haig. 2000. Viability of piping plover *Charadrius melodus* metapopulations. Biological Conservation 92: 163-173.

Priddel, D. and R. Wheeler. 1997. Efficacy of fox control in reducing the mortality of released captive-reared malleefowl, *Leipoa ocellata*. Wildlife Research 24: 469-482.

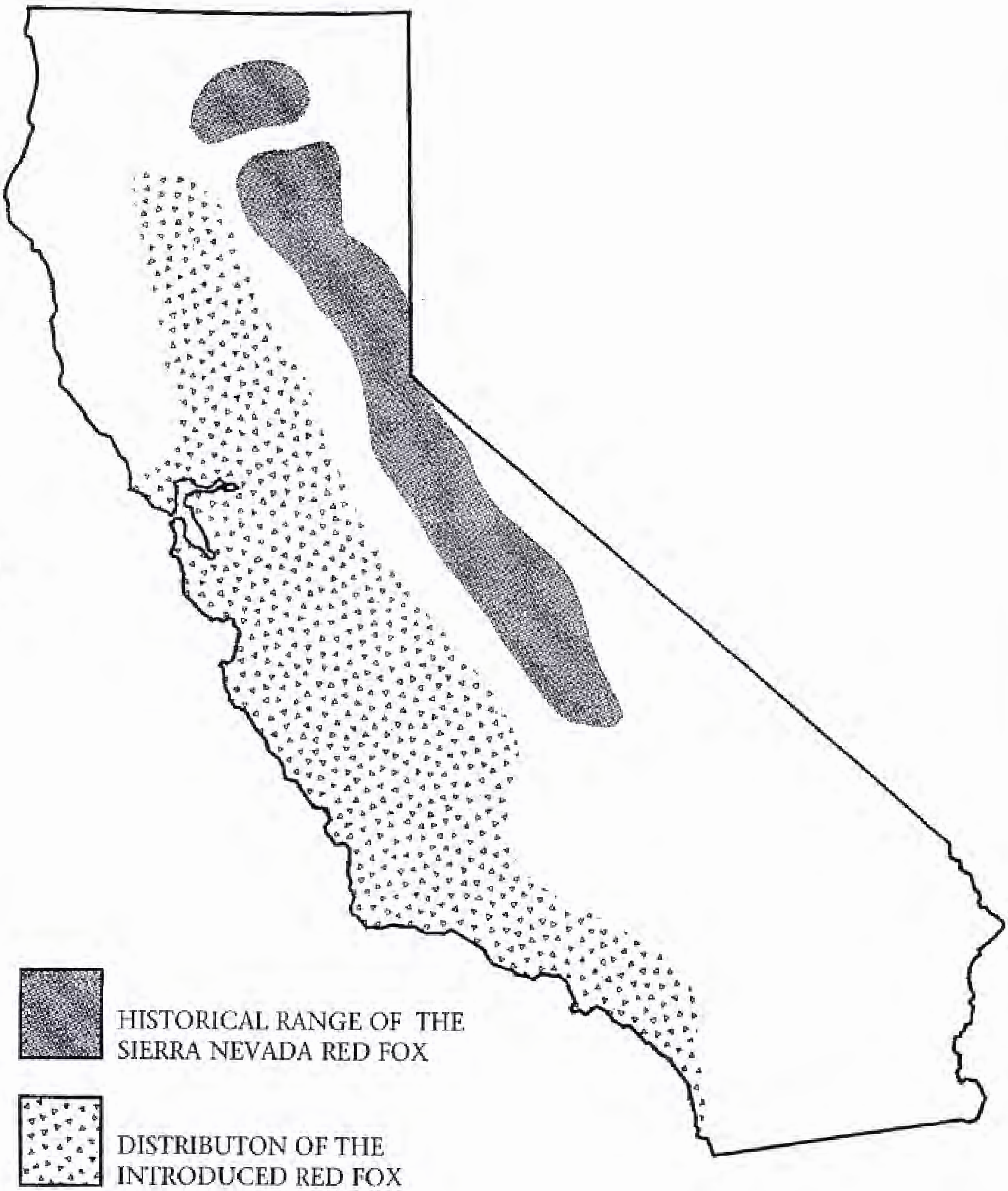
Rimmer, D. W. and R. D. Deblinger. 1990. Use of predator exclosures to protect piping plover nests. Journal of Field Ornithology 61: 217-223.

U.S. Fish and Wildlife Service. 2001. Western Snowy Plover (*Charadrius alexandrinus nivosus*) Pacific Coast Population Draft Recovery Plan, Portland, OR.

Vaske, J. J., D. W. Rimmer and R. D. Deblinger. 1994. The impact of different predator exclosures on piping plover nest abandonment. Journal of Field Ornithology 65: 201-209.

Warriner, J. S., J. C. Warriner, G. W. Page and L. E. Stenzel. 1986. Mating system and reproductive success of a small population of polygamous snowy plovers. Wilson Bulletin 98: 15-37.

Red Fox Range Map



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Evaluating the ecological and behavioural factors influencing Snowy Plover *Charadrius nivosus* egg hatching and the potential benefits of predator exclosures

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Summary

An understanding of the ecological factors influencing nest success and the effectiveness of management activities focused on improving nest success can be critical to successful conservation strategies for rare or declining species. Over seven breeding seasons (2006–2012) we examined the influence of nest spacing and habitat characteristics on hatching success for the nationally threatened Pacific coast population of the Snowy Plover *Charadrius nivosus* in coastal Washington, USA in two study areas. Specifically, we assessed the influence of clutch age, nesting season date, distance to conspecific nests, perpendicular distance to the high-tide (wrack) line, vegetation cover and other habitat characteristics at three spatial scales ($1 m^2$, $5 m^2$, and $25 m^2$) centred on the nest. We also assessed the effectiveness of wire mesh cages placed around nests to exclude mammalian and avian nest-predators. We discovered and monitored 307 nests, placed predator exclosures around 142 of these nests and measured habitat variables at 251. Our selected base model included site and quadratic function of season-date. For the analysis examining habitat effects on nest success, only models with distance to nearest active nest ranked higher than the baseline model even when removing the nests that were very distant from conspecific nests (outliers). For these unexclosed nests, predation was the primary source of nest failure and crows and ravens were apparently the primary nest predators. Predator exclosures had a clear positive influence on nest survival. Even though we observed a positive exclosure effect, we recommend that they be used cautiously because we and others have observed adult mortality associated with exclosures. Regardless of the spatial scale, Snowy Plovers are primarily using nest sites with little vegetation, shell or woody material cover suggesting the need for large expanses of very sparsely or unvegetated habitats that allow birds to nest semi-colonially (with near neighbours).

Introduction

When attempting to identify the mechanisms responsible for population declines, conservation biologists often employ modelling approaches to first identify the relative importance of different vital rates (fecundity and survival) to declines (Ryan *et al.* 1993, Wisdom *et al.* 2000, Fieberg and Ellner 2001, Camfield *et al.* 2011) and then attempt to identify the mechanisms responsible for the depressed vital rate(s). With this approach, managers can employ management actions most likely to reverse negative trends (Table 1). For birds, adult and juvenile survival is often difficult to influence through management (Porneluzi and Faaborg 1999, Anders and Marshall 2005, Knutson *et al.* 2006, Camfield *et al.* 2011) and annual fecundity is relatively easy (Camfield *et al.* 2011). As a result, it is often the target of conservation actions.

Table 1. Examples of management targets and activities intended to improve plover/shorebird fecundity and/or survival *in situ* (not including translocations, introductions or conspecific attractions).

Target	Example of specific targets	Impact on shorebird	Examples of management activities	Examples of literature
Human activities	Walking, dog walking, horseback riding, kite flying, sand/dune boarding, driving, noise, etc.	Flushing (from nest, roosting location, or foraging), crushing of eggs, chicks or adults	Education (pamphlets, videos, signing, press releases); access restrictions (signing, roped off areas, fencing); activity restrictions (e.g., no dogs, dogs on leash only, no driving).	Schultz and Stock 1993, Dowling and Weston 1999, Ruhlen *et al.* 2003, Lafferty *et al.* 2006, Weston and Elgar 2007, Wright *et al.* 2010, Weston *et al.* 2011, Weston *et al.* 2012, McLeod *et al.* 2013, Webber *et al.* 2013
Human debris	Synthetic fibres	Leg injuries, leg loss, or entrapments	Free entangled bird, beach cleanups to remove synthetic fibres	Melville 1982, Briggs 1984, Lewin *et al.* 2006, Weston *et al.* 2009
Predators	Corvids, raptors, feral dogs and cats, coyotes, foxes, etc.	Flushing, predation of adults, chicks, eggs	Predator capture and removal, killing, harassing, aversion conditioning, predator exclosures (e.g. fencing and caging), removing predator food sources, removing predator perches	Dowding and Murphy 2001, Neuman *et al.* 2004, Isaksson *et al.* 2007, Andersson *et al.* 2009, Maguire *et al.* 2009, Smith *et al.* 2010, 2011
Habitat loss or degradation	Change in habitat structure and function caused by human activities (e.g., off road vehicles, beach raking), invasive plants or changes in primary disturbance factors; direct loss of habitat due to human development	Reduces available habitat or creates unsuitable or less suitable conditions for reproduction, foraging and self-maintenance	Habitat acquisition or protection, habitat improvement (e.g. use of herbicides or hand pulling to remove or reduce cover of invasive plant species), manipulation of beach topography, adding cover to improve reproduction, etc.	Zarnetske *et al.* 2010, Catlin *et al.* 2011, Maguire *et al.* 2011, Webber *et al.* 2013

Low fecundity is often a source of population declines in birds (Nagy and Holmes 2004) and predation of eggs and nestlings is the major cause of nest failure (Ricklefs 1969, Martin 1992). To reduce predation rates, managers can use techniques that change predator behaviour, reduce their numbers, or prevent them from accessing nests, chicks and/or adults (Table 1). Alternatively, managers can manipulate habitat to create conditions that have lower predation rates. For some species there is an apparent relationship between habitat characteristics and nest success (e.g. Newton 1998, Willson *et al.* 2001). When this relationship exists, an understanding of those factors can provide critical information for conservation efforts such as habitat restoration (e.g. Catlin *et al.* 2011).

Genetic research indicates that the Snowy Plover *Charadrius nivosus* is a separate species from the Kentish Plover *Charadrius alexandrinus* (Küpper *et al.* 2009) and now both the International

Ornithologists' Union (Gill and Donsker 2014) and American Ornithologists' Union (Chesser *et al.* 2011) recognise them as separate species. The IUCN Red List of Threatened Species has not separated these two species and considers the Kentish Plover *Charadrius alexandrinus* to be a species of "Least Concern" with a "decreasing population" (IUCN 2014). The United States Pacific coastal population of the Snowy Plover is listed as Threatened under the U.S. Endangered Species Act, and is listed as endangered, threatened, or a species of special concern by several states, including the states of Washington, Oregon, and California (see USFWS 1993, Page *et al.* 2009). This coastal population extends from Midway Beach, Washington, to Bahia Magdalena, Baja California, Mexico. According to the U.S. Fish and Wildlife Service (USFWS 2007), "Habitat degradation caused by human disturbance, urban development, introduced beachgrass *Ammophila* spp. and expanding predator populations have resulted in a decline in active nesting areas and in the size of the breeding and wintering populations". Population modelling indicates that intensive management is needed to prevent continued population declines and suggests the goal of fledging 1.2 chicks per adult male per year to achieve a growing population (Nur *et al.* 1999). This goal can be accomplished through management activities that improve both hatching success and early chick survival (fledging is defined as surviving 28 days post-hatching).

Because most Snowy Plover nest failures are a result of predation (Wilson-Jacobs and Meslow 1984, Wilson-Jacobs and Dorsey 1985, Powell 2001, Page *et al.* 2009, Colwell *et al.* 2005, 2010, Saalfeld *et al.* 2011), we would expect plovers to select nest sites with characteristics that mitigate predation risks. For example, nests can be placed adjacent to objects (Page *et al.* 1985) or vegetation (Amat and Masero 2004) that helps conceal nests or by selecting substrates that are naturally concealing (Page *et al.* 1985, Colwell *et al.* 2005, 2011). Alternatively, birds can adjust spacing patterns between conspecifics (Page *et al.* 1983) to reduce nest predation. Colonial or semi-colonial nesting results in more eyes detecting predators and moving away from nests early thereby making it difficult for the predator to locate nests or it may result in more birds responding to a potential nest predator with distraction flight and vocal displays.

In an attempt to identify habitat conditions that might affect Snowy Plover egg hatching success, we examine the influence of nest spacing and habitat characteristics on hatching success in coastal Washington, USA using variables measured over a seven-year period in two study areas. Unlike most studies to date, we include nest exposure (number of days nests were exposed to potential nest failure), season date, and vegetation structure (but see Hardy and Colwell 2012). We also evaluate the effects of vegetation structure at three spatial scales, perpendicular distance from each nest to the high tide (wrack) line, distance to the nearest active nest, and whether or not the nest was in the habitat restoration area (area cleared of vegetation and where oyster shells were added to the surface) on nest success. This statistical approach allows us to evaluate the relative influence of site, season, and various habitat characteristics at different spatial scales on overall nest success and on predation rates specifically. Finally, we evaluate the influence of an ongoing conservation activity, mesh wire cages (predator exclosures), placed around nests to exclude potential mammal and bird nest-predators, on egg hatching success.

Methods

Study species

In Washington, Snowy Plover clutch initiation may occur as early as late-March and as late as late July, but most nests are initiated from mid-April through mid-July. Complete confirmed clutch sizes ranged from one to four eggs. The two one-egg clutches that we observed in this study are apparently unusual (Warriner *et al.* 1986, Page *et al.* 2009) but the nest scrapes were discovered prior to egg-laying and both consistently contained one egg that ultimately hatched. Snowy Plover young are precocial and leave the nest within hours of hatching. Snowy Plovers will re-nest after loss of their eggs.

Study sites

We monitored Snowy Plover nests from 2006 to 2012 at three study areas along the Pacific coast of Washington, USA: (1) Midway Beach (near Grayland; 46°45′60″N, 124°06′10″W), (2) Graveyard Spit (North Cove; 46°42′57″, 124°01′25″), and (3) Leadbetter Point (Long Beach Peninsula; 46°38′00″, 124°04′10″). We combined Graveyard Spit with Midway Beach for our analyses below and collectively refer to them as "Midway Beach" because these areas are: 1) very close to each other (approximately 4 km), 2) birds fly back and forth throughout a given nesting season, and 3) because of small sample sizes and irregular nesting at Graveyard Spit. The resulting two study sites, Leadbetter Point and Midway Beach, are dune backed beaches that have an exceptionally wide area between the mean high tide and the foredune that is unvegetated or sparsely vegetated relative to the adjacent linear sandy beaches of the Washington coast. The Snowy Plover habitat at Midway Beach located on the outer coast and north shore of Willapa Bay consists of hummocks and swales, sparsely vegetated foredunes, and a large deflation plain with ephemeral dune ponds (dune feature terminology follows Wiedemann 1984). Leadbetter Point along the outer coast of Washington is part of a very long sand spit or peninsula. The habitat at Leadbetter Point consists of unvegetated beach above the summer high tide line, sparsely vegetated foredunes, blowouts, and a 49 ha "habitat restoration area". The habitat restoration area is located landward of the primary foredune and was restored to improve Snowy Plover habitat but also conditions for other native plants and animals. The restoration area was: (1) re-contoured with large machinery to knock down the steep foredune and to create an relatively flat open site dominated by sand, (2) non-native American and European beach grasses *A. arenaria* and *A. breviligulata* were sprayed with herbicide to reduce their cover on a nearly annual basis, and (3) oyster shell was spread across much of the site to help hold the sand in place and presumably to provide crypsis for Plover eggs, brooding adults, and young of the year.

Nest searching and monitoring

We visited all active study sites 3–6 times a week from late-March/early-April until mid-September to search for and monitor Snowy Plover nests. In most cases, we located nests by following Plover tracks to nests. We also located nests by observing males creating conical depressions in the sand known as "scrapes", by locating adults incubating eggs, or by flushing incubating adults. We recorded date and status (presence of adults and eggs) of each nest approximately every 3–5 days to assess outcome. Unless observed directly, we calculated clutch initiation date by: backdating from known laying or hatching dates (Weston and Elgar 2005) or by using the egg floating technique (Hays and LeCroy 1971, Dunn *et al.* 1979, Rizzolo and Schmutz 2007) in the cases of nests discovered with completed clutches. Backdating using hatch dates requires information on the time intervals associated with the egg laying and incubation stages. We used the following time intervals from California and reported in Page *et al.* (2009) to calculate clutch initiation dates: egg laying = 2.5 days between laying egg 1 and 2 and 2.3 days between laying eggs 2 and 3, incubation = 27 days or 32 days from the first egg laid until hatching. We defined a "successful nest" as a nest with at least one chick leaving the nest cup after hatching. For unsuccessful nests, we attempted to determine the source of failure and reported the nest as lost to predation (and predator species if possible), abandoned, covered by drifting sand, lost to human activities (crushed by vehicles, walking, horseback riding, or eggs removed), or unknown source of failure. In nearly all cases, we identified suspected predators by tracks left in the sand. In only a couple of cases we observed the predation event. Not all adult plovers were banded and, as a result, we cannot control for multiple nests by the same individuals within or between seasons in the analyses that follow. Even if one or more individuals are associated with more than one nest, it is very unlikely that the nest would be placed in the exact location as the previous nest and they are therefore making a new decision on where to nest.

Exclosures

We placed open-bottom cuboid shaped (1.2 m long x 1.2 m wide x 0.9 m high) wire-mesh (5 x 10-cm) cages around some nests to exclude larger bird and mammal nest-predators. We used the "mini-exclosure" design commonly used for Snowy Plovers (Lauten *et al.* 2004, Hardy and Colwell 2008) because the wire mesh size excludes most bird nest-predators while still allowing ingress and egress by Snowy Plovers and because nest cages have a greater effect on hatching success than exclusion fences (Smith *et al.* 2011). These predator exclosures are portable and can be set up rapidly (10–15 min) with minimal disturbance to the birds. We placed stakes (~17 cm in length) at each corner and at the margins of exclosures to hold them in place. No clutches were exclosed until they were complete and being incubated (average = day 7 of incubation, range = day 2–12). Exclosures were placed as a management action and did not include all of the factors one would like to see in a rigorous experimental design testing their effectiveness (e.g. Pearson *et al.* 2012). However, our modelling approach accounts for potential site, date, exposure, and habitat restoration area effects, as described below. Predator exclosures were placed around nests after shorebird migration (falcon abundance is higher during migration and falcons use exclosures as perches and to help them locate adult plovers) in areas with particularly high predation rates and areas where they would not attract people to the nests.

Habitat assessment

We visually estimated the percentage cover of the following habitat variables within 1 m², 5 m², and 25 m² plots centred on the nest: bare ground (primarily sand), shell, wood, grass (primarily non-native beachgrass and native American dune grass *Leymus mollis*), all other vegetation, and dead vegetation (primarily grass thatch). For each cover variable measured, we assigned it one of the following cover categories at each spatial scale: 0 = < 1 % cover; 1 = 1–5 %; 2 = 6–25 %; 3 = 26–50 %; 4 = 51–75 %; 5 = 76–95 %; 6 = 96–100 %. In addition, we measured the perpendicular distance from the nest to the wrack line in meters (a measure of how far inland the nest was from the high tide line) and distance to the nearest active nest in meters (an indication of proximity to other nests). We also included a large-scale modified habitat variable – inside or outside the habitat restoration area.

Statistical analyses

To examine the effects of habitat variables on nest survival, we used the logistic exposure method (Stephens 2003, Shaffer 2004, Rotella *et al.* 2004, Stephens *et al.* 2005). We ran analyses in SAS PROC NLMIXED (SAS 2007). The SAS code used follows Rotella *et al.* (2004, appendix 4). We used the effective sample size ("n_{ess}"; Rotella *et al.* 2004) when computing AIC_c (n_{ess} equals the sum, over all nests, of the number of days each nest was under observation and survived, plus the number of observed failures).

Before testing for habitat and exclosure effects on nest survival, we first established a baseline model. For this analysis, we used only observations without exclosures. In addition to a null (intercept-only) model we tested the following variables for our candidate baseline model: nest age (linear and quadratic functions), season date (linear and quadratic functions, where 1 April was considered season date 0 for each year), a fixed effect of site (Leadbetter = 1, Midway Beach = 0), and a random year effect. Nest age is the age of the nest in days with 1 = the day the first egg was laid and 32 = hatch date. We never included nest age and season date in the same model as these would be highly correlated. Because we were including quadratic effects of season date and nest age, we also tested models where nest age and season date were centred. Nest age was centred by subtracting 15.5 (making 0 the midpoint the incubation period). Season date was centred using two methods: by subtracting the median season date over all years from observed values, 77 ("Median Date") and also by subtracting the median clutch initiation date for the observation year plus the 15.5 ("Median Initiation"). Because nest age was not available for all nests, we could not compare models with and without nest age for all data. Therefore we created two subsets of data for the purpose of choosing a baseline model: We compared all models without nest age using the full set of non-exclosed nests (n_{ess} = 1,832). We also compared all models using the subset of non-exclosed nests that included nest age (n_{ess} = 1,731).

Once we had selected our baseline model (site + a quadratic function of season-date), we tested models with the baseline plus each of the following: (1) all cover variables at 1 m^2, (2) all cover variables at 5 m^2, (3) all cover variables at 25 m^2, (4) distance to wrack line (high tide, meters), (5) whether or not the nest was in the habitat restoration area (HRA), (6) distance to the nearest active nest (DNN; meters), and (7) distance to the nearest active nest plus an interaction effect of distance to nearest active nest and nest site. For these analyses, we used only observations without exclosures and only nests for which we had all the habitat variables (n_{ess} = 1039). Because there were a few outliers with distance to nearest nest (see Results), we also ran the models excluding distance to nearest nest >1,000 m (n_{ess} = 993).

We examined the effects of habitat on whether a nest survived or failed specifically due to depredation and whether exclosures were effective. For the depredation analysis, we used the same approach as when examining habitat effects on overall nest survival. However, here we subset the data to only nests that survived to hatching or failed due to depredation (n_{ess} = 818). We removed nests that failed due to abandonment, human-related causes, sand, or unknown causes from this analysis. Finally, to assess the effectiveness of exclosures, we compared the baseline model to the baseline model + exclosure effect + an exclosure-by-site interaction effect. For this analysis we included all observations (n_{ess} = 4,483).

Results

Across the two sites and seven years (2006–2012), we discovered 307 nests that were monitored for more than one day: 154 nests at Midway Beach and 153 nests at Leadbetter. Number of nests ranged from 10 to 29 per site per year with similar numbers per year. Of the 307 total nests, 142 were exclosed and we measured habitat variables at 251 nests (no habitat variables were measured in 2006). Of the nests where we measured habitat variables, we also measured distance to the nearest active conspecific nest at 165 nests. Because of these sample size differences, the number of nests included in each analysis below varies.

When looking at outcomes of unexclosed nests only, there was a higher percentage of unknown failures at Leadbetter (Table 2), there were more abandonments and human caused failures at Midway Beach and the only identified predators (based primarily on tracks) were crows (American Crow *Corvus brachyrhynchos* or Northwestern Crow *C. caurinus*), Common Raven *Corvus corax*, and coyote *Canis latrans*; Table 2. For the predation events where the predator was indirectly identified, corvids comprised approximately 90% of those events (Table 2). We only observed depredation by crows and coyotes at Midway Beach and we observed depredation by Common Ravens at both sites (Table 2).

Selecting the baseline model: Using the subset of data that included only observations with nest-age, the top models included Site and quadratic season-date (there was no difference between the model with centred age date (Median Date) and non-centred date) (Table 3). The next highest ranked models included Site and quadratic nest-age (delta-AIC_c = 1.678; there was no difference between the model with centred age and non-centred age). All other models we examined had delta-AIC_c > 2.

Using the subset of data that included observations with and without nest-age, the top models included Site and quadratic season-date (there was no difference between the model with centred date, Median Date and non-centred date; Table 4). The next highest ranked model (delta AIC_c = 1.068) had site and centred (Median Initiation) quadratic season-date. All other models had delta AIC_c > 2. None of these comparisons included models with nest-age. Because the models with season-date were highly competitive to the models with nest-age and because using season-date instead of

Table 2. Counts by nest outcome category (percent within column) of all unexclosed nests at Leadbetter and Midway Beach, WA, USA (2006–2012). In addition, we also provide counts (percent within column) by predator of all unexclosed, depredated nests. In nearly all cases, the predator was identified by tracks left at the nest. Note: "Sand" = nest buried by sand; "Human" = human caused failure including stepped on, crushed by horseback riders, and crushed by a vehicle; "Unknown failure" indicates that the nest failed (eggs disappeared) but could not have hatched based on date and the cause of the failure was undetermined; "Corvid" = tracks in the sand were consistent with corvid but we could not determine the species.

Outcome	Leadbetter	Midway
Successful hatch	5 (14)	36 (28)
Depredated	9 (26)	53 (41)
Sand	5 (14)	10 (8)
Abandoned	1 (3)	8 (6)
Human	0 (0)	4 (3)
Unknown failure	11 (31)	19 (15)
Unknown outcome	4 (11)	0 (0)
	Depredated nests only	
Predator	Leadbetter	Midway
Crow	0 (0)	8 (15)
Raven	2 (22)	15 (28)
Corvid	4 (44)	14 (26)
Coyote	0 (0)	5 (9)
Unknown predator	3 (33)	11 (21)

nest-age would allow the inclusion of more data, we chose to include quadratic season-date (non-centred) and site in our baseline model. In general, early season nests and nests on Leadbetter Point survive poorly relative to late season nests and nests at Midway Beach (Figure 1).

Habitat effects on nest survival: Of the models with habitat variables, none performed better than the baseline model except for the models with distance-to-nearest-nest (Table 5). The model

Table 3. AICc table for choosing baseline model using only nests with nest age data and observations without exclosures ($n_{ess} = 1{,}731$). The two models with site and season date centered and non-centered were equally supported.

Model	k	AICc	Delta AICc
Quadratic Season Date + Site	4	503.726	0.000
Quadratic Centered Season Date (Median Date) + Site	4	503.726	0.000
Quadratic Nest Age + Site	4	505.404	1.678
Quadratic Centered Nest Age + Site	4	505.404	1.678
Quadratic Centered Season Date (Median Initiation) + Site	4	505.739	2.013
Centered Season Date (Median Initiation) + Site + Year	4	506.009	2.283
Quadratic Centered Nest Age	3	506.447	2.721
Centered Nest Age	2	506.511	2.785
Centered Season Date (Median Initiation)	2	506.751	3.025
Quadratic Nest Age + Site + Year	5	507.409	3.683
Quadratic Centered Nest Age + Site + Year	5	507.409	3.683
Quadratic Centered Season Date (Median Initiation) + Site + Year	5	507.734	4.008
Quadratic Centered Season Date (Median Initiation)	3	508.279	4.553
Quadratic Season Date (Median Initiation) + Site + Year	5	512.397	8.671
Quadratic Centered Season Date (Median Date) + Site + Year	5	512.438	8.712
Quadratic Centered Season Date (Median Initiation) + Year	4	516.488	12.762
Site	2	524.772	21.046
Site + Year	3	526.545	22.819
intercept-only	1	527.251	23.525
Year	2	529.190	25.464

Table 4. AICc table for choosing baseline model using only observations without exclosures and including nests with and without Nest Age (n_{ess} =1,832). Because we include nests both with and without Nest Age, there are no models with Nest Age in this table. The best supported models include Quadratic Centered (and non-Centered) Season Date and Site.

Model	k	AICc	Delta AICc
Quadratic Centered Season Date (Median Date) + Site	4	586.069	0.000
Quadratic Season Date + Site	4	586.069	0.000
Quadratic Centered Season Date (Median Initiation) + Site	4	587.137	1.068
Quadratic Season Date (Median Initiation) + Site + Year	5	595.410	9.341
Quadratic Centered Season Date (Median Initiation)	3	597.005	10.936
Centered Season Date (Median Initiation)	2	597.258	11.189
Quadratic Centered Season Date (Median Date) + Site + Year	5	597.375	11.306
Centered Season Date (Median Initiation) + Site + Year	4	597.528	11.459
Quadratic Centered Season Date (Median Initiation) + Site + Year	5	597.985	11.916
Quadratic Centered Season Date (Median Initiation) + Year	4	599.009	12.940
Site	2	609.103	23.034
Site + Year	3	610.806	24.737
intercept-only	1	620.037	33.968
Year	2	621.965	35.896

with distance-to-nearest-nest and a distance-to-nearest-nest × site interaction effect ranked highest, followed by the model with distance-to-nearest-nest without the interaction effect (delta AIC_c = 1.630). The baseline model followed with delta AIC_c = 4.239. The remaining models all had delta AIC_c > 6. Whether or not we include the outliers, nests with close neighbours are more successful than nests more distant from their nearest neighbour and nests located on Midway Beach are more successful than those located on Leadbetter (Figure 2). This analysis includes all successful (hatched) and unsuccessful nests regardless of the cause of failure (depredated, abandoned, buried by drifting sand, crushed by horses, etc.) but does not include exclosed nests.

Even though we found no effect of habitat variables on nest success, plovers appear to use nest sites with specific characteristics. Looking at natural sites outside the habitat restoration area (Midway and Graveyard) there was very little cover of any type near nests (Figure 3). For example, at the 1 m^2 scale 90% of the nests had < 5% shell cover, and 80% had < 5% wood and live vegetation cover (Figure 3). Oyster shell was added at Leadbetter to improve nest crypsis and to help hold sand in place, thus percent shell cover was considerably higher at Leadbetter than at Midway Beach (Figure 3) yet there was no effect on nest success. At the 25 m^2 scale, the percent vegetation cover increases considerably relative to the 1m^2 but it remains generally < 25% cover (Figure 3).

Habitat effects on nest depredation: For the analysis examining habitat effects on nest depredation (including successful and depredated nests only), only models with distance-to-nearest-nest ranked higher than the baseline model (Table 6). Here the model with distance-to-nearest-nest and the distance-to-nearest-nest × site interaction ranked second (delta AIC_c = 0.503) behind the model without the distance-to-nearest-nest × site interaction. Again, the baseline model ranked third (delta AIC_c = 1.364) and the models with all other habitat variables had delta AIC_c > 2.

Predator exclosures: Exclosures had a substantial positive influence on nest survival (Figure 1). The model that included the baseline variables plus exclosures was far superior to the baseline model (delta AIC_c = 78.510).

Discussion

A number of studies have found Snowy Plover nesting success to vary greatly depending on location and year (Page *et al.* 1983, 1985, 2009, Wilson-Jacobs and Meslow 1984, Powell 2001, Colwell *et al.* 2005, 2010). Similarly, we found site differences in nest survival but little evidence for a year

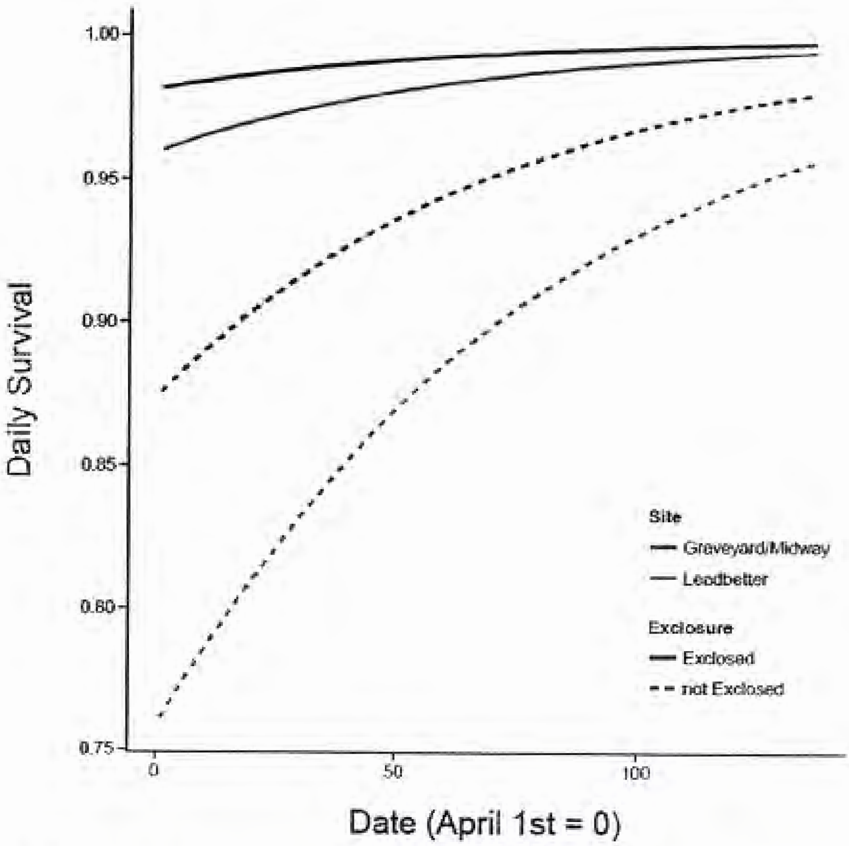

Figure 1. Relationship between nesting season date and daily survival rate for nests on Midway Beach (Black) and Leadbetter (Gray) for nests with (solid) and without exclosures (dashed) (2006–2012). For nests without exclosures (dashed), we used the baseline model and for nests with exclosures we used baseline + exclosure.

effect despite seven years of nest monitoring; nest success at Leadbetter was consistently lower than Midway Beach. Differences in nest success among sites can be influenced by a variety of factors including predator abundance and composition, food availability, natural events (e.g. drifting sand and high tides), and nest disturbance and destruction by human activities (Dowling and Weston 1999). Throughout much of coastal California, Oregon and Washington, egg predation is

Table 5. AICc Table for comparing models with habitat variables for all nest success vs. failure (n_{ess} = 1039). Includes only nests without exclosures and without missing habitat variables or distance to nearest nest values. Includes distance to nearest nest outliers (see text). DNN = Distance to Nearest Active Nest, HRA = Habitat Restoration Area.

Model	k	AICc	Delta AICc
baseline + DNN + DNN×Site	6	323.235	0.000
baseline + DNN	5	324.865	1.630
baseline	4	327.475	4.239
baseline + Distance to Wrack	5	329.373	6.137
baseline + HRA	5	329.452	6.216
baseline + 1 m² Cover Variables	9	334.549	11.314
baseline + 5 m² Cover Variables	9	336.536	13.301
baseline + 25 m² Cover Variables	9	337.217	13.981

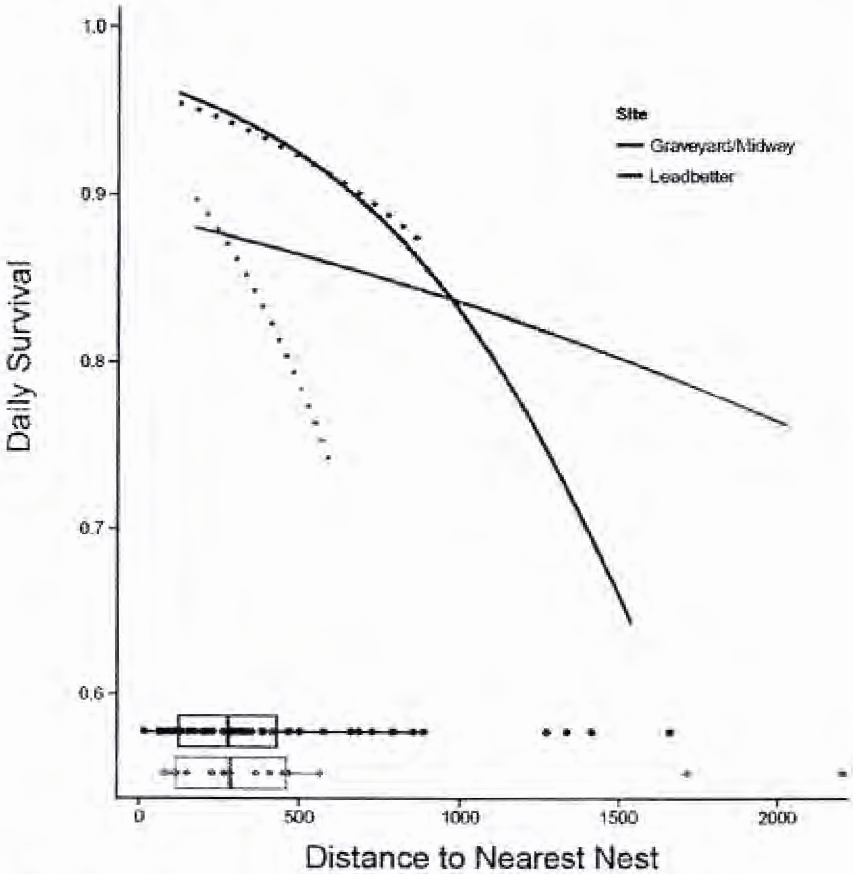

Figure 2. Relationship between distance to nearest active nest (DNN) and daily survival rate at Midway Beach/Graveyard Spit and Leadbetter (2007–2012) for the model: baseline + DNN + DNN-by-site interaction. Daily survival rate was calculated for day = 68.5 (the midpoint of the season). Solid lines include outliers and dotted lines do not. Boxplots below the curves show the distribution of DNN for each site.

the primary source of Snowy Plover nest failure and ravens and crows are the primary predators (Wilson-Jacobs and Meslow 1984, Wilson-Jacobs and Dorsey 1985, Powell 2001, Colwell *et al.* 2005, 2010, Burrell and Colwell 2012). In addition, Plover nest and fledging success negatively correlates with raven activity (Burrell and Colwell 2012). In our study, we also found predators to be the primary source of egg loss and indirect evidence (primarily tracks left at depredated nests) identified ravens and crows as the primary egg predators (Table 2). As indicated by Burrell and Colwell's (2012) nest camera study, the rate of predation by corvids may be much higher than suggested by our data because some of the predation events, where we could not attribute the event to a specific predator, may be the result of raven or crow predation.

Regardless of site, nest success improved as the season progressed. Seasonal variation in nest success is not uncommon in birds. Some studies have reported increases in predation rates as the nesting season date increases (Wiebe 2003, Grant *et al.* 2005, Muller *et al.* 2005, Kroll and Haufler 2009), while others have reported seasonal decreases (Davis 2005, Brown and Roth 2002, Winter *et al.* 2005). These patterns can be driven by seasonal changes in vegetation structure resulting in better nest concealment (Hartley and Shepherd 1994, Winter *et al.* 2005, Borgmann *et al.* 2013), or by seasonal changes in the diet, abundance or behaviour of nest predators (Nolan 1963, Roseberry and Klimstra 1970, Wilson *et al.* 2007, Grant *et al.* 2005, Hardy and Colwell 2012,

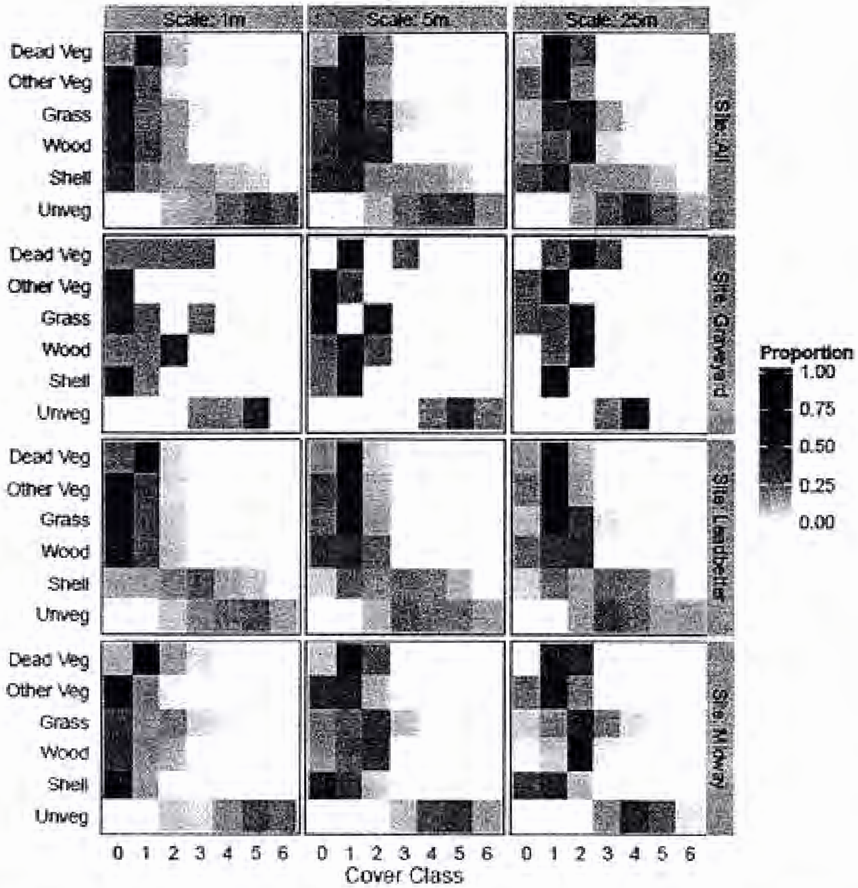

Figure 3. Proportion of nests that fell into each cover type-scale-site combination. Sites = Leadbetter, Midway Beach, and Graveyard Spit; scales = 1 m^2, 5 m^2, and 25 m^2 rectangular plots centered on the nest; cover classes = dead vegetation, grass and other live vegetation, wood, shell, and unvegetated ground (sand); and cover classes: 0 = < 1 % cover, 1 = 1-5%, 2 = 6-25%, 3 = 26-50%; 4 = 51-75%; 5 = 76-95%; 6 = 96-100%. Within a box (scale), the proportions will sum to one across a row. Note that Leadbetter includes a habitat restoration area where oyster shell was added and non-native beach grasses *Ammophila* spp. were killed to improve nest crypsis and site suitability respectively.

Borgmann *et al.* 2013). Given that the percentage cover of vegetation adjacent to the nest is extremely sparse at our study sites (generally 0–5%; Figure 3) and what little vegetation that exists is dominated by perennial grasses that have year-round foliage, it is unlikely that seasonal changes we observed are due to better concealment later in the season. Instead, these changes may be due, in part, to changes in predator behaviour (alternative food resources) and/or better weather conditions later in the nesting season.

Distance to nearest active nest had a positive effect on nest success in our study and the slope of this relationship is quite steep even after removing the outliers (Figure 2). Some have suggested that Snowy Plovers nest semi-colonially (territorial birds aggregating at low densities) to reduce predation rates (Powell 2001, Saalfeld *et al.* 2012, Patrick 2013). Increased vigilance driven by higher plover densities (more eyes looking) is thought to increase nest survival in semi-colonial nesting birds (Brown and Brown 2001, Varela *et al.* 2007). Alternatively, apparent semi-colonial nest clustering may be driven by patchy habitat (Brown and Brown 2001) and it is difficult to separate these two potential mechanisms for nest clustering. Suitable Snowy Plover

Table 6. AIC_c table for Hatch vs. Depredated. n_{ess} = 818 (Data subset = 7; does not exclude nests with outlier DNN). DNN = Distance to Nearest Neighbour, and HRA = Habitat Restoration Area

Model	k	AIC_c	Delta AIC_c
baseline + DNN	5	202.170	0.000
baseline + DNN + DNN×Site	6	202.673	0.503
baseline	4	203.534	1.364
baseline + Distance to Wrack	5	204.553	2.383
baseline + HRA	5	204.789	2.620
baseline + 25 m² Cover Variables	9	209.154	6.984
baseline + 1 m² Cover Variables	9	210.346	8.176
baseline + 5 m² Cover Variables	9	212.195	10.025

nesting habitat – large expanses of sparsely vegetated, relatively flat sandy landscapes adjacent or very close to marine waters – is very limited in coastal Washington (Cooper 1958, Seabloom and Wiedemann 1994, Wiedemann and Pickart 2004; Zarnetske *et al.* 2010) and throughout much of its range due to the expansion of non-native grasses. However, within our two coastal patches or colonies, we found that nests that were closer to other nests survived better and that low nest success was driven by nest predation suggesting an anti-predator advantage to nesting semi-colonially.

Studies have found a similar relationship between nest success and distance to nearest neighbour for Snowy Plovers (Powell 2001) and for congenerics (*C. melodus;* Burger 1987) but others have found no relationship (Saalfeld *et al.* 2012, Patrick 2013). These differences among studies may be driven by an interaction between nest density and predator assemblages (Saalfeld *et al.* 2012). Page *et al.* (1983) suggested that extremely low Snowy Plover nest density (densities 20 times less than coastal environments) was an important anti-predator adaptation at Mono Lake, California where low nest densities made it difficult for the primary nest predator, the California Gull *Larus californicus* to locate the nests. Similarly, the lack of a nearest neighbour effect for Snowy Plovers nesting in the southern high plains of Texas (Saalfeld *et al.* 2012), might also be the result of the local predator community (coyote *Canis latrans*, domestic dog *C. familiaris*, raven *Corvus* spp. and Black-crowned Night Heron *Nycticorax nycticorax;* Saalfeld *et al.* 2011). Herons for example, appear to be attracted to higher nest densities of their prey and anti-predator defence is rarely directed toward herons because of their large size and the potential risks they pose to responding birds (Brunton 1999). In contrast to these two studies, ravens and crows are the primary nest predators of coastal Snowy Plovers in Washington, Oregon and northern California and there appears to be a negative relationship between nest density and levels of crow predation for some bird species (Brunton 1999) suggesting a potential advantage to close neighbours when corvids are the primary nest predator.

Patrick (2013) measured coloniality and nearest neighbour distances in the Snowy Plover and found evidence that coloniality occurred when the population was large but not when the population was small. This was a small population (19–64 breeding adults depending upon the year) spread across a very large area (95 km of beach and gravel bars) and the average nearest neighbour distance was considerable (1,284 m, SD = 4,019 m). In contrast, each of our two study sites had an annual population of about 18–35 birds (depending upon the year and site) distributed along only 10 km of coastline (nearly 10 times less) with mean nearest neighbour distances of only 288 m (median = 274 m). It may be difficult to assess the effect of nearest neighbour distance on nest survival when Snowy Plover density is very low because distance to nearest neighbour is in a narrow range of large values. Conversely, there may be a disadvantage of too many close neighbours; especially at densities greater than those observed at our study sites if higher densities make it easier for predators to locate and exploit Snowy Plover eggs (Brunton 1999).

Differences in nest success can be driven by the composition and structure of the habitat surrounding nests that influence crypsis of eggs and incubating adults. For example, Colwell *et al.* (2005)

suggest that Snowy Plover eggs and chicks are more cryptic in river substrates (large, heterogeneous substrates, with more egg-sized stones) compared to homogeneous substrates such as beaches. This conclusion was reached because nests are difficult for a naïve human observer to locate when searching gravel bars with more egg sized cobbles (Colwell *et al.* 2011). They also found higher nest success on gravel bars than nearby coastal beaches thereby providing additional evidence for the crypsis hypothesis (Colwell *et al.* 2005, 2010) or suggesting differences in nest predator assemblages between sites (Burrell and Colwell 2012). Similarly to the observation by Colwell *et al.* (2011), we found it very difficult to locate nests in the habitat restoration area at Leadbetter where oyster shells had been liberally spread across the beach, but we found no effect of shell cover on nest success in our models. In fact, we found no effect of any habitat variables on nest success even when assessing them at three different spatial scales. In a similar modelling approach that included the effect of site and year, Hardy and Colwell (2012) found little evidence that habitat variables in the vicinity of the nest influenced overall nest success. Instead, there was a strong site effect as we observed and a weaker effect of corvid abundance on nest success.

Despite the lack of a relationship between nest predation rates and habitat variables, coastal Snowy Plovers appear to select very specific habitat types. At the coastal landscape scale, Snowy Plovers use sites adjacent to or very close to the ocean or marine waters including coastal streams, estuaries, but they nest primarily on sandy coastal beaches (both bluff-backed and dune conditions) and occasionally they nest on gravel or former salt ponds (Page *et al.* 1995, USFWS 2007). Within these habitats, site occupancy and colonisation is negatively influenced by inter-dune vegetation and they tend to use relatively large open and relatively flat sites (MacDonald *et al.* 2010, Webber *et al.* 2013). Snowy Plovers are less likely to use areas with high percentage cover of dense vegetation among dunes (Webber *et al.* 2013). Also, beach debris and access to nearby foraging areas influence site occupancy, colonisation, and extinction (Webber *et al.* 2013).

Even though long-distance breeding dispersal occurs in western North America Snowy Plovers (Stenzel *et al.* 1994), dispersal distances between nest attempts are relatively short and do not move many individuals beyond the local "site" (Pearson and Colwell 2014). This dispersal pattern supports the need to manage for higher breeding productivity at occupied sites, specifically activities targeted at reducing predation on chicks and eggs, rather than relying on dispersal after nest failure to move birds away from sites with high predation pressure and toward sites with lower pressure (Pearson and Colwell 2014). Within occupied sites, Snowy Plovers use sparsely vegetated areas for nesting (0–12% cover; Wilson-Jacobs and Meslow 1984, Page and Stenzel 1981, Powell 2001, this study) which may facilitate early predator detection (Martin 1988, Cresswell 1997). These results in combination with the importance of relatively close nest spacing suggest the importance of protecting large expanses of suitable habitat where Plovers can nest semi-colonially in our study area. When considering the transferability of our results to other regions, we recommend additional research to examine the relationship between nest success and site/landscape features, predator assemblages and nest spacing to better inform management strategies. For example, is there an adult survival advantage to early detection as suggested by Amat and Masero (2004) and if so, under what conditions?

Snowy Plover nest predation rates can be reduced through various management activities (Table 1) including wire mesh cages placed around nests (exclosures) designed to exclude large mammals and birds intent on depredating eggs. Predator exclosures are used widely by managers because they are easy to install, they are inexpensive, and they appear to have a positive effect on nest success. For some species and under some ecological conditions, predator exclosures can increase reproductive success without increasing adult mortality (e.g. Pauliny *et al.* 2008) and can have positive population effects (e.g. Larson *et al.* 2002, Smith *et al.* 2011). For other species, exclosures either have no effect on nest success (e.g. Nol and Brooks 1982, Mabee and Estelle 2000, Pearson *et al.* 2012) or have detrimental effects on adult survival (e.g. Murphy *et al.* 2003). Generally, exclosures significantly increase hatching success (Smith *et al.* 2011) as we observed in this study.

Even though we observed a consistent positive effect of exclosures on nest success, we recommend that they be used with caution without additional research on their influence on overall population growth. Some studies have found that predators appear to use exclosures to locate and kill adult ground nesting birds in or near the exclosure cage (Smith *et al.* 2011, Pearson *et al.* 2012). Avoiding negative effects on adult survival is particularly important for species like the Snowy Plover because of its disproportionate effect on population growth (Nur *et al.* 1999). We observed two cases where it appears that an adult Snowy Plover was killed in association with an exclosure (adult feathers and blood found on the exclosure or adjacent to it) yet we never observed similar evidence of adult mortality at unexclosed nests. In response to these incidents, we discontinued the use of exclosures immediately for the season. Similarly, in northern California, managers discontinued the use of exclosures after an episode of high adult mortality associated with predator exclosures (Hardy and Colwell 2008, Mullin *et al.* 2010).

When reviewing the literature and considering the adult Snowy Plover mortality associated with exclosures in California, Oregon and Washington, we recommend: (1) exclosures not be used at sites with resident or migrating falcons or with other species that may use exclosures to detect and kill adult birds (Murphy *et al.* 2003, Neuman *et al.* 2004, Niehaus *et al.* 2004, Isaakson *et al.* 2007, Hardy and Colwell 2008, Pearson *et al.* 2012); (2) their use should be accompanied by close monitoring to evaluate their effectiveness (Hardy and Colwell 2008); (3) if they are found to be ineffective or detrimental (e.g. causing adult mortality or nest abandonment), their use be discontinued (Pauliny *et al.* 2008) or managed to address the shortcomings of the equipment design (Pearson *et al.* 2012). In addition, management activities other than exclosures should also be considered, especially if they benefit plover fecundity without the negative effects on adult survival. For example, preliminary data suggests that once predator management (including removal) was initiated on Oregon's coastal beaches, the need to use exclosures, and the associated risk of adult plover mortality, was reduced (Dinsmore *et al.* 2014).

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References

Amat, J. A. and Masero, J. A. (2004) Predation risk on incubating adults constrains the choice of thermally favourable nest sites in a plover. *Anim. Behav.* 67: 293–300.

Anders, A. D. and Marshall, M. R. (2005) Increasing the accuracy of productivity and survival estimates in assessing landbird population status. *Conserv. Biol.* 19: 66–74.

Andersson, M., Wallander, J. and Isaksson, D. (2009) Predator perches: a visual search perspective. *Functional Ecol.* 23: 373–379.

Borgmann, K. L., Conway, C. J. and Morrison, M. L. (2013) Breeding phenology of birds: Mechanisms underlying seasonal declines in the risk of nest predation. *PLoS ONE* 8(6): e65909. doi:10.1371/journal.pone.0065909.

Briggs, K. B. (1984) Injuries to oystercatchers wintering and breeding inland in northwest England. *Wader Study Group Bull.* 40: 39–41.

Brown, C. R. and Brown, M. B. (2001) Avian coloniality – progress and problems. Pp. 1–82 in V. Nolan, Jr. and C. F. Thompson, eds. *Current ornithology 16.* Boston, Massachusetts: Springer.

Brown, W. P. and Roth, R. R. (2002) Temporal patterns of fitness and survival in the Wood Thrush. *Ecology* 83: 958–969.

Brunton, D. (1999) "Optimal" colony size in least terns: An inter-colony study of opposing selective pressures by predators. *Condor* 101: 607–615.

Burger, J. (1987) Physical and social determinants of nest-site selection in Piping Plover in New Jersey. *Condor* 89: 811–818.

Burrell, N. S. and Colwell, M. A. (2012) Direct and indirect evidence that productivity of Snowy Plovers *Charadrius nivosus* varies with occurrence of a nest predator. *Wildfowl* 62: 202–221.

Camfield, A. F., Pearson, S. F. and Martin, K. (2011) Demographic model to evaluate population declines in the endangered Streaked Horned Lark. Avian Conserv. *Ecol.* 6: 4. http://www.ace-eco.org/vol6/iss2/art4/

Catlin, D. H., Fraser, J. D., Felio, J. H. and Cohen, J. B. (2011) Piping Plover habitat selection and nest success on natural, managed, and engineered sandbars. *J. Wildl. Manage.* 75: 305–310.

Chesser, R. T., Banks, R. C., Barker, F. K., Cicero, C., Dunn, J. L., Kratter, A. W., Lovette, I. J., Rasmussen, P. C., Remsen, J. V., Rising, J. D., Stotz, D. F. and Winker, K. (2011) Fifty-second supplement to the American Ornithologists' Union check-list of North American birds. *Auk* 128: 600–613.

Colwell, M. A., Burrell, N. S., Hardy, M. A., Kayano, K., Muir, J. J., Pearson, W. J., Peterson, S. A. and Sesser, K. A. (2010) Arrival times, laying dates, and reproductive success of Snowy Plovers in two habitats in coastal northern California. *J. Field Ornithol.* 81: 349–360.

Colwell, M. A., Millett, C. B., Meyer, J. J., Hall, J. N., Hurley, S. J., McAllister, S. E., Transou, A. N. and Levalley, R. R. (2005) Snowy Plover reproductive success in beach and river habitats. *J. Field Ornithol.* 76: 373–382.

Colwell, M. A., Meyer, J. J., Hardy, M. A., McAllister, S. E., Transou, A. N., Levalley, R. R. and Dinsmore, S. J. (2011) Western Snowy Plovers *Charadrius alexandrines nivosus* select nesting substrates that enhance egg crypsis and improve nest survival. *Ibis* 153: 303–311.

Cooper, W. S. (1958) *Coastal sand dunes of Oregon and Washington.* Denver, Colorado, USA: Geological Society of America. Memoir 72.

Cresswell, W. (1997) Nest predation: the relative effects of nest characteristics, clutch size and parental behavior. *Anim. Behav.* 53: 93–103.

Davis, S. K. (2005) Nest-site selection patterns and the influence of vegetation on nest survival of mixed-grass prairie passerines. *Condor* 107: 605–616.

Dinsmore, S. J., Lauten, D. J., Castelein, K. A., Gaines, E. P. and Stern, M. A. (2014) Predator exclosures, predator removal, and habitat improvement increase nest success of Snowy Plovers in Oregon, USA. *Condor* 116: 619–628.

Dowding, J. E. and Murphy, E. C. (2001) The impact of predation by introduced mammals on endemic shorebirds in New Zealand: a conservation perspective. *Biol. Conserv.* 99: 47–64.

Dowling, B. and Weston, M. A. (1999) Managing a breeding population of the Hooded Plover *Thinornis rubricollis* in a high-use recreational environment. *Bird Conserv. Internatn.* 9: 255–270.

Dunn, E. H., Hussell, D. J. T. and Ricklefs, R. E. (1979) The determination of incubation stage in starling eggs. *Bird-Banding* 50: 114–120.

Fieberg, J. and Ellner, S. P. (2001) Stochastic matrix models for conservation and management: a comparative review of methods. *Ecol. Lett.* 4: 244–266.

Gill, F. and Donsker, D., eds. (2014) *IOC world bird list (v 4.2).* doi : 10.14344/IOC.ML.4.2.

Grant, T. A., Shaffer, T. L., Madden, E. M. and Pietz, P. J. (2005) Time-specific variation in passerine nest survival: New insights into old questions. *Auk* 122: 661–672.

Hardy, M. A. and Colwell, M. A. (2008) The impact of predator exclosures on Snowy Plover nesting success: a seven-year study. *Wader Study Group Bull.* 115: 161–166.

Hardy, M. A. and Colwell, M. A. (2012) Factors influencing Snowy Plover nest survival on ocean-fronting beaches in coastal northern California. *Waterbirds* 35: 503–511.

Hartley, I. R. and Shepherd, M. (1994) Nesting success in relation to timing of breeding in the Corn Bunting on North Uist. *Ardea* 822: 173–184.

Hays, H. and LeCroy, M. (1971) Field criteria for determining incubation stage in eggs of the Common Tern. *Wilson Bull.* 83: 425–429.

Isaksson, D., Wallander, J. and Larsson, M. (2007) Managing predation on ground-nesting birds: the effectiveness of predator exclosures. *Biol. Conserv.* 136: 136–142.

IUCN (2014) *IUCN Red List of Threatened Species*. Version 2014.1. <www.iucnredlist.org>. Downloaded on 27 June 2014.

Knutson, M. G., Powell, L. A., Hines, R. K., Friberg, M. A. and Niemi, G. J. (2006) An assessment of bird habitat quality using population growth rates. *Condor* 108: 301–314.

Kroll, A. J. and Haufler, J. B. (2009) Age and clutch size variation in Dusky Flycatcher nest survival. *J. Ornithol.* 150: 409–417.

Küpper, C., Augustin, J., Kosztolányi, A., Figuerola, J., Burke, T. and Székely, T. (2009) Kentish versus Snowy Plover: Phenotypic and genetic analyses of *Charadrius alexandrinus* reveal divergence of Eurasian and American subspecies. *Auk* 126: 839–852.

Lafferty, K. D., Goodman, D. and Sandoval, C. P. (2006) Restoration of breeding by Snowy Plovers following protection from disturbance. *Biodivers. Conserv.* 15: 2217–2230.

Larson, M. A., Ryan, M. R. and Murphy, R. K. (2002) Population viability of Piping Plovers: effects of predator exclusion. J. Wildl. Manage. 66: 361–371.

Lauten, D. J., Castelein, K. A., Gaines, E. P. and Stern, M. A. (2004) The efficacy of predator exclosures for the Western Snowy Plovers (*Charadrius alexandrinus nivosus*) on the Oregon coast, 1990–2003. Portland, OR: Oregon Natural Heritage Information Center Institute for Natural Resources, Oregon State University.

Lewin, W-C., Arlinghaus, R. and Mehner, T. (2006) Documented and potential biological impacts of recreational fishing: insights for management and conservation. *Reviews in Fisheries Sci.* 14: 305–367.

Mabee, T. J. and Estelle, V. B. (2000) Assessing the effectiveness of predator exclosures for plovers. *Wilson Bull.* 112: 14–20.

MacDonald, B., Longcore, T. and Dark, S. (2010) Habitat suitability modeling for western Snowy Plover in central California. Los Angeles, CA: The Urban Wildlands Group.

Maguire, G. S., Stojanovic, D. and Weston, M. A. (2009) Conditioned taste aversion reduces fox depredation on model eggs on beaches. *Wildl. Res.* 36: 702–708.

Maguire, G. S., Duivenvoorden, A. K., Weston, M. A. and Adams, R. (2011) Provision of artificial shelter on beaches is associated with improved shorebird fledging success. *Bird Conserv. Internatn.* 21: 172–185.

Martin, T. E. (1988) Processes organizing open-nesting bird assemblages: competition or nest predation? *Evol. Ecol.* 2: 37–50.

Martin, T. E. (1992) Interaction of nest predation and food limitation in reproductive strategies. *Curr. Ornithol.* 9: 163–197.

McLeod, E. M., Guay, P-J., Taysom, A. J., Robinson, R. W. and Weston, W. A. (2013) Buses, cars, bicycles and walkers: The influence of human transportation on flight responses of waterbirds. *PLoS ONE* 8(12): e82008. Doi:10.1371/journal.pone.0082008.

Melville, D. S. (1982) Notes on "disabled" waders in East Asia. *Wader Study Group Bull.* 36: 14–15.

Muller, M., Pasinelli, G., Schiegg, K., Spaar, R. and Jenni, L. (2005) Ecological and social effects on reproduction and local recruitment in the Red-backed Shrike. *Oecologia* 143: 37–50.

Mullin, S. M., Colwell, M. A., McAllister, S. E. and Dinsmore, S. J. (2010) Apparent survival and population growth of Snowy Plovers in coastal northern California. *J. Wildl. Manage.* 74: 1792–1798.

Murphy, R. K., Michaud, I. M. G., Prescott, D. R. C., Ivan, J. S., Anderson, B. J. and French-Pombier, M. L. (2003) Predation on adult Piping Plovers at predator exclosure cages. *Waterbirds* 26: 150–155.

Nagy, L. R. and Holmes, R. T. (2004) Factors influencing fecundity in migratory songbirds: is nest predation the most important? *J. Avian Biol.* 35: 487–491.

Neuman, K. K., Page, G. W., Stenzel, L. E., Warriner, J. C. and Warriner, J. S. (2004) Effect of mammalian predator management on Snowy Plover breeding success. *Waterbirds* 27: 257–376.

Newton, I. (1998) *Population limitation in birds*. London, UK: Academic Press.

Niehaus, A. C., Ruthrauff, D. R. and McCaffery, B. J. (2004) Response of predators to Western

Sandpiper predator exclosures. *Waterbirds* 27: 79–82

Nol, E. and Brooks, R. J. (1982) Effects of predator exclosures on nesting success of Killdeer. *J. Ornithol.* 53: 263–268.

Nolan, V., Jr. (1963) Reproductive success of birds in a deciduous scrub habitat. *Ecology* 44: 305–313.

Nur, N., Page, G. W. and Stenzel, L. E. (1999) Population viability analysis for Pacific coast western Snowy Plovers. Appendix D in U.S. Fish and Wildlife Service (2007) Recovery plan for the Pacific coast population of the Western Snowy Plover (*Charadrius alexandrines nivosus*). Sacramento, CA: U.S. Fish and Wildlife Service.

Page, G. W. and Stenzel., L. E. (1981) The breeding status of the Snowy Plover in California. *Western Birds* 12: 1–40.

Page, G. W., Stenzel, L. E., Winkler, D. W. and Swarth, C. W. (1983) Spacing out at Mono Lake: Breeding success, nest density, and predation in the Snowy Plover. *Auk* 100: 13–24

Page, G. W., Stenzel, L. E. and Ribic, C. A. (1985) Nest site selection and clutch predation in the Snowy Plover. *Auk* 102: 347–353.

Page, G. W., Stenzel, L. E., Page, G. W., Warriner, J. S., Warriner, J. C. and Paton, P. W. (2009) Snowy plover (*Charadrius alexandrinus*). Account 154 in A. Poole, ed. *The birds of North America online*. Ithaca, New York, USA, Cornell Lab of Ornithology. <http://bna.birds.cornell.edu/bna/species/154>. Accessed 3 Oct 2010.

Patrick, A. M. (2013) Birds of a feather flock (somewhat) together: Semi-colonial nesting in the Snowy Plover. Masters Thesis, Humboldt State University, Wildlife Department.

Pauliny, A., Larsson, M. and Blomqvist, D. (2008) Nest predation management: effects on reproductive success in endangered shorebirds. *J. Wildl. Manage.* 72: 1579–1583.

Pearson, W. J. and Colwell, M. A. (2014) Effects of nest success and mate fidelity on breeding dispersal in a population of Snowy Plovers *Charadrius nivosus*. *Bird Conserv. Internatn.* Available on CJO 2013 doi:10.1017/S0959270913000403

Pearson, S. F., Moore, R. and Knapp, S. M. (2012) Predator exclosures do not improve Streaked Horned Lark nest success. *J. Field Ornithol.* 83: 315–322

Porneluzi, P. A. and Faaborg, J. (1999) Season-long fecundity, survival, and viability of ovenbirds in fragmented and unfragmented landscapes. *Conserv. Biol.* 13: 1151–1161.

Powell, A. N. (2001) Habitat characteristics and nest success of Snowy Plovers associated with California Least Tern colonies. *Condor* 103: 785–792.

Ricklefs, R. E. (1969) An analysis of nestling mortality in birds. *Smithsonian Contrib. Zool.* 9: 1–48.

Rizzolo, D. J. and Schmutz, J. A. (2007) Egg flotation estimates nest age for Pacific Red-throated Loons. *Waterbirds* 30: 207–213.

Roseberry, J. L. and Klimstra, W. D. (1970) The nesting ecology and reproductive performance of the Eastern Meadowlark. *Wilson Bull.* 82: 243–267.

Rotella, J. J., Dinsmore, S. J. and Shaffer, T. L. (2004) Modeling nest-survival data: a comparison of recently developed methods that can be implemented in MARK and SAS. *Anim. Biodivers. Conserv.* 27: 187–204.

Ruhlen, T. D., Abbot, A., Stenzel, L. E. and Page, G. W. (2003) Evidence that human disturbance reduces Snowy Plover chick survival. *J. Field Ornithol.* 74: 300–304.

Ryan, M. R., Root, B. G. and Mayer, P. M. (1993) Status of Piping Plovers in the Great Plains of North America: A demographic simulation. *Conserv. Biol.* 7: 581–585.

Saalfeld, S. T., Conway, W. C., Haukos, D. A. and Johnson, W. P. (2011) Nest success of Snowy Plovers (*Charadrius nivosus*) in the Southern High Plains of Texas. *Waterbirds* 34: 389–399.

Saalfeld, S. T., Conway, W. C., Haukos, D. A. and Johnson, W. P. (2012) Snowy Plover nest site selection, spatial patterning, and temperatures in the Southern High Plains of Texas. *J. Wildl. Manage.* 76: 1703–1711.

SAS Institute (2007) *SAS/STAT user's guide, version 9.2*. Cary, NC: SAS Institute.

Schultz, R. and Stock, M. (1993) Kentish Plovers and tourists: competitors on sandy coasts? *Wader Study Group Bull.* 68: 83–91.

Seabloom, E. W. and Wiedemann, A. M. (1994) Distribution and effects of *Ammophila breviligulata* Fern (American beachgrass) on the foredunes of the Washington coast. *J. Coastal Res.* 10: 178–188.

Shaffer, T. L. (2004) A unified approach to analyzing nest success. *Auk* 121: 526–540.

Smith, R. K., Pullin, A. S., Stewart, G. B. and Sutherland, W. J. (2010) Effectiveness of predator removal for enhancing bird populations. *Conserv. Biol.* 24: 820–829.

Smith, R. K., Pullin, A. S., Stewart, G. B. and Sutherland, W. J. (2011) Is nest predator exclusion an effective strategy for enhancing bird populations? *Biol. Conserv.* 144: 1–10.

Stenzel, L. E., Warriner, J. C., Warriner, J. S. Wilson, K. S., Bidstrup, F. C. and Page, G. W. (1994) Long-distance breeding dispersal of Snowy Plovers in western North America. *J. Anim. Ecol.* 63: 887–902

Stephens, S. E. (2003) *The influence of landscape characteristics on duck nesting success in the Missouri Coteau region of North Dakota.* Ph.D. dissertation. Bozeman, MT: Montana State University.

Stephens, S. E., Rotella, J. J., Lindberg, M. S., Taper, M. L. and Ringelman, J. K. (2005) Duck nest survival in the Missouri Coteau of North Dakota. Ecol. *Applic.* 15: 2137–2149.

USFWS (1993) Endangered and threatened wildlife and plants; determination of threatened status for the Pacific coast population of the western Snowy Plover. *Federal Register* 58: 12864–12874.

USFWS (2007) *Recovery plan for the Pacific coast population of the western Snowy Plover (Charadrius alexandrinus nivosus).* Two volumes. Sacramento, CA: US Fish and Wildlife Service.

Varela, S. A. M., Danchin, E. and Wagner, R. H. (2007) Does predation select for or against avian coloniality? A comparative analysis. *J. Evol. Biol.* 20: 1490–1503.

Warriner, J. S., Warriner, J. C., Page, G. W. and Stenzel, L. E. (1986) Mating system and reproductive success of a small population of polygamous Snowy Plovers. *Wilson Bull.* 98: 15–37.

Webber, A. F., Heath, J. A. and Fischer, R. A. (2013) Human disturbance and stage-specific habitat requirements influence snowy plover site occupancy during the breeding season. *Ecol. Evol.* 3: 853–863.

Weston, M. A., Dodge, F., Bunce, A., Nimmo, D. G. and Miller, K. K. (2012) Do temporary beach closures assist in the conservation of breeding shorebirds on recreational beaches? *Pacific Conserv. Biol.* 18: 47–55.

Weston, M. A., Ehmke, G. and Maguire, G. S. (2011) Nest return times in response to static versus mobile human disturbance. *J. Wildl. Manage.* 75: 252–255.

Weston, M. A. and Elgar, M. A. (2005) Parental care in Hooded Plovers (*Thinornis rubricollis*). *Emu* 105: 283–292

Weston, M. A. and Elgar, M. A. (2007) Responses of incubating Hooded Plovers (*Thinornis rubricollis*) to disturbance. *J. Coastal Res.* 23: 569–576.

Weston, M. A., Liu, X, Tsuzuki, T., Fallaw, J. and Dann, P. (2009) Forensic fibre analysis to determine the origins of leg-entangling threads on shorebirds: a case study. *Wader Study Group Bull.* 116: 46–48.

Wiebe, K. L. (2003) Delayed timing as a strategy to avoid nest-site competition: testing a model using data from starlings and flickers. *Oikos* 100: 291–298.

Wiedemann, A. M. (1984) The ecology of Pacific Northwest coastal sand dunes: A community profile. U.S. Fish and Wildlife Service. FWS-OBS-84-04.

Wiedemann, A. M. and Pickart, A. J. (2004) Temperate zone coastal dunes. Pp. 53–65 in M. Martinez and N. Psuty, eds. *Coastal dunes: ecology and conservation.* Berlin, Germany: Springer-Verlag.

Willson, M. F., Morrison, J. L., Sieving, K. E., de Santo, T. L., Santisteban, L. and Diaz, I. (2001) Patterns of predation risk and survival of bird nests in a Chilean agricultural landscape. *Conserv. Biol.* 15: 447–456.

Wilson, S., Martin, K. and Hannon, S. J. (2007) Nest survival patterns in willow ptarmigan: influence of time, nesting stage, and female characteristics. *Condor* 109: 377–388.

Wilson-Jacobs, R. and Meslow, E. C. (1984) Distribution, abundance, and nesting characteristics of Snowy Plovers on the Oregon coast. *Northwest Sci.* 58: 40–48.

Wilson-Jacobs, R. and Dorsey, G. L. (1985) Snowy plover use of Coos Bay North Spit, Oregon. *The Murrelet* 66: 75–81.

Winter, M., Johnson, D. H. and Shaffer, J. A. (2005) Variability in vegetation effects on density and nesting success of grassland birds. *J. Wildl. Manage.* 69: 185–197.

Wisdom, M. J., Mills, L. S. and Doak, D. F. (2000) Life stage simulation analysis: Estimating vital-rate effects on population growth for conservation. *Ecology* 81: 628–641.

Wright, M. D., Goodman, P. and Cameron, T. C. (2010) Exploring behavioural responses of shorebirds to impulsive noise. *Wildfowl* 260: 150–167.

Zarnetske, P. L., Seabloom, E. W. and Hacker, S. D. (2010) Non-target effects of invasive species management: beachgrass, birds, and bulldozers in coastal dunes. *Ecosphere* 1(5):art13. doi:10.1890/ES10-00101.1

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Relationships between the Red Fox and Waterbirds in the Ebro Delta Natural Park, N.E. Spain

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Relationships between the Red Fox and Waterbirds in the Ebro Delta Natural Park, N.E. Spain

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Abstract.—We studied the basic biology of the Red Fox (*Vulpes vulpes*) and its interactions with the waterbird colonies in the Ebro Delta natural park, Spain. Dens (earths) were found in areas characterized by sandy dune vegetation, a few buildings, areas where human entry was prohibited, and areas where hunting of waterfowl was banned. Regression associated the presence of dens to the abundance of dunes, halophytic vegetation and prohibited entry. Birds constituted 96% of the prey found at dens, mainly waterfowl (68%), gulls (16%) and rails (10%), but this differed markedly between areas. During the breeding season, foxes obtained their food from a reduced number of sources in the area surrounding their dens, and impacted the nearest breeding birds. We propose changes in the management of foxes in the natural park to safeguard internationally threatened bird species and to prevent them from decreasing, or even disappearing, as a result of fox predation. *Received 30 April 2002, accepted 7 December 2002.*

Key words.—Red Fox, Audouin's Gull, Yellow-legged Gull, colonial waterbirds, predation, Ebro Delta, management.

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The Ebro Delta in Spain is one of the most extensive wetlands in the western Mediterranean and has been protected as a natural park since 1983. A total of 36 species of waterbirds breed there, among which are some of the most vulnerable and threatened species in the European, including Audouin's Gull (*Larus audouinii*), with between 60 and 70% of the world's breeding population, Glossy Ibis (*Plegadis falcinellus*), Greater Flamingo (*Phoenicopterus ruber*), and colonies of the Mediterranean Gull (*Larus melanocephalus*) and Slender-billed Gull (*L. genei*) (Díaz *et al.* 1996; Hagenmeijer and Blair 1997; Oró 1998). This ornithological interest is reflected in the recognition of the area as an internationally important area for birds, and it is included in the Ramsar agreement of 1993 and as a Special Protection Area under Directive 79/409/CEE, for the protection of birds in the European Union. In the years that have elapsed since the creation of the reserve, the numbers of birds have increased, and nine additional species of waterbirds have become established as regular breeders.

Studies carried out during the 1970s, showed that carnivores present in the area were almost exclusively Weasels (*Mustela nivalis*), with the occasional Red Fox (*Vulpes vulpes*) and the European Badger (*Meles meles*) sporadically recorded (Gosálbez 1977). At the time of the park's creation in 1983 and until the early 1990s, only the Weasel was reported regularly within the park (Ruiz-Olmo and Aguilar 1995). In 1998 and 1999, the deaths of many adult Audouin's Gulls from fox predation were reported (Oró 2000; Oró and Pradel 2000). Several groups requested that foxes should be controlled, while others were opposed to such control, since it is a wild species and that it would cause a natural check on bird numbers. The natural park authorities began control of foxes, paying attention to the vulnerability of the certain bird species, the possible dispersion of the bird colonies. This decision was influenced by the effect that foxes and other canids have had on colonial and aquatic birds elsewhere (Kruuk 1964, 1972; Ennion and Tinbergen 1967; Sargeant and Eberhardt 1975; Johnson and Sargeant 1977; Southern and Southern 1978; Petersen 1982; Sargeant *et al.* 1984; Southern *et al.* 1985; Bailey 1993; Oró 2000; Oró and Pradell 2000; Erwin *et al.* 2001).

The Yellow-legged Gull (*Larus cachinnans*) has bred in the natural park since 1982. The colonies were initially located in La Punta de la Banya (the area where Audouin's Gull nests), but the numbers have grown, producing a simultaneous displacement of the

Audouin's Gull colonies from natural areas to the salina areas, where they used man-made sand strips (Oró 2000; personal data). The problems of competition and predation by the Yellow-legged Gull on Audouin's Gull have been considered with in depth (Plan Coordinado para la Gaviota de Audouin 1994; Pedrocchi and Oró in press). However the presence of foxes could have unforeseen and negative consequences on the conservation of Audouin's Gull and other threatened species, and a study of the Red Fox was initiated.

The aims of this study were 1) to identify the areas used by the fox for breeding and to locate their dens (earths), 2) establish their most common prey within the colonial waterbirds and where they captured them and, 3) to propose methods to manage the fox population in such a way that it does not disappear, yet that it does not have a major and adverse effect on the conservation of internationally threatened waterbird species.

METHODS

Covering 320 km², the Ebro Delta (Lat. 0°39'26"E; Long. 37°49'40"N) is located at the mouth of the Ebro River, where it enters the Mediterranean Sea. It includes 7,802 ha (principally natural habitat) as a natural park, and a total of 11,550 ha are included in a Special Protection Area. Its characteristics are described in Parés and Borràs (1997). The most extensive human activities in the general area are agriculture (mainly rice), marine fishing, waterfowl hunting and tourism. These activities are of minor importance within the natural park since only 10% of the area is agricultural, 30% is used for hunting. Visitors are prohibited from entry into 86% of the area (either throughout the year or during the breeding season, from March to August).

The avifauna is of major importance (Gosálbez 1977; Díaz *et al.* 1996; Queral and Borrero 1999). In 1999-2001, there were 18,000-19,000 breeding pairs of gulls, 5,000-6,000 pairs terns, 10,000-13,000 ducks and 6,000-8,000 herons (Ebro Delta Natural Park, 2001); there are also large numbers of wintering waterbirds; 60,000-90,000 waterfowl, 5,000-9,000 herons, 20,000-25,000 Coot (*Fulica atra*) and 30,000-50,000 plovers.

Detection and monitoring of the fox dens.—Four signs of the presence of foxes were used: dens, tracks, droppings and predation (identifiable by the typical bite; the fox is the only large carnivore that regularly occurred in the area). Dens (in some countries referred to as "earths") were dug into the ground among vegetation and were attributed to foxes when their tracks, droppings, or remains of their prey were found (Strom *et al.* 1976; Pils and Martin 1978). The study area was covered mainly by sand and mud, which facilitated the task of detecting tracks.

An effort was made to detect all fox dens by examining the whole of the study area in 1999 and 2000. All areas where signs of activity were detected in 1999-2000 were visited several times in 2001. Reports by people who saw foxes were also used. Dens used for breeding were identified by the tracks of the young (cubs), accumulations of small droppings or the presence together of more than ten prey-items or their remains (Corbet and Harris 1991). The positions of all dens were mapped on a 1:50,000 scale using GPS (Magellan 3000 XL).

The majority of the most vulnerable colonial waterbird species were in the La Punta de la Banya nature reserve and a special effort was made to assess the presence of foxes there, by recording when they entered and left the area. Two methods were used: 1) Four transects on foot, of 100-150 m in length, transversing the obligatory path the foxes had to take along the narrow, 7-km isthmus which linked the nature reserve with the Delta. 2) Routes taken by vehicle and on foot through the nature reserve every 1-3 days during the whole nesting period (April to July), searching for fox tracks.

The selection of sites for fox dens and feeding habits.—A total of 51 attributes were recorded within a radius of ten m of each fox den (Table 1). In order to compare these with their availability elsewhere, 90 points were selected at random within the study area and the same attributes were measured.

Fox diet was identified through the remains of prey found within 50 m of dens. This record of diet is biased, as small prey are totally ingested and not usually recorded. However, the analyses of carnivore droppings are also biased (Carss and Parkisson 1996). The results are presented as relative frequency (RF = number of a particular prey in each food category × 100/total prey-items) In the analysis, the data obtained from the dens in each of five homogeneous areas have been grouped as follows: the La Punta de la Banya, the La Tancada, l'Alfacada, the Illa de Buda and the El Fangar nature reserves. In all cases, the shortest feasible distance between the dens and the nearest breeding area of gulls/terns and waterfowl/rails was measured, using GIS.

Monitoring breeding success of gulls.—The monitoring was carried out at La Punta de la Banya nature reserve in 1999, 2000 and 2001. The areas occupied by the colonies of Audouin's Gull and Yellow-legged Gull were mapped. In order to establish the effect of foxes on the breeding of both gull species, two different methods were used. In the case of Audouin's Gull, results obtained by Oró (2000 and 2001) were used, so as to avoid disturbing the colonies unnecessarily. In the case of the Yellow-legged Gull, specific counts were carried out on the colonies during 2001, in relation to the distances from the fox dens. A total of eight different variables related to nesting were used (Table 4).

Statistical Methods.—The diet in the different areas and the orientation of the dens has been compared by chi-square tests (Siegel 1956). In order to establish the selection of the habitat for the location of the dens, two types of analysis have been used:

a) Univariant statistical comparison of the 51 attributes. Appropriate statistical tests were used according to whether the data were normally distributed attributes or not. In the first case, Student t-test was used, while in the second, the Mann-Whitney U-test was applied. In the contingency tables, chi-square tests were used.

b) Stepwise logistic regression was used to establish quantitative, linear relationships, using all parameters. The aim was to predict areas where there was a

Table 1. Mean values of Red Fox den characteristics (N = 43) and randomly selected points (N = 90), and compared by t tests, except for small irrigation channels and human activities, for which chi-squared tests were used.

Attributes		Information recorded	Dens Mean or %	Random points Mean or %	P
Dens		Distance to freshwater (m)	7381 ± 1078	3120 ± 537	<0.001
		Distance to lagoon, marshes, lakes (m)	1106 ± 164	1161 ± 156	n.s
		Distance to the sea (m)	660 ± 52	764 ± 90	n.s
		Small irrigation channel within 500 m	29%	48%	<0.011
		Width of vegetation > 0.5 m height (m)	579 ± 84	118 ± 38	<0.001
		Height of vegetation (m)	1.97 ± 0.29	0.38 ± 0.08	<0.001
		Distance to paved road	4.63 ± 0.11	3.97 ± 0.11	<0.001
		Distance to unpaved road	3.41 ± 0.24	2.77 ± 0.26	n.s
Habitat structure	Diameter 10 m	Large rocks	0	0.03 ± 0.03	n.s
		Stones	0	0.1 ± 0.06	n.s
		Gravel	0	0.02 ± 0.02	n.s
		Sand	5	1.99 ± 0.24	<0.001
		Dunes	4.19 ± 0.20	0.29 ± 0.10	<0.001
		Mud	0	0.06 ± 0.06	n.s
		Grass	0	0.01 ± 0.01	n.s
		Psammophyl vegetation	3.35 ± 0.29	0.29 ± 0.10	<0.001
		Rushes	0.23 ± 0.09	0.17 ± 0.07	n.s
		Helophytic vegetation	0	0.48 ± 0.14	<0.04
		Lagoon/Lake/Marsh	0	0.51 ± 0.14	<0.001
		River/Channel	0	0.12 0.06	<0.05
		Halophytic vegetation	1.14 ± 0.25	0.5 ± 0.14	<0.03
		Pine forest	0.19 ± 0.13	0.01 ± 0.01	n.s
		Rice fields	0	1.76 ± 0.25	<0.001
	Diameter 100 m	Large rocks	0	0.03 ± 0.03	n.s
		Stones	0	0.16 ± 0.07	<0.02
		Gravel	0.14 ± 0.12	0.13 ± 0.05	n.s
		Sand	4.81 ± 0.09	2.02 ± 0.27	<0.001
		Dunes	2.93 ± 0.20	0.64 ± 0.11	<0.001
		Mud	0	0.03 ± 0.03	n.s
		Grass	0.07 ± 0.07	0.06 ± 0.03	n.s
		Psammophyl vegetation	2.58 ± 0.25	0.66 ± 0.11	<0.001
		Rushes	0.98 ± 0.16	0.29 ± 0.09	<0.001
		Halophytic vegetation	0.33 ± 0.14	0.59 ± 0.13	n.s
		Lagoon/Lake/Marsh	0.05 ± 0.05	0.68 ± 0.15	<0.001
		River/Channel	0.33 ± 0.13	0.46 ± 0.10	n.s
		Halophytic vegetation	2.4 ± 0.25	0.79 ± 0.14	<0.001
		Pine forest	0.19 ± 0.14	0.03 ± 0.02	n.s
		Rice fields	0.21 ± 0.12	1.73 ± 0.23	<0.001
		Salines	0.09 ± 0.07	0	n.s
Structure diversity	Diameter 10 m	Substract	9.19 ± 0.28	2.54 ± 0.30	<0.001
		Vegetation	4.91 ± 0.20	2.21 ± 0.38	<0.001
	Diameter 100 m	Substract	7.88 ± 0.21	3.04 ± 0.33	<0.001
		Vegetation	7.21 ± 0.54	3.74 ± 0.42	<0.001
		Human structures	0.98 ± 0.12	1.89 ± 0.14	<0.001
Human activities <500 m		Legal protection (highly protected)	91%	26%	<0.001
		Hunting forbidden	88%	55%	<0.001
		Land ownership (public)	84%	60%	<0.011
		Urban	0%	26%	<0.001
		Paved road	9.8%	26%	<0.02
		Unpaved road	24%	70%	<0.001
		Prohibited access	95%	44%	<0.001

Habitat structure attributes were recorded as 6 categories, with 0 representing 0% cover, 1 representing 1-20%, 2-21-40%, 3-41-60%, 4-61-80% and 5-81-100% (units are referred to these values). Structure diversity was calculated as follows. Distance to paved and unpaved road was recorded as 5 categories, with 1 represents less than 1 minute walking, 2-1 to 5 minutes, 3-6 and 15 minutes, 4-16 and 30 minutes and 5 more than 30 minutes walking.

greater probability of dens, and to recognize the main variables determining these. This type of analysis used presence-absence data of the dependent variable (fox dens). A logit transformation was used to adjust the logistical curve of the data (Collett 1991). Logistic models were fitted using SPSS.

RESULTS

During the period of study, 23 foxes were culled (21 adults and two cubs). In addition, one fox was run over near Vilacoto in 2000. The control of foxes was effective and the size of the local population decreased. Using all available data, we detected the presence of 17-18 adult foxes in the spring of 1999, 8-10 in the spring of 2000 and 3-4 in the spring of 2001, resulting in densities of about 0.15, 0.08 and 0.03 foxes/km^2. In 2001, foxes were till detected in most of the study area (with the exception of L'Illa de Buda and L'Illa de Sant Antoni), but they showed nomadic behavior, moving relatively quickly from one area to another. The frequency of entry and departure of foxes from La Punta de la Banya during a nine-month period between 2000 and 2001 showed that most movement took place between November and March. During the avian breeding season, foxes stayed for longer in this part of the reserve than at other times of the year.

A total of 43 fox dens were detected (Fig. 2). They were all located on sandy substrate and generally on dunes (95%), with abundant plant cover (on average two m in height). About 93% were dug into sand with galleries extending below ground, while the rest were half buried among vegetation. In all, 91% were found within the nature reserve and far from the built-up areas, in areas where hunting is prohibited (88%), on public property (84%) and in areas where entry by humans is forbidden (95%). The orientation of the entrances did not indicate a directional preference (χ^2_{11} =13.2; n.s.). Dens, including those for breeding were often located far from freshwater (maximum was 15.7 km). A number of specific attributes were found (Table 1). The stepwise logistic regression of the presence or absence of dens selected dunes and halophytic vegetation as the important attributes (Table 2), and these variables correctly classifying the presence of 96% of dens. The following predictive equation was obtained (attributes according to Table 1):

$$\text{Logit (probability of the presence of dens)} = -10.413 + 2.412\ (\%\ \text{dunes}) + 2.086\ (\%\ \text{halophytic vegetation})$$

A total of 20 different prey-species were found in the area around the dens in 2000 and 2001. Birds constituted 96% of the species, mainly waterfowl (68%), gulls (16%) and rails (10%) (Table 3). Significant differences occurred between the areas studied. At La Punta de la Banya, diet was predominantly gulls (71% of prey remains found; 69% Yellow-legged Gull), at La Tancada, Mallard (*Anas platyrhynchos*) accounted for 86% of the diet, while at El Fangar, gulls and ducks formed 33% and 67% of the total, respectively. Foxes of the Ebro Delta obtain food from a relatively small number of sources. There was a correlation between the frequency of particular waterbird groups appearing in the diet and the distance to the nearest colony (Fig. 1). Results show that most prey are obtained at relatively short distances from the dens, typically less than

Table 2. Logistic models using maximum likelihood estimates fitted to the presence or absence of Red Fox dens, following the final model (difference in deviance approximates the chi-square distribution with respective degrees of freedom).

Variable added	Model deviance	Difference in deviance	d.f.	% correct classification
+ Dunes	10.18	10.18	1	94
+ Halophytic vegetation	16.41	6.23	1	96
Variable	**Regression coefficient**		**S.E.**	**Significance**
Dunes	2.412		0.701	<0.001
Halophytic vegetation	2.086		0.747	<0.001

Table 3. Diet of the Red Fox in the Ebro Delta natural park (relative frequencies), based on prey remains found in the surroundings of dens.

	Punta de la Banya	Tancada	Alfacada	Illa Sant Antoni	Fangar	Total for Delta
Audouin's Gull (*Larus audouinii*)	1.4	0	0	0	0	0.3
Yellow-legged Gull (*L. cachinnans*)	68	0	3.2	13	33	15
Eggs of Yellow-legged Gull	1.4	0	0	0	0	0.3
Common Tern (*Sterna hirundo*)	1.4	0	0	0	0	0.3
Little Tern (*S. albifrons*)	1.4	0	0	0	0	0.3
Mallard (*Anas platyrhynchos*)	13	87	46	59	67	61
Shelduck (*Tadorna tadorna*)	1.4	0	0	0	0	0.3
Unidentified duck	1.4	8.5	11	0	0	6.7
Moorhen (*Gallinula chloropus*)	0	3.4	21	2.6	0	6.8
Coot (*Fulica atra*)	0	1.7	5.3	0	0	1.9
Purple Gallinule (*Porphyrio porphyrio*)	0	0	6.3	0	0	1.5
Avocet (*Recurvirosta avocetta*)	0	0	0	2.6	0	0.3
Godwit (*Limosa* sp.)	1.4	0	0	0	0	0.3
Unidentified sandpiper	0	0	0	2.6	0	0.3
Little Egret (*Egretta garzetta*)	0	0	0	2.6	0	0.3
Grey Heron (*Ardea cinerea*)	2.8	0	0	0	0	0.5
Rock Dove (*Columba livia*)	1.4	0	0	0	0	0.3
Turtle Dove (*Streptopelia turtur*)	1.4	0	0	0	0	0.3
Unidentified bird	0	0	2.1	0	0	0.5
Rabbit (*Oryctolagus cunniculus*)	0	0	2.1	0	0	0.5
Iberian Watervole (*Arvicola sapidus*)	0	0	0	2.6	0	0.3
Montpellier's Snake (*Malpolon monspesulanus*)	4.2	0	0	0	0	0.8
Fish (*Liza macrocephalus* and *Mugil cephalus*)	0	0	3.2	15	0	1.9
N	72	179	95	39	9	394

three km in the case of gulls and terns (in sandy areas), and less than four km for waterbirds that live and breed in wetlands with helophytic vegetation (ducks and rails). This relationship also existed for the Yellow-legged Gull.

Audouin's Gull represented 1% of the fox's diet in 2000 and 2001 (no data for 1999). During 1999, several attacks by foxes took place on colonies of this species, and at least 258 (mainly adults) were killed. In addition, at least 50 Avocets (*Recurvirostra avosetta*) and twelve Common Terns (*Sterna hirundo*) were taken by foxes. In 2000, the group studying Audouin's Gull found only 24 corpses killed by foxes, although tracks indicated that several colonies were visited by foxes. In 2001, Audouin's Gull colonies were also visited by foxes (especially those located on the neck of the isthmus), but no fox predation occurred.

Some tens of adults and juveniles Yellow-legged Gulls were decapitated and abandoned by foxes without been eaten at La Punta de la Banya. The effect on the colonies of this gull was measured (Table 4). Late in the breeding season, there was an increase in the percentage of nest with eggs (second clutches) or empty nests (abandoned and half-built) and a decrease was found in the percentage of nests with chicks ($\chi^2_4 = 10.8$; $P < 0.03$). The average number of eggs per nest decreased by half, and a lower average number of chicks per nest was found in colonies near to fox dens.

Figure 2 shows the distribution of gull colonies during the study period and how they tended to move towards the salt marshes. During the study, the Yellow-legged Gull progressively invaded the area inhabited by Audouin's Gull. The year with the greatest damage to the colonies of the Audouin's Gull (1999), coincided with the presence of active fox dens within their colonies. However, in the following two years (2000 and 2001), foxes did not occupy dens within the Audouin's Gull colonies, but they still had a major effect on the Yellow-legged Gull. It

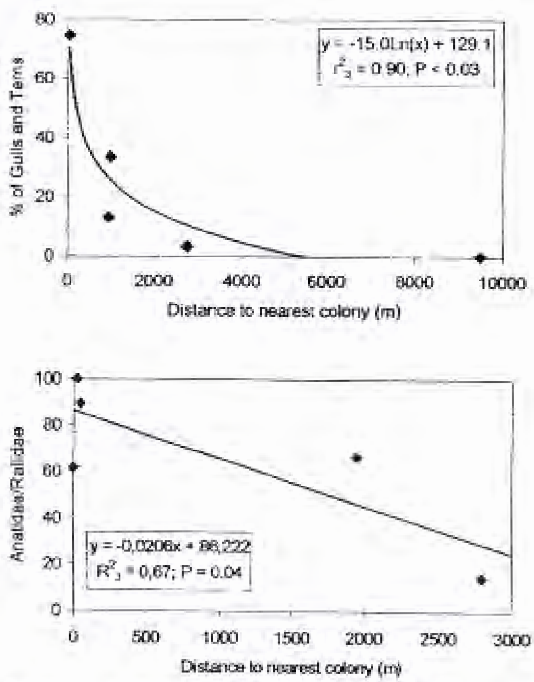

Figure 1. Correlation between the relative frequency (percentage) of main groups of food in fox's diet and the distance from the den to the closest breeding groups of these taxa. Both relationships are significant ($P < 0.05$).

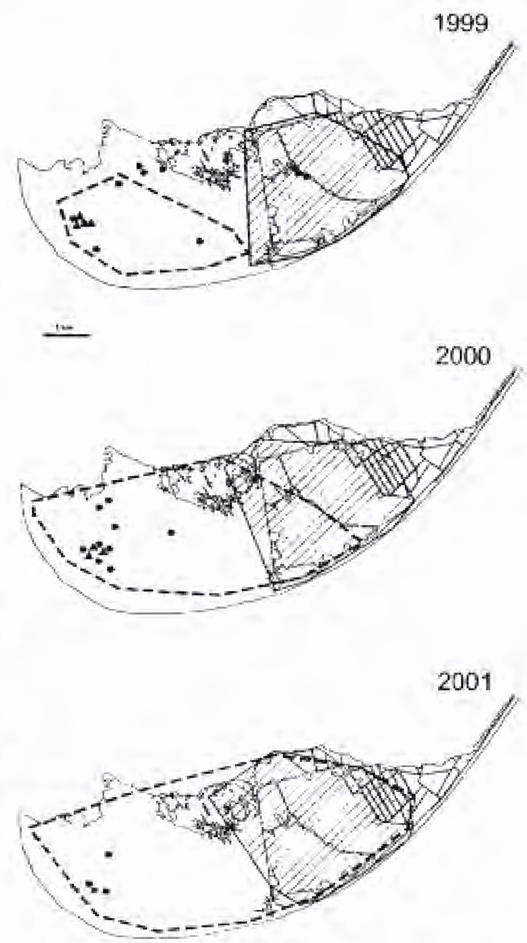

Figure 2. Distribution of colonies of Yellow-legged Gull and Audouin's Gull during the three years of the study, and active Fox's dens within its nesting grounds. Dots are Fox's dens and triangles, are breeding dens (used by families with cubs). Areas occupied by gull colonies are shown (solid line Audouin's Gull and dashed line Yellow-legged Gull).

should be noted that, in 2001, despite foxes passing through gull colonies on many occasions, there was not one case of gull mortality attributable to fox predation.

DISCUSSION

The Red Fox is a generalist predator (Artois 1989; Macdonald 1988). The increase of colonial waterbirds at the Ebro Delta has provided this species with abundant, predictable prey (Bailey 1993; Erwin *et al.* 2001), and the Red Fox has become a resident and breeding species in the Delta. The fox density was low in comparison with values in the literature (Artois 1989; López-Martín and Ruiz-Olmo 2002), and this may be explained by the recent arrival of foxes and by the removal of 30-50% of the adults each year. With this pressure of trapping and removal, which is not being counterbalanced by a sufficient immigration and successful breeding, the fox may soon disappear from the park.

Foxes were found in all habitats. Nevertheless, sites of dens were carefully selected, as was also suggested by Artois (1989) and Macdonald (1988). This selection is important as they provide a refuge, microclimatic stability and shelter (Artois 1989; Reichman and Smith 1990; Laureson 1994), and the infrequency of suitable places may also have limited the number of individuals present and breeding (Alt 1984; Oli *et al.* 1997).

In the study area, the foxes needed dry areas within sand dunes, well protected by vegetation, to establish dens; similar requirements were reported by Ennion and Tingerben

Table 4. The effect of predation on the Yellow-legged gull by the Red Fox in three different sectors at a series of distance zones from the main den occupied in 1991 in the La Punta de la Banya nature reserve (Ebro Delta Natural Park), during the second half of May 2001. Differences were statistically significant (Student t-test) at P < 0.001 for all the results indicated by *.

	Den area (0-300 m) (5)	Neighboring area (100-500 m)	Far area (500-2000 m)
Habitat	Dunes with dense vegetation	Flat area with some bushes	Flat area with mainly thin, disperse vegetation
Sampled area (ha)	1.75	4.50	6.00
Density of nests (nests/ha) (1)	17.7 (31)	11.8 (53)	21.8 (131)
Density of half-built nests (1)	10.3 (18)	8.8 (42)	3.3 (20)
% used/half-built nests	1.7	1.3	6.6
% of nests with eggs (2)	19	4.5	17
% of nests with chicks (2)	16	42	36
% of nests empty (3)	65	53	47
Average number of eggs/nest (4)*	1.0 ± 0	1.89 ± 0.93	2.17 ± 0.98
Average number of young/nest (4)*	1.60 ± 0.55	1.84 ± 0.69	1.95 ± 0.76

(1) The number of nests (N) is found in parentheses; (2) Refers only to the nests used for breeding; (3) Since this period is late in the breeding season it mainly refers to chicken that have flown the nest, although it includes those that have fallen prey and abandoned young; (4) Standard Deviation is also included; (5) This area is referred to a buffer (radius of 300 m) centred on the fox den.

(1966). In the Ebro Delta, foxes inhabited La Punta de la Banya for months without freshwater being available. This disagrees with the findings of Heptner and Naumov (1974) and Artois (1989), who indicated that the availability of water was an essential requirement for the creation of a den.

Specialization by individual foxes on different waterbird species was found in this study and has been reported elsewhere (Kruuk 1964; Frank 1979). The two most frequently consumed prey during 2000 and 2001 were ducks and gulls (mainly Yellow-legged Gull), and these jointly accounted for 83% of all prey. The internationally endangered bird species formed only 5% of the prey, except in 1999, when several hundred adult Audouin's Gulls were killed by foxes. The lower impact by foxes in more recent years is not due to lower efficiency by the predator or to the gulls having "learned" to elude foxes (which attack at night; Southern and Southern 1978). Rather, the reduced gull predation was a consequence of the position of the bird colonies with respect to the foxes' dens and their home ranges. Foxes tend to locate their dens near areas with an abundance of food (Artois 1989), and, when possible, they look for food close to the den. Dekker *et al.* (2001) showed that the Red Fox had relatively small home ranges (<250 ha) in coastal dunes. For these reasons, their effect on waterbird colonies is determined by the location of dens. The capture and removal of two foxes and their dens within the Audouin's Gulls colonies stopped the attacks on these gulls.

We know that the numbers and breeding success of Audouin's Gull in the Ebro delta has not varied appreciably in recent years (Oró 2000, 2001) and this is the case for other waterbirds in the study area (Parc natural del Delta de l'Ebre 2001). The role of the fox in the relationship with nesting waterbirds in the Ebro delta is complex. The effect of the fox on rare and threatened bird species is not always negative. The Yellow-legged Gull competes for space with Audouin's Gull (Pedrochii and Oró in press), and has been a greater problem than the fox. As a result, the predation by foxes on Yellow-legged Gulls has been an advantage to Audouin's Gulls, by reducing competition and predation. Foxes regularly visited the Yellow-legged Gull colonies. Further, the breeding of this gull is approximately three weeks earlier than that of Audouin's Gull, and is therefore more synchronized with that of foxes (Artois 1989; Ruiz-Olmo 1992). The fact that the fox adversely affects the Yellow-legged Gull may positively affect

Audouin's Gulls, and other threatened species, makes it possible to suggest a modification to the management strategy.

If the fox affected threatened species when there are dens within or close to colonies, it would be logical to prevent foxes from getting close to these colonies by using electric fences, physical barriers (Minsky 1980; McKillop and Sibley 1988; Erwin *et al.* 2001), or by preventing the establishment of dens in vulnerable areas. Fox control must be maintained especially near the colonies of threatened species. On the other hand, the fox could be left uncontrolled in areas inhabited by the Yellow-legged Gull, since they would help to regulate numbers of this gull. Of course, the fox is unlikely to determine the breeding success and survival of this gull on its own, but it can make an important contribution to management. The predation of foxes should probably be complemented by other action that will reduce the Yellow-legged Gull and prevent their moving towards areas of conflict with threatened species. This system would maintain some of the positive effects of predation (Bueno 1996).

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LITERATURE CITED

Alt, G. L. 1984. Black bear cub mortality due to flooding of natal dens. Journal of Wildlife Management 48: 1432-1434.

Artois, M. 1989. Le renard roux (*Vulpes vulpes* Linnaeus, 1758). Encyclopèdie des Carnivores de France 3: 1-90.

Bailey, E. P. 1993. Introduction of Foxes to Alaskan Islands. History, Effects on Avifauna, and Eradication. Fish and Wildlife Service (U.S. Dept. of the Interior), Resource Publication 193: 1-54.

Bueno, F. 1996. Importancia ecológica de los Carnívoros. Pages 171-182 *in* Carnívoros. Evolución, Ecología y Conservación. Consejo Superior de Investigaciones Científicas, Museo Naconal de Ciencias Naturales and Sociedad Española para la Conservación y el Estudio de los Mamíferos, Madrid, Spain.

Carss, D. N. and S. G. Parkinson. 1996. Errors associated with otter *Lutra lutra* faecal analysis I. Assessing general diet from spraints. Journal of Zoology. London 238: 301-317.

Collett, D. 1991. Modelling binary data. Champan and Hall. London.

Corbet, G. B. and S. Harris. 1991. The Handbook of Briths Mammals. Third Edition. Blackwell Science, Frome and London.

Dekker, J. J. A., A. Stein and I. M. A. Heitkönig. 2001. A spatial analysis of a population of red fox (*Vulpes vulpes*) in the Dutch coastal dune area. Journal of Zoology, London 255: 505-510.

Díaz, M., B. Asensio and J. L. Tellería. 1996. Aves Ibéricas I. No Paseriformes. J. M. Reyero, Ed. Madrid, Spain.

Ennion, E. A. R. and N. Tinbergen. 1967. Tracks. Clarendon Press. Oxford.

Erwin, R. M., B. R. Truit and J. E. Jiménez. 2001. Ground-nesting waterbirds and mammalian carnivores in the Virginia barrier island region: Running out of options. Journal of Coast Research 17: 292-296.

Frank, L. G. 1979. Selective predation seasonal variation in the diet of fox *Vulpes vulpes* in north-east Scotland. Journal of Zoology, London 189: 526-532.

Gosálbez, J. 1977. Herpetofauna i mastofauna del Delta de l'Ebre. Pages 303-321 *in* Els sistemes naturals del Delta de l'Ebre. Institució Catalana d'Història Natural, Barcelona.

Hagenmeijer, J. M. and M. J. Blair. 1997. The EBCC Atlas of European Breeding Birds. European Bird Census Council. T & A D Poyser, London.

Heptner, V. G. and N. P. Naumov. 1974. Die Säugetiere der Sowjetunion. II. Seekühe und Raubtiere. VEB Gustav Fischer Verlag. Jena, Germany.

Johnson, D. H. and A. B. Sargeant. 1977. The impact of red fox predation on the sex ratio of prairie mallards. U.S. Fish and Wildlife Service, Wildlife Research Reports 6: 1-56.

Kruuk, H. 1964. Predators and anti-predator behaviour of the black-headed gull (*Larus ridibundus* L.). Behaviour (Suppl.) 11: 1-130.

Kruuk, H. 1972. The urge to kill. New Scientist 54: 735-737.

Laureson, M. K. 1994. High juvenile mortality in heeahs (*Acinonyx jubatus*) and its consequences on maternal care. Journal of Zoology, London 234: 387-408.

López-Martín, J. M. and J. Ruiz-Olmo. 2002. Suivi et gestion des populations de renards et d'autres carnivores: implications pour le contrôle des prédateurs. Pages 64-69 *in* L'Etude et la Conservation des Carnivores (G. Chapron and F.Moutou, Eds.), Societé Française pour l'Etude et la Conservation des Mammifères, Paris.

Lovett, L., H. Kruuk and X. Lambin. 1997. Factors influencing use of freshwater polls by otters, *Lutra lutra*, in a marine environment. Journal of Zoology, London 243: 825-831.

Macdonald, D. W. 1988. Running with the fox. Urwin-Hyman. London.

McKillop, I. G. and R. M. Sibley. 1988. Animal behaviour at electric fences and the implications for management. Mammal Review 18: 91-103.

Minsky, D. 1980. Preventing fox predation at least tern colony with an electric fence. Journal of Field Ornithology 51: 180-181.

Oli, M. K., H. A. Jacobson and B. D. Leopold. 1997. Denning ecology of Black bears in the White River National Wildlife Refuge, Arkansas. Journal of Wildlife Management 611: 700-706.

Oró, D. 1998. Audouin's gull. Pages 47-61 in M. Ogilvie, Ed. BWP Update. Oxford University Press, Oxford.

Oró, D. 2000. Censo de nidificantes, reproducción y anillamiento de gaviota de Audouin (*Larus audoui-*

nii) en el Delta del Ebro (Campaña 2000). Universitat de Barcelona-Dept. de Medi Ambient, Barcelona.

Oró, D. 2001. Censo de nidificantes, reproducción y anillamiento de gaviota de Audouin (*Larus audouinii*) en el Delta del Ebro (Campaña 2001). Universitat de Barcelona-Dept. de Medi Ambient, Barcelona.

Oró, D. and R. Pradel, 2000. Determinants of local recruitment in a growing colony of Audouin's gull. Journal of Animal Ecology 69: 1-14.

Parc natural del Delta de l'Ebre (2001). Cens d'ocells nidificants. Temporada 2001. Parc Natural del Delta de l'Ebre, Deltebre, Spain.

Parés, E. and B. Borràs. 1997. Parcs naturals de Catalunya. Generalitat de Catalunya. Edicions 92. Barcelona.

Pedrochii, V. and V. Oró. In press. Pla de recuperació de la Gavina Corsa: Biologia i conservació. Documents dels Quaderns del Medi Ambient 10.

Petersen, M. R. 1982. Predation on seabirds by red foxes at Shaiak island, Alaska. Canadian Field Naturalist 96: 34-43.

Pils, C. M. and M. A. Martin. 1978. Population dynamics, predator-prey relationships and management of the red fox in Wisconsin. Wisconsin Department of Natural Resources Technical Bulletin 105: 1-56.

Plan Coordinado de Actuaciones de la Gaviota de Audouin. 1994. Ecología y situación de la gaviota de Audouin en España. Quercus 100: 4-11.

Queral, J. M. and J. M. Borrero. 1999. Peixos, amfibis i plantes aquàtiques del Delta de l'Ebre. Parc natural del Delta de l'Ebre. Deltebre, Spain.

Reichman, O. J. and S. C. Smith. 1990. Burrows and burrowing behaviour by mammals. Current Mammalogy 2: 197-244.

Ruiz-Olmo, J. 1992. Datos sobre el ciclo reproductor y el "sex-ratio" del zorro (*Vulpes vulpes* L.) en el Vallès Oriental (NE de la Península Ibérica). Historia Animalium 1: 121-127.

Ruiz-Olmo, J. and A. Aguilar. 1995. Els Grans Mamífers de Catalunya i Andorra. Lynx Edicions, Barcelona.

Ruiz, X., L. Jover, D. Oró, J. González-Solís, V. Pedrocchi, V. Roca, M. Genovart, J. C. Abella, J. S. Aguilar and M. Lafuente. 1996. Ecología y dinámica de la población de la gaviota de Audouin (*Larus audouinii*). ICONA-Universitat de Barcelona, Barcelona.

Sargeant, A. B. and L. E. Eberhardt. 1975. Death feigning by ducks in response to predation by red foxes. American Midwest Naturalist 94: 108-119.

Sargeant, A. B., S. H. Allen and R. T. Eberhardt. 1984. Red fox predation on breeding ducks in midcontinent North America. Wildlife Monographs 89: 1-4.

Siegel, S. 1956. Nonparametric statistic for the behavioural Sciences. MacGraw-Hill, New York.

Southern, L. K. and W. E. Southern. 1978. Absence of nocturnal predator defense mechanisms in breeding gulls. Proceedings Colonial Waterbird Group: 157-162.

Southern, W. E., S. R. Patton, L. K. Southern and L. A. Hanners. 1985. Effects of nine years of fox predation on two species of breeding gulls. Auk 102: 828-833.

Storm, G. L., R. D. Andrews, R. L. Phillips, R. A. Bishop, D. B. Siniff and J. R. Tester. 1976. Morphology, reproduction, dispersal and mortality of midwestern red fox populations. Wildlife Monographs 49: 6-82.

Weber, D. 1985. Zur Baubenutzung und ihrer Funktion beim Fuchs (*Vulpes vulpes*). Zeitschrift für Säugetierkunde 50: 356-368.

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Landscape genetics of the nonnative red fox of California

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Abstract

Invasive mammalian carnivores contribute disproportionately to declines in global biodiversity. In California, nonnative red foxes (*Vulpes vulpes*) have significantly impacted endangered ground-nesting birds and native canids. These foxes derive primarily from captive-reared animals associated with the fur-farming industry. Over the past five decades, the cumulative area occupied by nonnative red fox increased to cover much of central and southern California. We used a landscape-genetic approach involving mitochondrial DNA (mtDNA) sequences and 13 microsatellites of 402 nonnative red foxes removed in predator control programs to investigate source populations, contemporary connectivity, and metapopulation dynamics. Both markers indicated high population structuring consistent with origins from multiple introductions and low subsequent gene flow. Landscape-genetic modeling indicated that population connectivity was especially low among coastal sampling sites surrounded by mountainous wildlands but somewhat higher through topographically flat, urban and agricultural landscapes. The genetic composition of populations tended to be stable for multiple generations, indicating a degree of demographic resilience to predator removal programs. However, in two sites where intensive predator control reduced fox abundance, we observed increases in immigration, suggesting potential for recolonization to counter eradication attempts. These findings, along with continued genetic monitoring, can help guide localized management of foxes by identifying points of introductions and routes of spread and evaluating the relative importance of reproduction and immigration in maintaining populations. More generally, the study illustrates the utility of a landscape-genetic approach for understanding invasion dynamics and metapopulation structure of one of the world's most destructive invasive mammals, the red fox.

Introduction

Invasive species can have detrimental effects on native communities and threatened or endangered prey populations through competition or maladaptive hybridization with closely related taxa (Rhymer and Simberloff 1996; Genovesi 2009; Doherty et al. 2015). Understanding the landscape level processes of invasions and factors maintaining invasive species is important to inform management strategies, for example, by identifying locations where control efforts are likely to be most effective (Lecis et al. 2008; Berry and Kirkwood 2010; Estoup and Guillemaud 2010; Fraser et al. 2013) and, more generally, by providing a conceptual understanding sufficient to prevent or manage future invasions.

Among invasive species, mammalian predators contribute disproportionately to declines in global biodiversity, and within this group the red fox (*Vulpes vulpes*) lists among the top-2 species in terms of global impact (Doherty et al. 2015; the other being the house cat). Red foxes are typically monogamous, with breeding pairs maintaining exclusive territories, and young dispersing and potentially breeding in their first year (Voigt 1987). Dispersal tends to be male-biased in terms of frequency, with females more often remaining on the natal territory as nonbreeding helpers, but distances of dispersers of both sexes can be up to 400 km or more (Allen and Sargeant 1993). In the absence of physical barriers or competitors, such as coyotes or native foxes, invading red foxes have the capacity for rapid geographic expansion (Lewis et al. 1999; Sacks et al. 2011; Abbott et al. 2014; Kasprowicz et al. 2016).

The most devastating impacts of red foxes have been associated with introductions of wild-caught individuals to locations where the species was formerly absent (Bailey 1993; Woinarski et al. 2015). However, the rapid propagation of fur farms beginning in the early 1900s led to an explosion in the numbers of introductions (inadvertent and deliberate) of captive-reared red foxes, particularly within the United States (Bailey 1993; Lewis et al. 1999; Long 2003; Bryce et al. 2011; Statham et al. 2012). Where they have become established, these captive-derived (i.e., feral) foxes have impacted numerous endangered ground-nesting bird species and threatened the genetic integrity of native red foxes through hybridization (Lewis et al. 1999; Sacks et al. 2011).

Although ultimately derived primarily from wild eastern Canadian and Alaskan ancestry, fur-farm red foxes reflect multiple generations of selective breeding for a variety of traits such as tameness, high fecundity, and even polygyny (Dearborn 1915), which potentially increase their invasiveness and predispose them to success in human-dominated environments. In contrast to Australian invasive red foxes, which derive from wild-caught European individuals that spread to remote habitats throughout the continent (Statham et al. 2014), introduced farm-reared foxes in the United States have tended to establish relatively localized populations in close proximity to humans, in urban or agricultural landscapes (Aubry 1984; Lewis 1994; Statham et al. 2012; Kasprowicz et al. 2016). In densely human-populated regions, such as along the east and west coasts of the United States, introduced red foxes can occur over large continuous ranges interspersed with native populations, which can serve to obscure their population structure (Lewis et al. 1999; Sacks et al. 2011; Kasprowicz et al. 2016).

Development of effective management strategies is often hindered by lack of understanding about the population structure, including connectivity, specific routes of spread, relative roles of reproduction or immigration in sustaining local populations, and potential for interbreeding with native populations. Genetic tools provide a means of elucidating points of introduction, identifying hybridization with native relatives, as well as reconstructing routes of spread and assessing the relative roles of continued immigration versus reproduction in sustaining local invasive populations (Hampton et al. 2004; Lecis et al. 2008; Kidd et al. 2009; Berry and Kirkwood 2010; Estoup and Guillemaud 2010; Sacks et al. 2011; Beauclerc et al. 2013; Fraser et al. 2013).

Limited genetic studies of fox farms from throughout the world (Sacks et al. 2009; Statham et al. 2011, 2012) confirm the general understanding (e.g., Dearborn 1915) that they derive primarily from populations of eastern Canada and Alaska, with some contribution from the Washington Cascades. However, virtually nothing is known about the particular genetic composition and structure among the many 20th-century fox farms in the United States, including the 69 farms known to have been established in California during the early 1900s (Lewis et al. 1999). It appears that most operations in the western United States were small and started from as few as one or two breeding pairs purchased from larger breeders in the East or Midwest (Westwood 1989). Thus, it seems likely that different farms contained small, potentially differentiated subsets of the available fur-farm stock. Moreover, there are very few records of escapes or releases with which to generate specific hypotheses about the sources, origins, and routes of spread by nonnative red foxes. Therefore, most of our understanding of fur-farm ancestry stems from genetic analyses of contemporary feral populations inferred to have been derived as escapees or releases from fur farms (e.g., Perrine et al. 2007; Sacks et al. 2010a,b; Statham et al. 2012; Kasprowicz et al. 2016). In the West, nonnative red foxes occur in low-elevation parts of Washington, Oregon, California, Utah, Colorado, Nevada, and Idaho, although their distributions are not well documented in many of these states and often difficult to know without genetic analyses to differentiate the typically higher-elevation native red foxes (Statham et al. 2012).

In California, nonnative red foxes were initially documented in the early to mid-1900s in two locations 650 km apart (Southern California [SO], Sacramento area), with no evidence of expansion until the 1970s (Vail 1942; Gray 1975; Lewis et al. 1999; Sacks et al. 2011). Between the mid-1970s and mid-1990s (by which time, no extant fox farms occurred within California), nonnative red fox range increased to a seemingly continuous span covering an area of ~170,000 km^2, which implied a continuous increase in area of ~20% per year (Lewis et al. 1999). While this type of exponential growth is typical of successful invading species, Lewis et al. (1999) hypothesized that it resulted from an increase in the frequency of human introductions and transplantations in the late twentieth century, rather than wholesale expansion from the one or both of the initial concentrations. In particular, the rise of the nonnative red fox in California corresponded in time to the demise of the state's fur-farm industry, suggesting the possible role of deliberate releases from defunct fur farms (Harvey et al. 1992).

In the present study, we used 13 microsatellites and ~700 bp of mitochondrial DNA (mtDNA) of 402 nonnative red foxes collected from throughout lowland areas of California to investigate numbers of introductions, routes of spread, and contemporary connectivity among populations. The broader purpose of this study was to understand as completely as possible the "anatomy" of the red fox invasion of California both to assist in its management and to provide guidance to management of other nonnative red fox populations. Our first objective was to test hypotheses relating to the mechanics of the range increase. If the contemporary range reflected a sudden expansion from one or two locations, we expected to see a pattern of high genetic connectivity (e.g., low F_{ST}) or isolation by distance. In contrast, if the contemporary range reflected many independent introductions of small numbers of individuals, we expected to observe substantial genetic structure with little relationship to proximity. Our second objective was to elucidate patterns of contemporary connectivity, which potentially affect the maintenance of particular populations or the entire metapopulation. To accomplish this, we applied a combination of population genetic statistics and ordination, tree-based, and Bayesian clustering approaches to elucidating population structure free of spatially explicit models, and landscape resistance surface modeling approaches that tested explicit habitat-based hypotheses about connectivity. We also investigated whether some populations were dependent on immigration ("sinks") from other populations ("sources") for persistence (Pulliam 1988).

Materials and Methods

Samples

We obtained most of our sample over a 15-year period spanning 1996–2010, and small numbers of additional samples from as far back as the early 1900s, which enabled us to investigate stability of genetic patterns to more directly assess these postestablishment dynamics. We obtained samples for genetic analyses primarily from foxes removed in predator control activities aimed at protecting endangered prey species. As a consequence, most of our sampling reflects some spatial clustering in localized sampling sites (Fig. 1A). For convenience, we therefore used discrete sampling sites as a basis of several analyses, although we did not consider sites to represent biologically meaningful population units. The dispersion of samples varied among sites, in some cases reflecting somewhat arbitrary groupings (e.g., San Joaquin Valley [SJV-S]); the grouping of such samples with a particular site was decided independently of genetic data, based solely on considerations of sample size, proximity, and commonality to a landscape (e.g., within the same valley). Consequently, it is likely that some sites contained multiple populations and some populations were spread across multiple sites. In total, we sampled 402 red foxes from 13 sites scattered across most of the known range of the nonnative red fox in California. These sites encompassed the range of nonnative red fox occurrence identified by Lewis et al. (1999), except the southernmost extent of San Diego, where foxes apparently were extirpated, and most of the Sacramento Valley, which was subsequently (to that study) found to contain the native Sacramento Valley red fox (Perrine et al. 2007; Sacks et al. 2010a,b; Fig. 1A). We included samples from the southern end of the Sacramento Valley, a known contact zone between native and nonnative red foxes (Sacks et al. 2011). After necropsy and tissue sampling, vouchers for many of these samples (n = 157) were accessioned in the UC Berkeley Museum of Vertebrate Zoology or other collections (n = 16). Data for these and all unaccessioned (i.e., all) samples were deposited in the Dryad Digital Repository (DOI No.: doi: 10.5061/dryad.hj722). For the purposes of distribution modeling, we used an independent data set of 349 red fox occurrence records that were obtained by Lewis et al. (1993) through a statewide survey of wildlife biologists and managers, including rigorous screening for reliability (Fig. 1B).

Laboratory procedures

We conducted DNA extraction, polymerase chain reaction (PCR) amplification, sequencing, and genotyping at the Mammalian Ecology and Conservation Unit of the Veterinary Genetics Laboratory of University of California, Davis. We extracted DNA from tissue (n = 379) and bone (n = 4) specimens using the DNeasy® tissue kit (Qiagen Inc., Valencia, CA), and from scats (n = 19) using the QIAamp® Stool Kit (Qiagen, Inc.). Primers, PCR chemistry, and cycling conditions for the mtDNA D-loop and cytochrome *b* loci were as previously reported (Perrine et al. 2007; Aubry et al. 2009; Sacks et al. 2010a,b; Statham et al. 2012) as were those for the 13 microsatellite loci. We included all microsatellite loci used by Sacks et al. (2010a,b), except for FH2001, which exhibited a null allele. All mtDNA analyses were based on a 696-bp portion of the mitochondrial genome composed of 354 bp of the cytochrome *b* gene and 342 bp of the D-loop. These subsets were used in previous analyses (e.g., Perrine et al. 2007; Aubry et al. 2009; Statham et al. 2012, 2014), facilitating direct comparison.

Within-population analyses

We estimated the mtDNA haplotype frequencies and gene diversity for each sampling site (Nei 1987). Using microsatellites, we estimated observed and expected

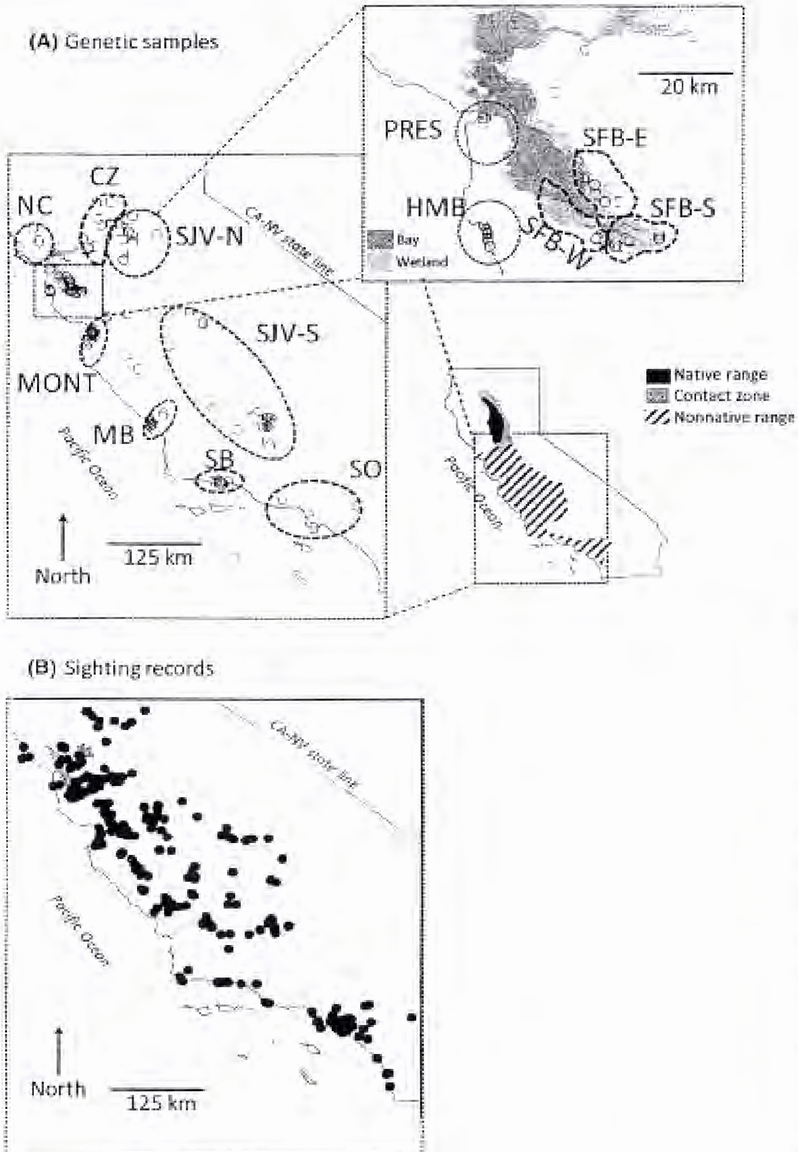

Figure 1. Distribution of nonnative red fox locations from central and southern California (SO), including (A) 402 genetic samples collected for this study and (B) 349 high-reliability sighting records independently assembled by Lewis et al. (1993) and used in the present study to construct a landscape resistance model. (A) Inset of California, illustrating ranges of native, nonnative red foxes, and their contact zone (CZ); dashed polygons indicate the following sampling sites: North coastal (NC), native–nonnative contact zone (CZ), San Joaquin Valley (SJV) north (-N) and south (-S), Monterey (MONT), Morro Bay (MB), Santa Barbara (SB), SO, and, in the inset (upper right), Presidio of San Francisco (PRES), Half Moon Bay (HMB), and the San Francisco Bay wetlands (SFB) south (-S), east (-E), and west (-W). Miscellaneous samples not associated with the 13 primary sampling sites are also shown.

heterozygosity, allelic richness, F_{IS}, and tested for deviations in Hardy–Weinberg and gametic equilibrium using permutation tests in FSTAT (version 2.9.3.2; Goudet 1995), followed by sequential Bonferroni corrections (Rice 1989). We estimated the genetic effective population size based on the bias-corrected linkage disequilibrium method (Waples 2006) implemented in LDNE (Waples and Do 2008). We assumed random mating based on evidence for a high frequency of mixed-parent litters in other lowland foxes (Converse 2012), excluded alleles with <0.05 frequency, and used jackknife-based confidence intervals (Waples and Do 2008). To assess signatures of demographic bottlenecks owing to founder effects, we tested microsatellites for heterozygote excess relative to expectation under mutation–drift equilibrium using program Bottleneck v 1.2.02 (Piry et al. 1999). We relied primarily on the 2-phase mutation model assuming 70% stepwise mutations, but also report significance with respect to the infinite alleles model (IAM) and stepwise mutation model (SMM; Cornuet and Luikart 1996). We used two-tailed Wilcoxon tests to assess statistical significance.

Population structure

To characterize population structure, we computed a matrix of pairwise genetic distances (Nei's D_A; Takezaki and Nei 1996) and used these values to generate a neighbor-joining tree, with bootstrap values calculated from 999 resampling cycles on loci using program Populations 1.2.30 (O. Langella, 1999; http://bioinformatics.org/~tryphon/populations/). For comparison to other studies, we computed standard allele-frequency-based estimates of F_{ST} for both mtDNA haplotypes and microsatellites in Arlequin 3.1 (Excoffier et al. 2005). We estimated the ratio of male to female gene flow using the global F_{ST} estimates for mtDNA and microsatellites as described by Hedrick et al. (2013, eq. 7c). For use in the population genetic distance-based analyses described below, we linearized the mtDNA estimates of F_{ST} as follows: $F_{ST}/(1 - F_{ST})$ (Rousette 1997). To visualize relative genetic distances among individuals, we used a principle coordinates analysis (PCoA) based on genotypic covariance, implemented in Genalex (Peakall and Smouse 2006).

Landscape-genetic analyses

To assess connectivity relative to the landscape, we employed empirical and model-based approaches using population genetic distances for both microsatellites (D_A) and mtDNA ($F_{ST}/[1 - F_{ST}]$). First, to visualize barriers and corridors affecting gene flow based solely on genetic distances (i.e., independently of any a priori model of landscape resistance), we used an approach similar to that by Keis et al. (2013) whereby we mapped and interpolated residuals from a regression of pairwise genetic distance on Euclidean distance (in km). This approach effectively exposed locations corresponding to greater-than- or less-than-expected genetic distances between sampling points, while removing any potential influence of separation distance. We used the centroids of sampling sites, rather than individuals, as sample units to avoid biases associated with our spatially clustered samples. We mapped the midpoints between each pair of sites and used inverse distance-weighted averaging among their associated residual values (i.e., observed minus expected genetic distance) to assign interpolated values to raster layer covering the study area. We examined general concordance of apparent barriers/corridors with major landscape features, rather than evaluating statistical support for any particular putative barrier or corridor. To assess whether such general correspondence could reflect chance, we conducted several permutations of midpoints to randomize them with respect to their associated genetic distances, simultaneously permuting rows and columns (Legendre 2000), and interpolated each permutation as described above (Fig. S1).

Next, we used the independent data set of 349 red fox occurrence records (Lewis et al. 1993) to derive a species distribution model, which we inverted for use as a hypothetical resistance surface to test against our genetic distance data (Fig. 1B). The occurrence records were based on telephone interviews with wildlife professionals and vetted for reliability on the basis of the interviewee's experience with the species, accuracy of the physical description, and documentation of exact date and location (Lewis et al. 1993). We developed the species distribution model using Maxent (v. 3.3; Phillips et al. 2006) to relate occurrences to the following landscape variables: Elevation, Shrubland, Forest, Woodland, Grassland, Urban-Agriculture, and Wetland (Appendix S1). Although occurrence reports likely reflected some bias toward locations where individuals spent most of their time, the wildlife professionals interviewed worked in a variety of habitats, many of which were remote. Therefore, we doubt that such biases would have been severe enough to substantially misrepresent the underlying habitat associations of the foxes, particularly given the relatively broad extent and coarse grain of our analysis. Because our purpose was to obtain a model that improved our understanding of gene flow on the landscape, rather than to understand habitat associations mechanistically, the ultimate value our model (i.e., resistance surface) depended on its ability to predict connectivity.

We evaluated the fit of this resistance surface based on correlation to genetic distances, which was an independent data source from that used to construct it. We used program Circuitscape to produce matrices of pairwise landscape resistance based on our landscape resistance model (McRae et al. 2008). We employed simple and partial Mantel tests to assess correlations between resistance matrices, Euclidian distance matrices, and genetic distances, specifically to assess whether the resistance model explained genetic distance significantly better than did Euclidian (geographic) distance. We conducted the Mantel tests in program Passage 2 because it uses an unbiased permutation method to assess significance (Legendre 2000; Rosenberg and Anderson 2011). Euclidean and resistance distances were log transformed prior to analysis (Rousette 1997).

Metapopulation dynamics

To investigate the directionality of gene flow between sampling sites, we used an assignment approach similar to that by Berry and Kirkwood (2010). Although the Bayesian method implemented in BIMr is, in principle, a more comprehensive approach to inferring directional gene flow patterns among sites within a metapopulation (Faubet and Gaggiotti 2008), our preliminary attempts to use this method produced inconsistent results, most likely because our sample size for most sites was below the recommended minimum ($n \geq 50$ per site). We therefore used program

Structure (v. 2.0) to cluster samples on the basis of genotype frequencies and then examined the spatial distribution of cluster assignments (Pritchard et al. 2000). In a structured population, each cluster would be expected to correspond to a particular sampling site and migrants could be identified as individuals assigning to a cluster other than that in which they were sampled. A sink population could then be characterized as one with many individuals assigning to one or more external sites, whereas a source population would contain individuals primarily assigned to the home population. In the case of extinction–recolonization dynamics, we would expect to see the cluster assignments change over time within a sampling site.

All Structure runs were conducted assuming admixture with correlated allele frequencies (Pritchard et al. 2000; Falush et al. 2003). After 10 replicate runs of 20,000 Markov Chain Monte Carlo (MCMC) cycles (first 10,000 discarded as burn-in) at each number of clusters (K), we performed a final run at each K consisting of 550,000 cycles (the first 50,000 discarded). We tested increasing values of K until the ln $P(D)$ either decreased or became notably more variable among replicate runs for 2 consecutive values of K. It is common to analyze patterns in "log probabilities of the data" associated with choices of K to infer the "correct" or "best" number of clusters describing structure of a population (e.g., Evanno et al. 2005). However, doing so to the exclusion of alternative choices of K can be misleading, particularly if populations are structured hierarchically (or are structured in other ways that deviate from a simple island model). Therefore, we developed an approach here that integrates multiple levels of K into "cluster profiles" characteristic of each sample, and then uses the most common cluster profiles among samples to assess hierarchical structure (Appendix S2, Figs. S2, S3). To optimize our ability to infer migration among sites, we chose the highest K for which assignments nested within those at lower levels of K. To assess potential influences of uneven sample size on results, we ran analyses with a smaller random subsample from the more heavily sampled sites and found little difference from the complete data set (Appendix S3, Figs. S5–S8).

Results

Mitochondrial data set

We obtained mitochondrial sequences and/or microsatellite genotypes from 402 red foxes from 13 predefined sampling locations, including two 1920s foxes from the native-nonnative contact zone. We obtained 392 full cytochrome b and D-loop mitochondrial sequences (Table 1). All except one haplotype, A-273, had been previously described. This haplotype (A-273) differed from haplotype A-63 by 1 substitution in the D-loop fragment, which was deposited in GenBank (Accession No. KU244024).

The gene diversity was high for the total sample (0.73) relative to gene diversities within sampling sites ($\bar{X}$ = 0.37, standard deviation [SD] = 0.23; Table 1). This pattern corresponded to a global estimate of F_{ST} = 0.49 (i.e., 1 − 0.37/0.73), and all but three haplotypes were restricted to ≤3 sampling sites, indicating considerable population structure (Fig. 2). Pairwise F_{ST} estimates averaged 0.54 (range: 0–1; Table S1). The two most

Table 1. Gene diversity and distribution of 10 mitochondrial haplotypes discovered in 392 red foxes from 13 samples and miscellaneous sites in California. Sampling sites include the following abbreviations. Half Moon Bay (HMB), Santa Barbara (SB), and San Joaquin Valley (SJV). The particular location of 10 samples from somewhere in the San Francisco Bay wetlands (SFB) was unknown (unk).

Samples	n	Gene diversity	D-19	O-26	N-7	G-38	A-273	E-9	I-9	F-12	F-14	K-36
SFB South	44	0.428	–	1	9	1		–	–	32	1	–
SFB East	54	0.205	–	–	48	2	–	–	1	3		–
SFB West	17	0.208	–	–	2		–	–	–	15		–
SFB-unk	10	–		–	2	4	–	–	–	4	–	–
Half Moon Bay	24	0.517	–	7	2	15	–	–		–	–	–
Monterey	115	0.235	–	1	4	100	–	–	–	10	–	–
Morro Bay	19	0.100		–	1	18	–	–		–	–	
Santa Barbara	13	0.000	–	–	–		–	–	–	–	–	13
SJV North	33	0.691	–		5	14		–	–	10	4	–
SJV South	28	0.513	–	–	7	3	–	18	–	–		–
Southern CA	9	0.593		–		–	2		5	2	–	–
Contact zone	9	0.593	5	–	1	3	–	–		–	2	–
North coastal	5		–		–	5		–	–	–	–	–
Presidio	4		–	3	–	1		–			–	–
Miscellaneous	6	–	–		–	4	–	–	1	1		–
Total	392	0.726	5	12	81	170	2	18	7	77	7	13

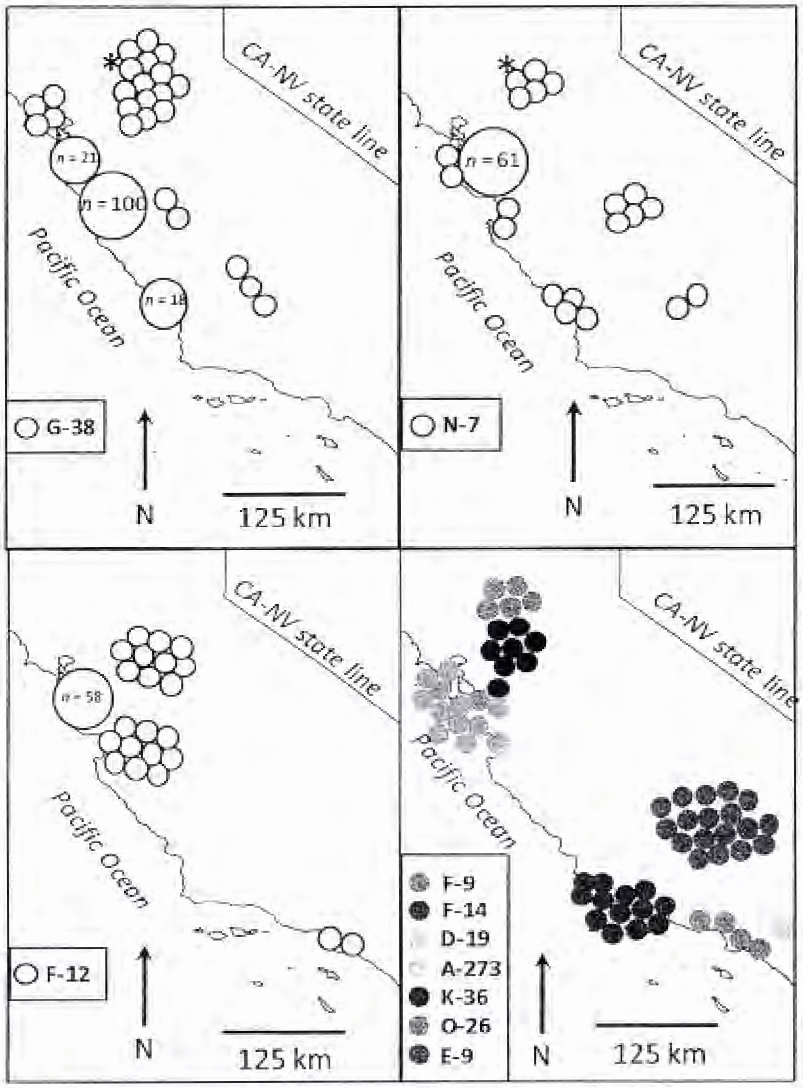

Figure 2. Distribution of 10 mitochondrial haplotypes from 392 red foxes sampled from central and southern California. Top and left panels each depict a single relatively widespread haplotype, whereas the bottom right panel shows the distribution of seven localized haplotypes. All haplotypes are nonnative except for D-19, which is endemic to the native Sacramento Valley red fox and found only in the contact zone between these and nonnative red foxes. Asterisks indicate the locations of two red foxes sampled from near Davis, California, in the 1920s.

widespread haplotypes were G-38 and N-7, which also were found in two specimens (UC Davis, Museum of Wildlife and Fish Biology, Catalog Nos. 10z, 17z) collected in the 1920s in southern Yolo County near an active fur farm (Lewis et al. 1999).

Microsatellite data set

We obtained genotypes from 381 of the 402 red foxes in 13 sampling sites, including 10 sites with 9–115 foxes each (Table 2). In total, we observed 106 alleles across 13 loci for which we genotyped 10–13 loci each (average No. loci = 12.8 loci). No single locus showed significant deviation from Hardy–Weinberg or gametic equilibrium in any sampling site. However, in the entire sample combined, all loci deviated significantly from Hardy–Weinberg equilibrium and 27 of 78 locus pairs deviated from gametic equilibrium, indicating considerable population structure in the total data set. The estimate of global F_{ST} (theta) was 0.086 (95% CI: 0.074–0.098). Pairwise F_{ST} estimates averaged 0.10 (range: 0.01–0.18; Table S1). Using the formula of Hedrick et al. (2013) with mtDNA and nuclear global F_{ST} estimates indicated a ratio of male to female gene flow of 4.2.

Observed heterozygosity was lowest in the three San Francisco (SF) Bay Area sampling sites (0.51–0.52) and highest in the northern SJV (0.67), followed closely by Monterey and Half Moon Bay (0.64 each) sites (Table 2). Expected heterozygosity (ranging 0.55–0.71) and allelic richness (ranging 2.2–2.6) were less variable, with most

Table 2. Population genetic statistics based on 13 microsatellite loci for 349 nonnative red fox from 10 sampling sites in California, including expected (assuming Hardy–Weinberg equilibrium) heterozygosity (H_e), observed heterozygosity (H_o), allelic richness (AR), inbreeding coefficient (F_{IS}), genetic effective population size (N_e), and significance (**, ***) of the Wilcoxon test for heterozygote excess indicative of a population bottleneck.

Sampling site	n	H_o (SE)	H_e (SE)	AR (SE)	F_{IS}	N_e (95% CI)	Bottleneck
South SF Bay	44	0.51 (0.02)	0.60 (0.05)	2.3 (0.1)	0.15*	21.7 (14.8–33.3)	**
East SF Bay	54	0.51 (0.02)	0.61 (0.05)	2.4 (0.1)	0.17*	18.4 (12.7–27.2)	**
West SF Bay	17	0.52 (0.03)	0.55 (0.05)	2.2 (0.1)	0.06	14.8 (7.7–37.0)	***
HMB	24	0.64 (0.03)	0.66 (0.05)	2.5 (0.2)	0.04	13.9 (8.6–24.2)	***
Monterey	115	0.64 (0.01)	0.69 (0.03)	2.6 (0.1)	0.08*	44.6 (28.9–73.0)	***
Morro Bay	18	0.57 (0.03)	0.60 (0.04)	2.3 (0.1)	0.05	2 (1.6–2.5)	***
SB	11	0.60 (0.04)	0.65 (0.04)	2.4 (0.1)	0.07	6.3 (2.9–13.1)	***
SJV North	29	0.67 (0.02)	0.68 (0.04)	2.6 (0.1)	0.02	12.6 (8.9–18.3)	***
SJV South	28	0.58 (0.03)	0.66 (0.05)	2.5 (0.1)	0.12*	31 (18.2–69.9)	**
Southern CA	9	0.56 (0.05)	0.71 (0.04)	2.6 (0.1)	0.22*	23.8 (10.9–260.4)	**

HMB, Half Moon Bay; SB, Santa Barbara; SJV, San Joaquin Valley; SE, standard error; IAM, infinite alleles model; SF, San Francisco; SMM, stepwise mutation model.

*$P < 0.05$. **$P < 0.01$ for IAM and TPM, not significant ($P > 0.05$) for SMM. ***$P < 0.01$ for IAM and TPM, $P < 0.03$ for SMM.

estimates falling within 2 standard errors of others. Five sites showed no statistically significant heterozygote deficiency, whereas five sites exhibited F_{IS} values significantly greater than zero (ranging 0.08–0.22), suggesting the presence of admixture. Genetic effective population size estimates ranged from 2 (95% CI: 1.6–2.5) in Morro Bay to 44.6 (28.9–73.0) in Monterey. All populations showed signatures of demographic bottlenecks, consistent with founder effects (Table 2). The neighbor-joining tree based on Nei's D_A indicated 3 sets of sites that clustered with moderate to high bootstrap support: (1) the SF Bay sampling sites; (2) Half Moon Bay and Monterey; and (3) Santa Barbara (SB) and SO (Fig. 3A). Additionally, within the SF Bay sampling sites, the West SF Bay and South SF Bay clustered together relative to the East SF Bay, consistent with a clockwise stepping-stone pattern of founding around the Bay. Except for the SF Bay populations, the positioning of populations relative to one another were consistent with their spatial arrangement on the landscape and, although not well supported by bootstrapping, both SJV sampling sites clustered together in the final tree. The PCoA similarly grouped the three SF Bay sites together as relatively distinct from the other sites (Fig. 3B).

Connectivity across the landscape

Interpolation of surfaces from spatially explicit genetic distances produced highly concordant results between mitochondrial (Fig. 4A–C) and microsatellite (Fig. 4D–F) markers. Superimposing these model-free surfaces over topographic relief showed a correspondence between low gene flow and mountainous terrain (coastal mountains) and between high gene flow and flat terrain (SJV; Fig. 4). Generally, the valley habitats promoting high gene flow also corresponded to urban and agricultural habitats. Permutations indicated low cumulative areas of genetic barrier and no meaningful or consistent geographic patterns for either marker, effectively ruling out the possibility that the observed patterns and their agreement between markers were artifactual (Fig. S1).

The Maxent model based on the independently collected sighting records predicted the highest probability of occurrence in the low-elevation, flat urban and agricultural habitats of the Central Valley and smaller coastal valleys, with low occurrence in the coastal and interior mountains (Fig. 5A). Although our use of incidental visual observations likely entailed some bias toward habitats where interviewees spent the most time, the high consistency of the habitat associations, including virtual absence of sightings in the higher mountainous habitats, supports the model, qualitatively. More importantly, the purpose of this model was to serve as a hypothesis for the rules governing landscape connectivity, which we tested with independent data.

Specifically, we used the inverse of this model as a resistance surface with which to project a hypothetical connectivity (or, in circuit-theory parlance, "current") map (Fig. 5B). Confronting the model with genetic data indicated a substantial improvement over the use of Euclidian distance as a predictor of genetic distance. Specifically, simple Mantel tests were significant for correlations between microsatellite genetic distance (D_A) and both landscape resistance ($r = 0.73$, $P < 0.0001$) and Euclidian distance ($r = 0.54$, $P < 0.001$), but the partial Mantel test was significant only for landscape resistance with Euclidian distance held constant ($r = 0.65$, $P < 0.001$), but not for Euclidian distance with landscape resistance held constant ($r = -0.35$, $P = 0.98$). The

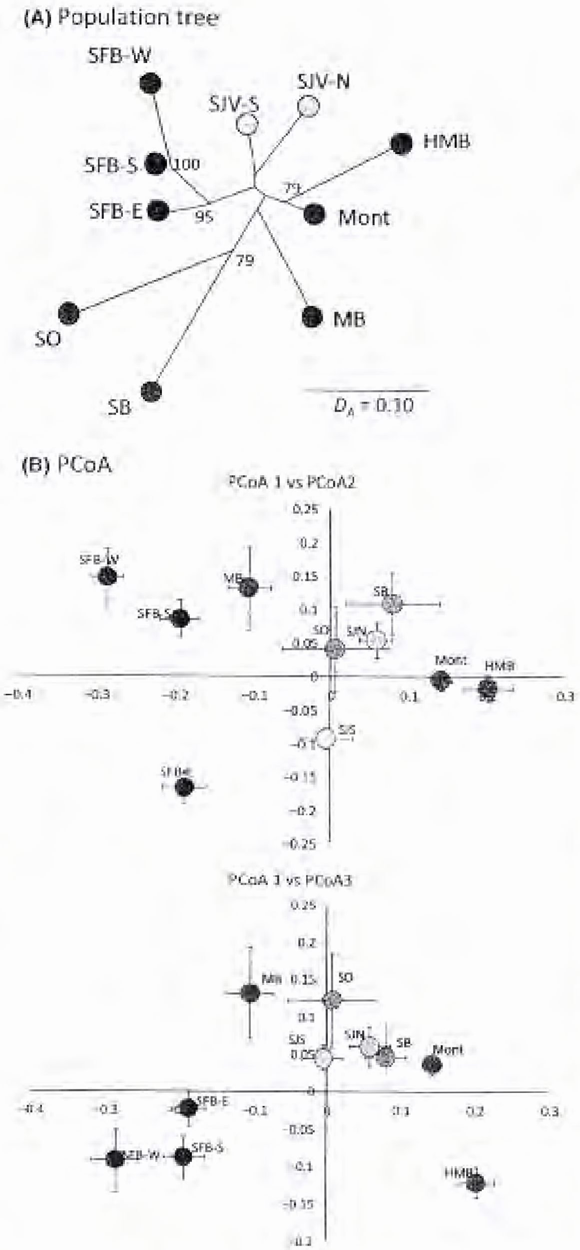

Figure 3. Genetic distances among 10 nonnative red fox sampling sites estimated from 13 microsatellite loci (n = 349 foxes), including (A) an unrooted neighbor-joining tree based on Nei's D_A with bootstrap support >65% indicated, and (B) principle coordinates (PCoA), including centroids and standard errors along two axes. Sampling sites were San Joaquin Valley (SJV) north (-N) and south (-S), Monterey (Mont), Morro Bay (MB), Santa Barbara (SB), Southern California (SO), Half Moon Bay (HMB), and the San Francisco Bay wetlands (SFB) south (-S), east (-E), and west (-W). Samples were color-coded for convenience to distinguish sites of the San Francisco Bay area (red), central coast (blue), inland (yellow), and south coast (green).

mtDNA-based correlations were nonsignificant for landscape resistance and Euclidian distance in both simple and partial Mantel tests.

Metapopulation dynamics

To infer source–sink relationships between sampling sites and whether populations were extirpated and then replaced by colonists from other populations, we first conducted an admixture analysis to elucidate meaningful population units from sampling sites. In this analysis, the greatest increase in posterior probability per increase in K corresponded to $K = 2$ (Figs. S2–S4, Appendix S2), which grouped all of the 3 SF Bay sites into one cluster, consistent with the previous analyses showing the SF Bay area to be distinct. However, the posterior probability continued to increase approximately linearly with increasing levels of K, indicating additional structure nested within each of these $K = 2$ primary clusters (Fig. S2). Clusters nested hierarchically up to $K = 8$, except for the Morro Bay sampling site, which did not consistently associate with any other particular sampling site (Figs. S3, S4, Appendix S2). This exception could have stemmed from the very small genetic effective size ($N_e = 2$) of the Morro Bay population, which would be expected to result in rapid differentiation from the founding and other populations.

At $K = 8$, most sampling sites were characterized by at least one cluster representative of the home population (Fig. 6). In some cases, these home clusters also predominated in adjacent sampling sites, suggesting they reflected the same population: (1) the South and West SF Bay, (2) Presidio and Half Moon Bay, and (3) SB and SO. In the first two cases, mtDNA haplotype frequencies supported subsuming of the sites in a single population, but SB and SO did not share any mtDNA haplotypes, suggesting these were distinct populations, at least maternally, despite clustering together with microsatellites (Table 1).

Next, to determine source–sink and extirpation–recolonization dynamics, we investigated symmetry in cluster sharing both irrespective of time (a static view) and, for samples spanning sufficient timeframes (Table 3), with respect to changes over time (a dynamic view). We first examined the genotypes that assigned primarily to a single cluster ($q > 0.75$) and were therefore most likely to expose first-generation migrants (Fig. 6). Monterey Bay, which was initially established by 1980 (Lewis et al. 1993), appeared to be a sink population, receiving immigrants from several external populations. Except for the one cluster that was nearly unique to Monterey Bay (dark blue, Fig. 6), genotypes sampled in this population primarily assigned to SJV (light blue, orange) or Half Moon Bay/Presidio (red). Additionally, many individuals in Monterey assigned only partially (<75%) to an immigrant

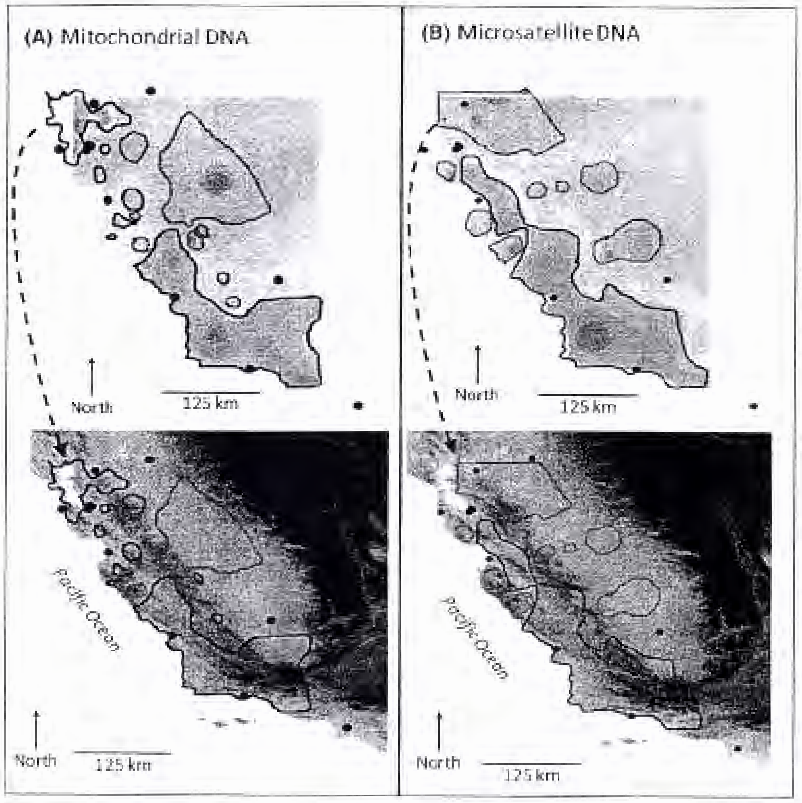

Figure 4. Empirical resistance surfaces inferred from inverse distance-weighted averaging among pairwise midpoints and their associated Euclidian distance-adjusted genetic distances (A) $F_{ST}/(1 - F_{ST})$ for mtDNA and (B) D_A for microsatellites. Interpolated surface with illustrative resistance contours highlighted by red lines and connectivity contours highlighted by blue lines are shown on top, with the same contours overlaid on elevation below. Sampling site centroids are shown as filled circles.

cluster, suggesting they were progeny of first-generation migrants. Conversely, however, there was little evidence of first- or second-generation migration from Monterey into any of the surrounding populations. The exception was three individuals sampled in the East SF Bay that assigned as first-generation migrants from Monterey, each of which was sampled after 2003 (see below). Examination of the clusters in time indicated that the proportion of immigrants in the Monterey sample approximately doubled during 2002–2007 compared to 1997–2000 (Fig. S9). Interestingly, however, the same mtDNA haplotype (G-38) remained the most prevalent throughout these periods, suggesting male gene flow was primarily responsible for the shift in cluster assignment over time (Fig. S10).

The SJV South site shared a cluster with SB and SO (dark green, Fig. 6), suggesting northward migration into the SJV, but there was no evidence of reciprocal gene flow from SJV (e.g., light blue cluster) in the two more southerly sampling sites. The East and South SF Bays apparently exchanged small numbers of dispersers with one another (black, gray). In addition to the three individuals in the East SF Bay assigning to Monterey Bay mentioned above, we sampled two individuals from the South SF Bay that assigned to the Presidio/Half Moon Bay cluster. Additionally, one individual in the East SF Bay was assigned to the SO/SB cluster, and also carried the F-9 mtDNA haplotype, otherwise found only in Los Angeles (Fig. 2); given the distance and landscape resistance, human-assisted translocation seems the most likely explanation. Importantly, although most individuals from the SF Bay included in our study were sampled prior to 2003 (Table 3), all six of the individuals assigning as immigrants to the SF Bay area were sampled after 2003 (and these composed 75% of the eight individuals sampled from the SF Bay after 2003). Thus, the SF Bay populations could have been essentially extirpated and recolonized. Otherwise, for most populations sampled over spans of 15–20 years, we observed little change in cluster assignment or haplotype frequency over time, suggesting that most populations sustained themselves reproductively and that extirpation–recolonization dynamics were the exception (Appendix S4, Figs. S9, S10).

Discussion

Understanding how invasive predators spread, establish, and maintain their populations is fundamental to managing their impacts. The feasibility of eradication or local control of invasive populations depends on their abundance, connectivity, and population growth rates (Bomford and

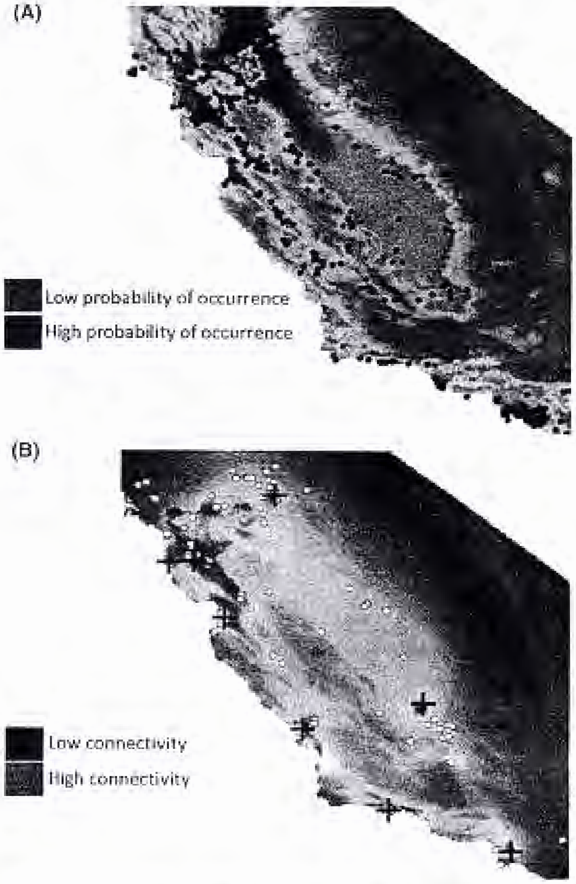

Figure 5. Landscape models, including (A) a Maxent species distribution model based on locations of 349 sighting reports (filled circles) from Lewis et al. (1993) and (B) connectivity ("current") map estimated using Circuitscape, along with 402 red fox genetic sample locations (open circles) and 10 corresponding centroids (+) used to test the resistance model.

O'Brien 1995; Adams et al. 2014). In the present study, we used landscape-genetic approaches to reconstruct a nonnative red fox invasion and to characterize the postestablishment metapopulation structure and dynamics, which also provided insights about the relative importance of demographic resilience versus immigration in enabling populations to withstand predator control measures. Below, we review our key findings and then revisit previous localized control efforts in the context of our findings.

Invasion dynamics

Prior to our study, the mapping of occurrence records of nonnative red foxes showed them to have increased from two isolated locations 650 km apart in the 1970s to many locations in-between, which, when viewed coarsely, appeared to reflect a large continuous population (Lewis et al. 1999). The rate of increase also was consistent with exponential growth and expansion or, alternatively, a long lag period followed by a relatively sudden "explosion." In contrast to predictions of the exponential expansion model, we found high localization of most mitochondrial haplotypes, which suggested multiple, independent sites of introduction, rather than spread from a single (or two) point source(s). Thus, our findings support the suggestion by Lewis et al. (1999) that the range increase fed off continuous introductions rather than proceeding solely of its own demographic volition. More concretely, by identifying a minimum number of populations on the basis of private haplotypes and then using shared haplotypes and dates of fox arrival to various locations to infer directionality of spread, we propose that at least eight founding populations led to the current distribution: SJV-N, Mont, San Francisco Bay (SFB)-E, SFB-S/W, Presidio, SJV-S, SB, and SO. Given our small sample size from SO and apparent haplotype heterogeneity, it seems likely that multiple introductions occurred there as well.

Nevertheless, the question remains as to the explanation for the relatively sudden appearance of red foxes over such a widespread region. We hypothesize that this population explosion was ignited by releases of foxes from defunct fur farms in multiple locations, a practice that apparently began in the 1960s in response to the economic downturn associated with the industry (Harvey et al. 1992). In contrast to episodic translocations by rehabilitators or other miscellaneous parties, which may have been common throughout the past century (Lewis et al. 1999), the large-scale release of multiple individuals from the same captive population would have significantly increased the probability of successful reproduction and establishment. Once initial populations became established, such as in the Monterey Bay area, SB, and in the SF Bay area, smaller, miscellaneous translocations could then coalesce with, or recruit from, these initial sources to seed new populations. The possibility of dispersers pairing with other dispersers of the opposite sex in locations previously unoccupied by foxes would become increasingly likely, potentially fueling new populations. For example, Morro Bay, which was the newest population we sampled (i.e., the only one not known a decade earlier; Lewis et al. 1993), had an estimated N_e of 2 (95% CI 1.6–2.5), suggesting it could have been founded by a single pair or possibly a single pregnant female.

Contemporary connectivity

Our findings further suggested that, although populations clearly exhibited some level of connectivity, the magnitude of gene flow was relatively low. First, the

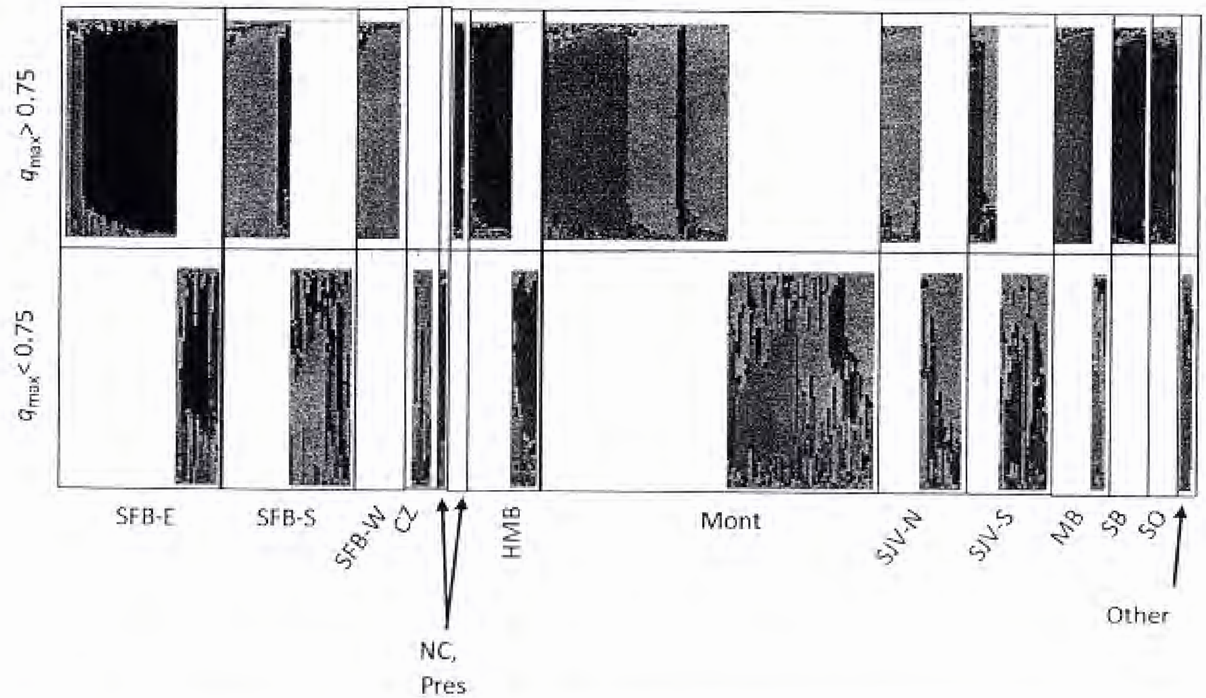

Figure 6. Genotypic assignments with bar graphs indicating the ancestry fraction (q) apportioned to individual genotypes of nonnative red foxes from California, showing 221 individuals with high assignment to a single cluster ($q_{max} > 75\%$, top) and 160 admixed individuals ($q_{max} < 75\%$, bottom) in 1 of $K = 8$ clusters according to admixture analysis in program Structure. Clusters indicated by light and dark shades of the same colors indicate those clustered together at $K = 6$ and 7 (green) or $K = 6$ (blue).

Table 3. Temporal distribution of 384 nonnative red fox samples from California (an additional 18 were undated).

Sample site	Time period							
	Pre-1980	1981–1985	1986–1990	1991–1995	1996–2000	2001–2005	2006–2010	>2010
East San Francisco (SF) Bay	–	–	–	–	45	3	3	–
South SF Bay	–	–	–	1	32	8	3	–
West SF Bay	–	–	–	–	16	–	1	–
Contact zone	2	–	–	–	–	–	6	4
North Coast	–	1	–	–	–	–	4	–
Presidio	–	–	–	–	–	4	–	–
Half Moon Bay	–	–	–	–	–	12	12	–
Monterey	–	1	–	–	43	43	21	–
San Joaquin Valley (SJV) North	–	–	–	–	2	8	23	1
SJV South	–	–	–	–	3	18	6	1
Morro Bay	–	–	–	–	–	7	11	–
Santa Barbara	–	–	1	3	1	1	7	–
Southern California	–	–	3	–	2	4	–	–
Other	–	–	–	1	10	2	4	–

low diversity of mitochondrial haplotypes we observed within sites suggests that founders were few and slow to spread from their sources. Nuclear gene flow, although higher than mitochondrial, also was relatively low among sampling locations. For example, the average microsatellite-based F_{ST} measured among sampling sites in the present study was >0.10, with several pairs of adjacent sites exhibiting estimates ≫0.10; in contrast, between the northern and southern ends of the Sacramento Valley native red fox population (spanning ~200 km), F_{ST} averaged <0.05 (Sacks et al. 2010b).

The presence of even limited gene flow (primarily nuclear) among populations enabled us to investigate aspects of the landscape preventing or promoting connectivity as well as the directionality of gene flow between neighboring sites. The observed correspondence between model-free genetic distance surfaces and topographic features for both mtDNA and microsatellite markers suggested a highly fragmented metapopulation. This pattern was corroborated by modeling the association of occurrence records – a completely independent data set – with landscape variables, which provided a more highly resolved map of the predicted distribution (i.e., occurrence habitat). The confrontation of this model with genetic data, which confirmed its utility for also representing dispersal habitat, indicated that human-dominated valleys were the primary dispersal corridors and less human-dense mountains, the primary barriers. The affinity of nonnative red foxes for human-dominated valleys may stem partly from their feral nature and consequent ability to thrive in disturbed habitat (e.g., Kaprowicz et al. 2016). However, aversion to mountain foothills also has been observed in the native Sacramento Valley red fox (Sacks et al. 2011) and therefore likely reflects non-human-related factors. In particular, competition from native canids (coyotes, *Canis latrans*; gray foxes, *Urocyon cinereoargenteus*) could be considerably greater in the foothills, as has been suggested for other lowland fox species (Nelson et al. 2007).

The resistance surface model also was insufficient to fully explain the observed population structure, in particular, the hierarchical relationship indicated by the population tree, Structure, and PCoAs. Sampling locations in the SF Bay area clustered more closely with one another than they did with other nearby sampling locations that were separated by habitat otherwise predicted by the landscape resistance model to facilitate gene flow (i.e., low-elevation, human-dominated landscape). The observed genetic distinctiveness of the SF Bay area populations could relate to the original sources founding them, to the lack of gene flow after their establishment, or to both. One particular mechanism potentially constraining gene flow was natal habitat-biased dispersal, that is, the tendency to disperse into familiar habitat (Sacks et al. 2004; Stamps and Swaisgood 2007). Specifically, it is possible that individuals born within the salt marsh wetland habitat of the SF Bay dispersed solely within the wetland landscape, rather than emigrating to the highly distinct dryland habitats of the adjacent populations, and vice versa.

Metapopulation dynamics and relation to predator management

Our genetic findings with respect to symmetry of gene flow or replacement are best interpreted in the context of control programs. The clearest example involved the relatively isolated populations of the SF Bay, where 80–100 foxes per year were removed as part of a predator control program beginning in 1992 (Harding et al. 2001). In the present study, we genotyped most of the foxes removed in 1996 and 1997, enabling us to characterize the genetic composition of the population at that time. Foxes sampled through 2002 continued to be dominated by those assigning to that population, suggesting that despite the large numbers of foxes removed each year, the population was able to maintain itself through reproduction rather than immigration. On the other hand, the small numbers of individuals we sampled between 2004 and 2007 were dominated by immigrants from coastal areas and the SJV, suggesting that control efforts eventually succeeded in reducing, and possibly eradicating, the original population. After our SF Bay area samples were collected for the present study (10/24/1995–3/31/2007), numbers of red foxes removed from this area continued to decline, suggesting that the intensity of control eventually was sufficient to overcome immigration (Foerster et al. 2011).

Red foxes also were removed from the Monterey area to protect snowy plovers, beginning in the early 1990s and continuing throughout our study, including 118 individuals removed from 1993 through 1999 (Neuman et al. 2004). Our sample included those foxes removed beginning in 1997. Our sample from the reporting period of Neuman et al. (2004) was primarily composed of two clusters and after that point continued to show these clusters, plus a significant component assigning to another cluster, which was otherwise shared with the northern SJV and could have represented unsampled locations between these sites. Although our data were insufficient to estimate the relative influence of immigration and mortality, field data on snowy plover nesting success in response to the removal efforts suggested that predator control had a net effect of reducing predator abundance (Neuman et al. 2004). Thus, it appears that in both of these populations where predator removal efforts were most intensive, immigration was increasingly frequent, compensating to some extent for the increased mortality, but depression of the populations also was possible. In the future, the use of genetic data to assess origins of individuals removed could be helpful in strategically removing individuals from contributing populations or in low-elevation choke points along dispersal corridors (e.g., as per our model).

Sex-biased dispersal in relation to spread versus contemporary connectivity

We estimated a fourfold difference in gene flow attributable to dispersing males relative to females, suggesting that males were the primary agents of gene flow, at least once populations became established. However, the correspondence between genetic distance and landscape features in both types of markers (e.g., Fig. 4) suggested that the relatively weak mitochondrial footprint on connectivity was nevertheless real. This faint signature could have resulted primarily from the preestablishment period when newly released females, like males, would have had to roam to find locations to settle and breed. Previous studies also have found males to be the primary dispersers, and that frequency of dispersal is especially high among males when population density is lowest (Allen and Sargeant 1993; Lewis 1994; Gosselink et al. 2010).

Management implications

The approach and resources developed in this study can aid local wildlife managers in planning future control activities. The landscape resistance model can be used to identify locations where predator control efforts can be most efficacious in reducing immigration or preventing recolonization. Similar approaches have been used with invasive American mink (*Neovison vison*) in Scotland (Fraser et al. 2013) and feral pigs in Australia (Hampton et al. 2004). The genetic data can also be used in the context of the landscape resistance model to identify potential eradication units (Adams et al. 2014). However, it would be important to obtain additional samples from intervening locations where foxes are likely to occur but where no control efforts are being employed (and, hence, we had no samples in the present study). In particular, two major valleys (Salinas, southern Santa Clara) east of Monterey Bay were known to contain nonnative red foxes (Lewis et al. 1993, 1999) but were not sampled in the present study. It seems likely that these populations contributed migrants to the Monterey Bay and possibly the SF Bay populations. Additionally, our findings that at least two populations changed in genetic composition over time indicate the need for continued genetic monitoring of foxes from the same sites to identify changes. For example, a relatively consistent genetic signature, such as we observed in the south and west SF Bay during 1995–2002, suggests that population persistence was most attributable to demographic compensation, whereas major changes in genetic composition, such as occurred in the same population after 2003, suggested that immigration eventually became the primary engine of persistence. Differentiating between these demographic processes is critical for identifying where future control efforts are best directed.

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Data Accessibility

DNA sequence: GenBank accession KU244024. Sampling locations, dates, types, mtDNA haplotypes, and microsatellite genotypes: Dryad doi: 10.5061/dryad.hj722.

Conflict of Interest

None declared.

References

Abbott, I., D. Peacock, and J. Short. 2014. The new guard: the arrival and impacts of cats and foxes. Pp. 69–104 *in* A. S. Glen and C. R. Dickman, eds. Carnivores of Australia: past, present and future. CSIRO Publishing, Collingwood, Vic., Australia.

Adams, A. L., Y. van Heezik, K. J. M. Dickinson, and B. C. Robertson. 2014. Identifying eradication units in an invasive mammalian pest species. Biol. Invasions 16:1481–1496.

Allen, S. H., and A. B. Sargeant. 1993. Dispersal patterns of red foxes relative to population density. J. Wildl. Manage. 57:526–533.

Aubry, K. B. 1984. The recent history and present distribution of the red fox in Washington. Northwest Sci. 58:69–79.

Aubry, K. A., M. J. Statham, B. N. Sacks, J. D. Perrine, and S. M. Wisely. 2009. Phylogeography of the North American red fox: vicariance in Pleistocene forest refugia. Mol. Ecol. 18:2668–2686.

Bailey, E. P. 1993. Introduction of foxes to Alaskan Islands history, effects on avifauna, and eradication. United States Department of Interior, U.S. Fish and Wildlife Service Resource Publication 193. Washington D. C.

Beauclerc, K. B., J. Bowman, and A. I. Schulte-Hostedde. 2013. Assessing the cryptic invasion of a domestic conspecific: American mink in their native range. Ecol. Evol. 3:2296–2309.

Berry, O., and R. Kirkwood. 2010. Measuring recruitment in an invasive species to determine eradication potential. J. Wildl. Manage. 74:1661–1670.

Bomford, M., and P. O'Brien. 1995. Eradication or control for vertebrate pests? Wildl. Soc. Bull. 23:249–255.

Bryce, R., M. K. Oliver, L. Davies, H. Gray, J. Urquhart, and X. Lambin. 2011. Turning back the tide of American mink invasion at an unprecedented scale through community participation and adaptive management. Biol. Conserv. 144:575–583.

Converse, K. E. 2012. Genetic mating system and territory inheritance in the Sacramento Valley red fox. Thesis. California State University, Sacramento, CA, USA.

Cornuet, J. M., and G. Luikart. 1996. Description and power analysis of two tests for detecting recent population bottlenecks from allele frequency data. Genetics 144:2001–2014.

Dearborn, N. 1915. Silver fox farming in eastern North America. US Department of Agriculture, No. 301, Washington D.C.

Doherty, T. S., C. R. Dickman, D. G. Nimmo, and E. G. Ritchie. 2015. Multiple threats, or multiplying the threats? Interactions between invasive predators and other ecological disturbances. Biol. Conserv. 190:60–68.

Estoup, A., and T. Guillemaud. 2010. Reconstructing routes of invasion using genetic data: why, how and so what? Mol. Ecol. 19:4113–4130.

Evanno, G., S. Regnaut, and J. Goudet. 2005. Detecting the number of clusters of individuals using the software STRUCTURE: a simulation study. Mol. Ecol. 14:2611–2620.

Excoffier, L., G. Laval, and S. Schneider. 2005. Arlequin ver. 3.0: an integrated software package for population genetics data analysis. Evol. Bioinf. Online 1:47–50.

Falush, D., M. Stephens, and J. K. Pritchard. 2003. Inference of population structure using multilocus genotype data: linked loci and correlated allele frequencies. Genetics 164:1567–1587.

Faubet, P., and O. E. Gaggiotti. 2008. A new Bayesian method to identify the environmental factors that influence recent migration. Genetics 178:1491–1504.

Foerster, K. S., J. E. Takekawa, and C. M. Strong. 2011. San Francisco Bay National Wildlife Refuge Predator Management Plan and Draft Environmental Assessment. U.S. Fish and Wildlife Service San Francisco Bay National Wildlife Refuge, Fremont, CA.

Fraser, E. J., D. W. Macdonald, M. K. Oliver, S. Piertney, and X. Lambin. 2013. Using population genetic structure of an invasive mammal to target control efforts-an example of the American mink in Scotland. Biol. Conserv. 167:35–42.

Genovesi, P. 2009. Invasive alien species in a changing world. Biodiversity 10:3–4.

Gosselink, T. E., K. A. Piccolo, T. R. Deelen, R. E. Warner, and P. C. Mankin. 2010. Natal dispersal and philopatry of red foxes in urban and agricultural areas of Illinois. J. Wildl. Manage. 74:1204–1217.

Goudet, J. 1995. FSTAT (Version 1.2): a computer program to calculate F-statistics. J. Hered. 86:485–486.

Gray, R. L. 1975. Sacramento Valley red fox survey. Nongame Wildl. Invest. Prog. Rep., Job II-1.2. California Department of Fish and Game, Sacramento, CA.

Hampton, J. O., P. Spencer, D. L. Alpers, L. E. Twigg, A. P. Woolnough, J. Doust, et al. 2004. Molecular techniques, wildlife management and the importance of genetic population structure and dispersal: a case study with feral pigs. J. Appl. Ecol. 41:735–743.

Harding, E. K., D. F. Doak, and J. D. Albertson. 2001. Evaluating the effectiveness of predator control: the non-native red fox as a case study. Conserv. Biol. 15:1114–1122.

Harvey, T. E., K. J. Miller, L. Hothem, M. J. Rauzon, G. W. Page, and R. A. Keck. 1992. Status and trends report on wildlife of the San Francisco Estuary. USDI Fish and Wildlife Service report for the San Francisco Estuary Project. U.S. Environmental Protection Agency, San Francisco, CA and San Francisco Bay Regional Water Quality Control Board, Oakland, CA.

Hedrick, P. W., F. W. Allendorf, and C. S. Baker. 2013. Estimation of male gene flow from measures of nuclear and female genetic differentiation. J. Hered. 104:713–717.

Kasprowicz, A. E., M. J. Statham, and B. N. Sacks. 2016. The fate of the other red coat: remnants of colonial British red foxes in the Eastern United States. J. Mammal. 97:298–309.

Keis, M., J. Remm, S. Y. Ho, J. Davison, E. Tammeleht, I. Tumanov, et al. 2013. Complete mitochondrial genomes and a novel spatial genetic method reveal cryptic phylogeographical structure and migration patterns among brown bears in north-western Eurasia. J. Biogeogr. 40:915–927.

Kidd, A. G., J. Bowman, D. Lesbarreres, and A. I. Schulte-Hostedde. 2009. Hybridization between escaped domestic and wild American mink (*Neovison vison*). Mol. Ecol. 18:1175–1186.

Lecis, R., A. Ferrando, J. Ruiz-Olmo, S. Manas, and X. Domingo-Roura. 2008. Population genetic structure and distribution of introduced American mink (*Mustela vison*) in Spain, based on microsatellite variation. Conserv. Genet. 9:1149–1161.

Legendre, P. 2000. Comparison of permutation methods for the partial correlation and partial Mantel tests. J. Stat. Comput. Simul. 67:37–73.

Lewis, J. C. 1994. Dispersal of introduced red foxes in urban Southern California. Thesis. Humboldt State University, Arcata, CA, USA.

Lewis, J. C., K. L. Sallee, and R. T. Golightly. 1993. Introduced red fox in California. California Department of Fish and Game, Sacramento, CA. Non-game Bird and Mammal Section Report 93-10.

Lewis, J. C., K. L. Sallee, and R. T. Golightly. 1999. Introduction and range expansion of nonnative red foxes (*Vulpes vulpes*) in California. Am. Midl. Nat. 142:372–381.

Long, J. L. 2003. Introduced mammals of the world: their history, distribution and influence. CSIRO Publishing, Collingwood, Vic., Australia.

McRae, B. H., B. G. Dickson, T. H. Keitt, and V. B. Shah. 2008. Using circuit theory to model connectivity in ecology, evolution, and conservation. Ecology 89:2712–2724.

Nei, M. 1987. Molecular evolutionary genetics. Columbia Univ. Press, New York, NY.

Nelson, J. L., B. L. Cypher, C. D. Bjurlin, and S. Creel. 2007. Effects of habitat on competition between kit foxes and coyotes. J. Wildl. Manage. 71:1467–1475.

Neuman, K. K., G. W. Page, L. E. Stenzel, J. C. Warriner, and J. S. Warriner. 2004. Effect of mammalian predator management on Snowy Plover breeding success. Waterbirds 27:257–263.

Peakall, R., and P. E. Smouse. 2006. GENALEX 6: genetic analysis in Excel. Population genetic software for teaching and research. Mol. Ecol. Notes 6:288–295.

Perrine, J. D., J. P. Pollinger, B. N. Sacks, R. H. Barrett, and R. K. Wayne. 2007. Genetic evidence for the persistence of the critically endangered Sierra Nevada red fox in California. Conserv. Genet. 8:1083–1095.

Phillips, S. J., R. P. Anderson, and R. E. Schapire. 2006. Maximum entropy modeling of species geographic distributions. Ecol. Model. 190:231–259.

Piry, S. G., G. Luikart, and J. M. Cornuet. 1999. BOTTLENECK: a computer program for detecting recent reductions in the effective population size using allele frequency data. J. Hered. 90:502–503.

Pritchard, J. K., M. Stephens, and P. Donnelly. 2000. Inference of population structure using multilocus genotype data. Genetics 155:945–959.

Pulliam, H. R. 1988. Sources, sinks, and population regulation. Am. Nat. 132:652–661.

Rhymer, J. M., and D. Simberloff. 1996. Extinction by hybridization and introgression. Annu. Rev. Ecol. Syst. 27:83–109.

Rice, W. 1989. Analyzing tables of statistical tests. Evolution 43:223–225.

Rosenberg, M. S., and C. D. Anderson. 2011. PASSaGE: pattern analysis, spatial statistics and geographic exegesis. Version 2. Methods Ecol. Evol. 2:229–232.

Rousette, F. 1997. Genetic differentiation and estimation of gene flow from F statistics under isolation by distance. Genetics 145:1219–1228.

Sacks, B. N., S. K. Brown, and H. B. Ernest. 2004. Population structure of California coyotes corresponds to habitat-specific breaks and illuminates species history. Mol. Ecol. 13:1265–1275.

Sacks, B. N., D. I. Våge, and M. J. Statham. 2009. A medium-throughput SNP assay for detecting genetic variation in coding and non-coding portions of the red fox genome. Conserv. Genet. Resour. 1:459–463.

Sacks, B. N., M. J. Statham, J. D. Perrine, S. M. Wisely, and K. A. Aubry. 2010a. North American montane red foxes: expansion, fragmentation, and the origin of the Sacramento Valley red fox. Conserv. Genet. 11:1523–1539.

Sacks, B. N., H. U. Wittmer, and M. J. Statham. 2010b. The Native Sacramento Valley red fox. Report to the California Department of Fish and Game, May 30, 2010.

Sacks, B. N., M. Moore, M. J. Statham, and H. U. Wittmer. 2011. A restricted hybrid zone between native and introduced red fox (*Vulpes vulpes*) populations suggests reproductive barriers and competitive exclusion. Mol. Ecol. 20:326–341.

Stamps, J. A., and R. R. Swaisgood. 2007. Someplace like home: experience, habitat selection and conservation biology. Appl. Anim. Behav. Sci. 102:392–409.

Statham, M. J., L. N. Trut, B. N. Sacks, A. V. Kharlamova, I. O. Oskina, R. G. Gulevich, et al. 2011. On the origin of a domesticated species: identifying the parent population of Russian silver foxes (*Vulpes vulpes*). Biol. J. Linn. Soc. 103:168–175.

Statham, M. J., B. N. Sacks, K. B. Aubry, J. D. Perrine, and S. M. Wisely. 2012. The origin of recently established red fox populations in the United States: translocations or natural range expansions? J. Mammal. 93:52–65.

Statham, M. J., J. Murdoch, J. Janecka, K. B. Aubry, C. J. Edwards, C. D. Soulsbury, et al. 2014. Range-wide multilocus phylogeography of the red fox reveals ancient continental divergence, minimal genomic exchange, and distinct demographic histories. Mol. Ecol. 23:4813–4830.

Takezaki, N., and M. Nei. 1996. Genetic distances and reconstruction of phylogenetic trees from microsatellite DNA. Genetics 144:389–399.

Vail, E. L. 1942. Fox ranching in southern California. Calif. Fish Game 28:87–88.

Voigt, D. R. 1987. Red fox. Pp. 378–392 *in* M. Novak, J. A. Baker, M. E. Obbard, B. Malloch. Wild Furbearer Management and Conservation in North America. Ministry of Natural Resources, Toronto, ON, Canada.

Waples, R. S. 2006. A bias correction for estimates of effective population size based on linkage disequilibrium at unlinked gene loci. Conserv. Genet. 7:167–184.

Waples, R. S., and C. Do. 2008. LDNE: a program for estimating effective population size from data on linkage disequilibrium. Mol. Ecol. Resour. 8:753–756.

Westwood, R. E. 1989. Early fur farming in Utah. Utah Hist. Q. 57:320–339.

Woinarski, J. C., A. A. Burbidge, and P. L. Harrison. 2015. Ongoing unraveling of a continental fauna: decline and extinction of Australian mammals since European settlement. Proc. Natl Acad. Sci. USA 112: 4531–4540.

Supporting Information

Additional Supporting Information may be found online in the supporting information tab for this article:

Appendix S1. Landscape resistance surface.
Appendix S2. An approach to uncovering hierarchical population structure.
Appendix S3. Influence of uneven sample size.
Appendix S4. Cluster assignments over time.
Table S1. Pairwise F_{ST} estimates among 10 nonnative red fox sampling sites in California.
Figure S1. Inverse distance-weighted (IDW) interpolations of residual genetic distances.
Figure S2. Relationship between average log probability of the data and the number of clusters (K) in 10 replicate runs of Structure in all foxes.
Figure S3. Cumulative frequency of genotypes relative to numbers of cluster profiles in all foxes.
Figure S4. Hierarchy diagram of cluster profiles in all foxes.
Figure S5. Relationship between average log probability of the data and the number of clusters (K) in 10 replicate runs of Structure in a subset of foxes.
Figure S6. Cumulative frequency of genotypes relative to numbers of cluster profiles in a subset of foxes.
Figure S7. Hierarchy diagram of cluster profiles in a subset of foxes.
Figure S8. Bar graph indicating the ancestry fraction (q) apportioned to individual genotypes in a subset of foxes.
Figure S9. Bar graphs indicating ancestry fraction (q) in red foxes in different sampling periods.
Figure S10. Bar graphs indicating mtDNA haplotypes in red foxes in different sampling periods.

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The origin of recently established red fox populations in the United States: translocations or natural range expansions?

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Red foxes (*Vulpes vulpes*) are native to boreal and western montane portions of North America but their origins are unknown in many lowland areas of the United States. Red foxes were historically absent from much of the East Coast at the time of European settlement and did not become common until the mid-1800s. Some early naturalists described an apparent southward expansion of native foxes that coincided with anthropogenic habitat changes in the region. Alternatively, red foxes introduced from Europe during Colonial times may have become established in the east and subsequently expanded their range westward. The red fox also was absent historically from most lowland areas of the western United States. Extant populations of red foxes in those areas are considered to have arisen from intentional introductions from the east (and by extension are putatively European), escapes or releases from fur farms, or range expansions by native populations. To test these hypotheses we compared mitochondrial DNA sequences (cytochrome *b* and D-loop) from 110 individuals from 6 recently established populations to 327 native (primarily historical) individuals from Eurasia, Alaska, Canada, the northeastern United States, and montane areas in the western contiguous United States, and to 38 individuals from fur farms. We found no Eurasian haplotypes in North America, but found native haplotypes in recently established populations in the southeastern United States and in parts of the western United States. Red foxes from the southeastern United States were closely related to native populations in eastern Canada and the northeastern United States, suggesting that they originated from natural range expansions, not from translocation of European lineages, as was widely believed prior to this study. Similarly, recently established populations in the Great Basin and in western Oregon originated primarily from native populations in western montane regions, but also contained a few nonnative North American haplotypes. In contrast, populations in western Washington and southern California contained nonnative, highly admixed stock that clearly resulted from intracontinental translocations. Several common haplotypes in these populations originated in regions where fur-farm stocks originated. Although European red foxes translocated to the eastern United States during Colonial times may have contributed genetically to extant populations in that region, our findings suggest that most of the matrilineal ancestry of eastern red foxes originated in North America.

Key words: fur farm, mitochondrial DNA, museum samples, phylogeography, red fox, translocation, *Vulpes vulpes*

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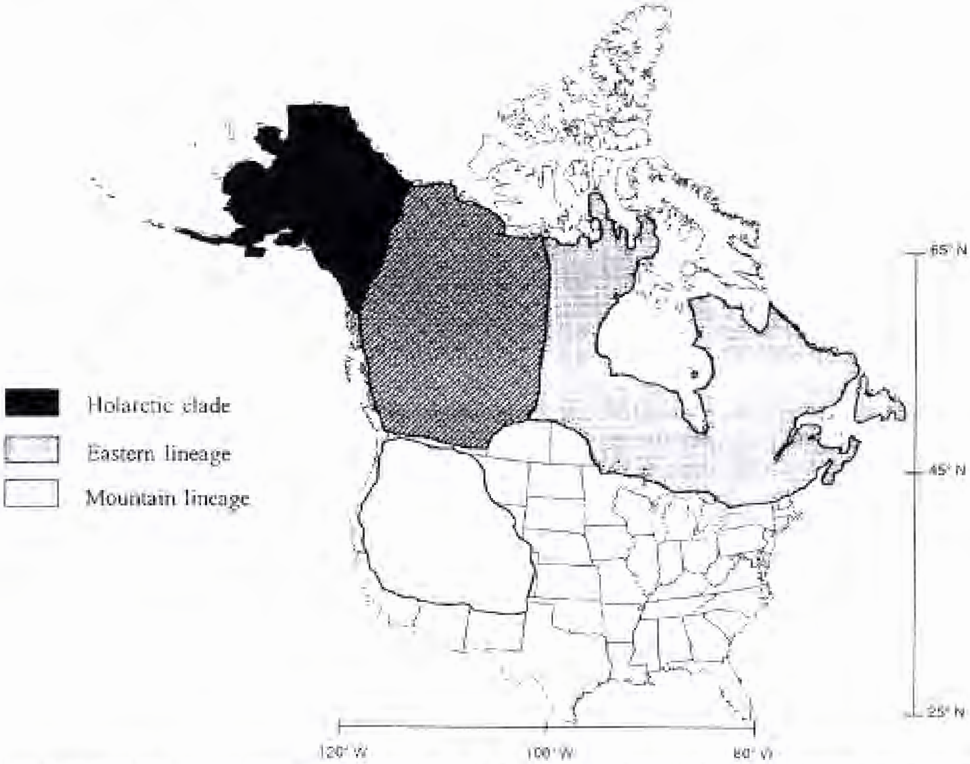

FIG. 1.—Approximate geographic distribution of North American red fox mitochondrial DNA lineages prior to European settlement modified from Aubry et al. (2009). The Eastern and Mountain lineages together comprise the Nearctic clade, which is restricted to North America. The Nearctic clade contains 3 subclades: Eastern, Mountain, and Widespread. The Mountain subclade makes up the majority of haplotypes within the Mountain lineage, whereas the Eastern subclade makes up the majority in the Eastern lineage; remaining haplotypes in both regions belong to the Widespread subclade. The Holarctic clade is distributed from Europe through Asia to Alaska and western Canada. The Holarctic and Eastern lineages overlap in western Canada, which is represented with gray and black diagonal lines. The area depicted for the Mountain subclade represents the distribution of native montane populations.

The red fox (*Vulpes vulpes*) is the world's most widely distributed terrestrial carnivore (Larivière and Pasitschniak-Arts 1996); its range has increased substantially in modern times due to expansion of native populations associated with habitat alterations (Lloyd 1980; Nowak 1991) and anthropogenic translocations (Long 2003). Whether origins of a particular population are natural or anthropogenic often is obscured by morphological similarity of even anciently diverged red fox lineages. For example, it remains unclear and contentious whether red foxes from the eastern United States originated from in situ range expansion from the north or intercontinental translocation of European foxes, which diverged from common ancestry 400,000 years ago and were once considered distinct species (Aubry et al. 2009; Churcher 1959; Kamler and Ballard 2002). Identifying the origins of red fox populations is important to conservation efforts aimed at endangered native populations and protection of endangered prey populations impacted by nonnative red foxes. Given the cryptic differences among native and nonnative populations, genetic tools are essential for understanding phylogeographic histories (Larsen et al. 2005; Sønstebø et al. 2008). Here, we focus on North American populations, particularly those established in the lowland areas of the contiguous United States.

Prior to European settlement, native populations of the red fox in North America comprised 3 evolutionarily divergent lineages that occurred primarily in the boreal forests of Canada and Alaska and the subalpine parklands and alpine meadows of montane regions in the western contiguous United States (Fig. 1; Aubry et al. 2009, but see Sacks et al. 2010). During the last or Wisconsin ice age, the Mountain and Eastern lineages (see Aubry et al. 2009) became isolated south of the ice sheets in the contiguous United States in forested refugia of the Rocky Mountains, Cascade Range, and Sierra Nevada (hereafter, the western mountains) and in the eastern contiguous United States (hereafter, the East). These 2 lineages, which currently dominate red fox populations in the western mountains and in eastern Canada, together comprise the Nearctic clade. The 3rd phylogenetically distinct lineage, the Holarctic clade, was isolated in unglaciated portions of Alaska and the Yukon during the last glaciation, and is the dominant lineage in Alaska and western Canada. The Nearctic and Holarctic clades diverged about 400,000 years ago and represent 2 separate colonization events by the red fox across the Bering Land Bridge from Eurasia during Pleistocene glaciations (Aubry et al. 2009).

During the past 300 years, humans have dramatically altered many habitats in the contiguous United States and implemented both inter- and intracontinental translocations of red foxes (Aubry 1984; Bailey 1936b; Lewis et al. 1999; Nowak 1991; Whitlow and Hall 1933). Consequently, it has been unclear (and biologists have long debated) whether recently established red fox populations in North America originated from natural range expansions or anthropogenic translocations (Aubry 1983, 1984; Churcher 1959; Grinnell et al. 1937; Kamler and Ballard 2002; MacPherson 1965; Newberry 1857). The emergence of red fox populations in new locations of North America occurred during 2 distinct time periods: those that appeared in the eastern United States during the Colonial era (approximately 1650–1800), and those that appeared in various parts of the western contiguous United States (hereafter, the West) during the 20th century (Aubry 1984; Kamler and Ballard 2003; Lewis et al. 1999; Seton 1929).

Red foxes were reportedly absent from much of the East during Colonial times, and did not become common in that region until the mid-1800s (Churcher 1959; Rhoads 1903). Some early naturalists described an apparent southward range expansion by populations of native red foxes that had been restricted previously to the northeastern United States and southeastern Canada. They hypothesized that this shift in the red fox's southern range boundary was driven by the conversion of hardwood forests to farmlands by European settlers, and resulting changes in competitive interactions with the gray fox (*Urocyon cinereoargenteus*—Audubon and Bachman 1849; Baird 1857; Newberry 1857). In particular, Audubon and Bachman (1849) described the serial emergence and increase of red foxes from southern New York and possibly northern Pennsylvania southward into Virginia, North Carolina, South Carolina, and, by 1840, northern Georgia, along the Appalachian Mountains. Newberry (1857) described a similar trend from eastern Canada southward into the Midwest. On the other hand, red foxes imported from Europe during the mid-1700s for hunting purposes provided another potential source of colonists to the changing landscape of the Eastern Seaboard, leading other naturalists to surmise that the "east American Red-fox is probably a mongrel ..." (Rhodes 1903:145) or as Seton (1929:475) later put it, that the European red fox "has mixed with the native Red fox and the offspring spread and increased through the forest region as it was opened up ... ."

Churcher's (1959) morphometric study of North American and Eurasian red foxes provided the 1st empirical evidence for evaluating the extent to which European ancestry might influence eastern red fox populations. Churcher (1959) found that certain dental and cranial characteristics varied clinally from Europe through North America, via Beringia, and that European red foxes were most distinct from those in eastern North America (i.e., that they represented opposite ends of a morphological continuum), indicating that eastern red fox populations were derived primarily from native North American ancestry. Nonetheless, some contemporary researchers have presumed that modern red fox populations in the east are primarily European in origin (Kamler and Ballard 2002).

During the 20th century, red fox populations arose in several areas in the West where they were absent historically. With the exception of an ecologically distinct subspecies endemic to the Sacramento Valley of California (Sacks et al. 2010), red foxes native to the West were thought to have been restricted to the subalpine parklands and alpine meadows of the western mountain ranges (Aubry 1983, 1984; Grinnell et al. 1937). Populations of unknown origin began appearing outside these ecologically restricted areas during the 1900s (Aubry 1983, 1984; Fichter and Williams 1967; Kamler and Ballard 2002; Lewis et al. 1999; Verts and Carraway 1998). Most recently established populations of the red fox in the West were hypothesized to have originated from translocations from the East or from the escape or release of fur-farm animals that were presumably imported primarily from Prince Edward Island, Canada, or southern Alaska (Aubry 1983, 1984; Balcom 1916; Laut 1921; Lewis et al. 1999; Petersen 1914; Westwood 1989). However, others hypothesized that the recent (after 1940) colonization of previously unoccupied habitats in southern Idaho (Fichter and Williams 1967) and in the Willamette Valley in Oregon (Verts and Carraway 1998) could partly or fully reflect natural range expansions by native populations or increases in density by previously undetected native populations. In the Central Valley of California, where the native Sacramento Valley red fox (*V. v. patwin*) is contiguous with a population of nonnative red foxes, the 2 populations interbreed within a narrow hybrid zone, suggesting the possibility of admixture in other locations as well (Sacks et al. 2011).

Based on their extensive review of the topic, Kamler and Ballard (2002) hypothesized that post-Colonial range expansions resulted primarily from the dispersal of introduced European red foxes throughout the East, whereas range expansions that occurred during the 20th century resulted from the gradual expansion westward of these putatively nonnative red foxes. They further hypothesized that European red foxes have expanded into the native red fox range and "likely replaced native red foxes throughout all northern boreal regions ... ." Thus, they proposed that, with the exception of montane populations in the West, most North American red foxes are of European ancestry.

Because of strong phylogenetic differences among native North American and Eurasian red fox populations (Aubry et al. 2009), sequence data from mitochondrial DNA (mtDNA) can be used to test these hypotheses. We used mtDNA analyses to investigate the ancestry of populations of red foxes in the contiguous United States that apparently became established after European settlement. In particular, we tested the following hypotheses: red foxes in the eastern United States are of European descent or stem from native populations in northern Appalachia or southeastern Canada; and red fox populations in lowland areas of the western United States stem from fur farms, a wave of expansion from the east, or range expansion by nearby native populations.

Materials and Methods

Sample collection.—We investigated the origins of red foxes in 6 geographical units (hereafter referred to as populations) in the contiguous United States. Populations 1 and 2 occupy areas south of the range of native red foxes in North America (Fig. 1) and did not appear in those areas until after European settlement: (1) Southeastern United States (Arkansas, Georgia, Indiana, North Carolina, Oklahoma, Texas, and West Virginia; $n = 18$) and (2) Central United States (Iowa, Kansas, Minnesota, North Dakota, and South Dakota; $n = 13$). We considered these populations as distinct because they have marked differences in body size, and are classified as separate subspecies (Bailey 1936b; Hall and Kelson 1959; Merriam 1900). The remaining 4 populations were more recently established (< 100 years ago) in the West: (3) Western Washington (lowland areas in Washington west of the Cascade Range; $n = 23$), (4) Western Oregon (lowland areas in Oregon west of the Cascade Range; $n = 13$), (5) Great Basin (lowland areas in Oregon and Washington east of the Cascade Range, in Idaho south of the Snake River plain, and in Nevada; $n = 28$); and (6) Southern California (lowland areas south of the American River in California; $n = 21$). We also included 38 samples from red fox fur farms in the United States, Canada, Norway, and Russia.

Most of our samples were nasal turbinate bones ($n = 66$), skin snips ($n = 7$), or frozen tissues ($n = 20$) obtained from museum specimens collected from 1885 to 1991 (Appendix I). Several modern samples were from frozen or dried tissue ($n = 25$) or buccal swabs ($n = 4$). Additionally, we used 8 previously extracted DNA samples from Norwegian farmed red foxes provided by D. I. Våge (Norwegian University of Life Sciences), and sequences from 24 domesticated Russian silver foxes known to have originated from fur farms (Statham et al. 2011).

To reference native North American populations, we used previously published cytochrome-*b* and D-loop haplotypes from Alaska ($n = 69$), Canada ($n = 72$), and the western mountains ($n = 94$), which were primarily museum specimens collected in the late 1800s and early 1900s, augmented with modern samples proven to reflect continuous ancestry (Aubry et al. 2009; Sacks et al. 2010). We included 7 additional samples from the northeastern United States and southeastern Canada in the native data set from eastern Canada because all were from the historical range of native red foxes, most were collected during the 1800s prior to the advent of fur farming, and all have native North American haplotypes. To reference European populations, we used cytochrome-*b* haplotypes collected from wild populations throughout continental Europe ($n = 47$) and Britain ($n = 10$—Aubry et al. 2009; C. Edwards and C. Soulsbury, in litt.; Frati et al. 1998), and 8 D-loop haplotypes from continental Europe (Aubry et al. 2009). To reference Asian populations, we used cytochrome-*b* and D-loop haplotypes from China, Mongolia, and eastern Siberia ($n = 21$—Aubry et al. 2009). Insufficient numbers of published European D-loop haplotypes homologous to our 342-base pair (bp) fragment (see below) were available for inclusion in formal analyses; however, we compared our sequences to overlapping portions of European ($n = 74$—Valiere et al. 2003) and Asian ($n = 88$—Inoue et al. 2007) D-loop haplotypes available in GenBank.

Laboratory procedures.—We extracted DNA from historical samples (turbinates and skin snips) at Kansas State University following a phenol–chloroform extraction procedure described in Wisely et al. (2004) in a designated ancient DNA laboratory. We followed rigorous protocols to control for contamination of historical samples with modern DNA or polymerase chain reaction products (Aubry et al. 2009). We extracted tissue samples and buccal swabs using a DNeasy Blood and Tissue kit (Qiagen, Inc., Valencia, California) in separate modern DNA laboratories as described previously (Perrine et al. 2007; Sacks et al. 2010).

We amplified the 5′ portion of the cytochrome-*b* gene and the D-loop, and purified and sequenced polymerase chain reaction products as described previously (Aubry et al. 2009; Perrine et al. 2007; Sacks et al. 2010). We used Chromas version 1.45 (Technelysium Pty. Ltd., Helensvale, Australia), and Sequencher version 4.2 (Gene Codes, Inc., Ann Arbor, Michigan) to visualize chromatograms, and MegaAlign (DNASTAR, USA, Madison, Wisconsin) to align sequences.

Data analyses.—We based our analyses on a 354-bp portion of the cytochrome-*b* gene, and a 342-bp portion (including insertions and deletions) of the D-loop (Aubry et al. 2009; Perrine et al. 2007; Sacks et al. 2010). We translated the cytochrome-*b* sequences into amino acid sequences to ensure that they encoded for a continuous polypeptide.

Introduced populations often show genetic signatures of admixture, founder effects, and recent population expansion (Kidd et al. 2009; Kolbe et al. 2004; Norén et al. 2005; Senn and Pemberton 2009). Therefore, we used contrasting patterns of haplotype and nucleotide diversity to detect these signatures in recently established red fox populations. We estimated haplotype diversity (h) and nucleotide diversity (π—Nei 1987) using Arlequin 3.5 (Excoffier and Lischer 2010). We used 3 neutrality statistics to detect signatures of past demographic events on population growth or stability using Arlequin 3.5 and DnaSP version 5 (Rozas et al. 2003). Tajima's (1989) D statistic compares the number of nucleotide differences between sequences in a sample (π) and the number of differences between segregating sites (θ). Fu and Li's (1993) D^* is based on the difference between the number of single-occurring mutations in a population and the total number of mutations. Fu and Li's (1993) F^* is based on the difference between the average number of nucleotide differences between pairs of sequences and the number of singleton mutations. For a stable and randomly mating population, all 3 statistics are expected to be 0; negative values indicate an excess of low-frequency polymorphisms, suggesting population expansion, whereas positive values indicate an excess of intermediate frequency polymorphisms (Zhu et al. 2007), suggesting secondary contact between 2 or more distinct lineages (Fredsted et al. 2007). We calculated these statistics for the D-loop, which has greater variability than cytochrome *b*, and is assumed to be neutrally evolving. We used DnaSP version 5 to calculate Strobeck's (1987) S, an index of admixture, which is characteristic of populations originating from multiple sources. We also used the data from the fur-farm samples to screen for the same and similar haplotypes in putative nonnative populations. Where these occurred in such populations, but not in adjacent native reference populations, they were considered to be indicative of fur-farm ancestry.

We described relationships among haplotypes using a median-joining network (Bandelt et al. 1999) within Network 4.2.0.1 (www.fluxus-engineering.com). We estimated the extent of geographic divisions among populations using Φ_{ST} (Nei and Li 1979) in Arlequin 3.5. This statistic takes into account the divergence between haplotype sequences. We determined statistical significance ($\alpha = 0.05$) based on 1,000 permutations, then corrected for multiple tests using the sequential Bonferroni method (Rice 1989). We displayed resulting cytochrome-*b* and D-loop Φ_{ST} values as a clustering tree, using a neighbor-joining algorithm in the program PHYLIP 3.67 (Felsenstein 1989).

We determined the degree of support for different hypothesized origins of recently established populations using analysis of molecular variance (AMOVA—Excoffier et al. 1992) in Arlequin 3.1. We used the following groups of reference populations in these analyses based on the results presented in Aubry et al. (2009): (1) Eurasia (Europe and Asia), (2) Northwestern North America (Alaska and western Canada), (3) Southeastern Canada (central Canada, eastern Canada, and northeastern United States), and (4) Western Mountains (Washington Cascade Range, Oregon Cascade Range, Sierra Nevada, and Rocky Mountains), and (5) fur-farm samples. We then systematically combined samples from each recently established study population with those from Eurasia, fur farms, and the geographically closest North American reference group, and calculated the resulting degree of support (the proportion of variation contained among groups, Φ_{CT}). Because the cytochrome-*b* marker evolves more slowly than the D-loop, we used cytochrome *b* primarily to test hypotheses about Eurasian origins and the D-loop primarily to test hypotheses about North American origins, although we conducted intracontinental analyses using both markers. We performed a Mantel test for isolation by distance (in Arlequin) to help differentiate between continuous spread versus independent introductions among recently established populations.

Results

We obtained complete cytochrome-*b* sequences (354 bp) from 141 of 154 samples, and partial sequences (1 of 2 cytochrome-*b* fragments, 221 or 145 bp) from 3 additional samples. We used only complete cytochrome-*b* sequences in statistical analyses, and used partial sequences only to indicate clade affiliation (Fig. 2). We identified 13 distinct cytochrome-*b* haplotypes, 1 of which was novel (Table 1). We obtained complete D-loop sequences (342 bp) from 136 samples, resulting in 23 distinct haplotypes, 5 of which were novel (Table 2). We assigned novel cytochrome-*b* and D-loop haplotypes to previously identified clades (Aubry et al. 2009; Sacks et al. 2010) based on their positioning in the relevant haplotype network. All novel sequences were deposited in EMBL/GenBank/DDBJ nucleotide database (accession numbers HM590004–HM590011). We found no European haplotypes or haplotypes that clustered with European haplotypes anywhere in North America.

All fur-farm samples from the United States and Canada ($n = 6$) had haplotypes belonging to the Eastern subclade, as did the majority of all fur-farm samples (81.6%). All Russian fur-farm samples were North American in origin, with Eastern subclade haplotypes predominating. The Norwegian fur-farm samples ($n = 8$) were more variable, including 3 with a Eurasian haplotype and 5 with Nearctic clade haplotypes, indicating intercontinental translocation from North America to European fur farms. Of these 5 Nearctic clade haplotypes, 3 were from the Eastern subclade, which predominates in southeastern Canada and the northeastern United States, and 2 were from the Widespread subclade, which occurs at low prevalence in many native North American populations (Tables 1 and 2; Fig. 2a).

Neighbor-joining clustering trees based on Φ_{ST} values (Appendix II) indicated that many populations were substantially impacted by human translocations. The native reference populations occurred at the tips of the clustering trees, indicating they were most differentiated (Fig. 3). In general, these populations had a limited number of closely related haplotypes and lower nucleotide diversities than other populations. The Southeastern United States, Great Basin, and Western Oregon populations also had lower nucleotide diversities and clustered with neighboring native populations near the tips of trees. The Western Oregon population had significant negative values for 2 neutrality statistics (Tajima's *D*, and Fu and Li's D^*), consistent with population expansion (Table 3).

Our hypothesis-driven AMOVA, using both cytochrome-*b* and D-loop data sets, gave highest support to grouping the Southeastern United States population with native populations in eastern and central Canada; grouping the Great Basin and Western Oregon populations with native populations in the western mountains; and grouping Southern California, Western Washington, and Central United States populations with the fur-farm population (Table 4). In contrast, we consistently found the lowest support for any grouping of the recently established United States populations with those from Europe and Asia. In addition, a Mantel test of genetic versus geographic distance among the putative nonnative populations was nonsignificant (cytochrome *b*: $r < 0.01$, $P = 0.48$; D-loop: $r = 0.1$, $P = 0.20$), in contrast to what would be expected if they resulted from an expansion from the East.

The Central United States, Western Washington, and Southern California populations had many features in common. All occurred toward the center of the neighbor-joining clustering trees (Fig. 3) and were closer to one another in genetic distance (Φ_{ST}; Appendix II), despite being widely separated geographically. All 3 of these populations and the fur-farm samples contained a substantial number of haplotypes from ≥ 2 clades or subclades (Fig. 2b), and many of the same haplotypes occurred in ≥ 2 of these populations (Fig. 4), suggesting a common source. These 3 populations also had much higher levels of nucleotide diversity than all other

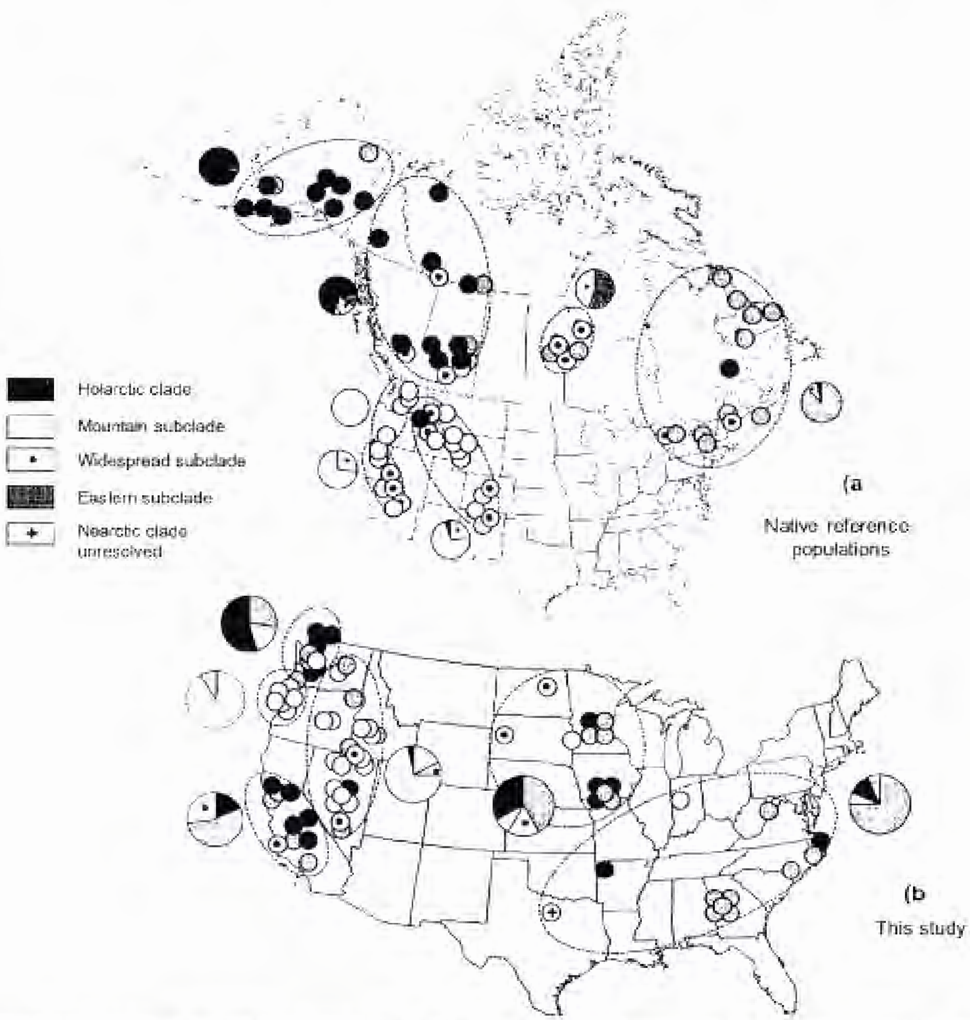

FIG. 2.—Geographic distribution of red fox mitochondrial DNA haplotypes among a) native reference populations (Aubry et al. 2009; Sacks et al. 2010; this study), and b) recently established populations (this study). Dotted lines encompass the populations analyzed, and shading indicates the clade or subclade.

populations (Table 3). The Western Washington and Southern California populations had significant signatures of admixture (Strobeck's S). We also found significant positive values for 2 neutrality statistics (Fu and Li's D^*, and Fu and Li's F^*) in the Western Washington population, consistent with admixture among lineages.

Discussion

European colonization of the eastern United States resulted in major anthropogenic changes to the landscape, including habitat conversion and introductions of nonnative animals and plants (Cronin 1983). By the 1700s, much of the east had been transformed by European-style agriculture, which greatly changed the character of the landscape and resulted in the extirpation of wolves (*Canis*) and the introduction of European red foxes in that region (Seton 1929). Since that time, there have been numerous translocations of red foxes within North America (Aubry 1983, 1984; Lewis et al. 1999). If all translocations had been successful, modern populations would likely reflect a complex admixture with intractable origins. However, introduced animals often fail to become established, especially where a competitively dominant native population is present (Norén et al. 2005; Rhymer and Simberloff 1996; Sacks et al. 2011). We investigated the origins of 2 spatially and temporally distinct range expansions by the red fox in the contiguous United States: one in the East that began about 300 years ago, and another in the West that occurred during the 20th century. Both of these range expansions could have resulted from human-mediated introductions in North America that began with an intercontinental translocation of red foxes from Europe to North America, followed by multiple intracontinental translocations associated primarily with fur farming. However, both of these expansion events also coincided with major anthropogenic landscape and faunal changes, including reductions in other canid populations, which could have facilitated natural range expansions by native red fox populations. Our findings indicate that natural

TABLE 1.—Occurrence of 13 cytochrome-*b* haplotypes[a] among recently established red fox populations in the contiguous United States and a sample of red foxes from fur farms based on 354 base pairs from 141 individuals. The clade to which haplotypes belong is indicated.

		Nearctic clade										Holarctic clade		
Population	*n*	A	A3	C	E	E2	F	F3	F4	K	O	G	N	U4
Southeastern United States	16	1	1	—	—	1	5	5	1	—	—	2	—	—
Central United States	11	1	—	—	—	—	5	—	—	—	1	3	1	—
Great Basin	27	19	—	1	—	—	5	—	—	—	1	1	—	—
Western Washington	20	1	—	—	—	—	6	—	—	—	3	10	—	—
Western Oregon	11	10	—	—	—	—	1	—	—	—	—	—	—	—
Southern California	18	—	—	—	1	—	7	—	—	6	—	2	2	—
Fur-farm samples	38	1	—	—	10	—	21	—	—	2	—	1	—	3
Total	141	33	1	1	11	1	50	5	1	8	5	19	3	3

[a] Haplotypes A, C, E, F, G, K, N, and O are as reported by Perrine et al. (2007); A3, E2, F3, and U4 are as reported in Aubry et al. (2009); and F4 is from this study.

range expansions by native populations have had a greater influence on the current distribution of red foxes in North America than previously believed (e.g., Kamler and Ballard 2002).

During the mid-1700s, settlers introduced European red foxes to multiple locations on the East Coast of the United States (Rhoads 1903; Seton 1929). Consequently, red fox populations in that area have been presumed to be either European in origin (Kamler and Ballard 2002), or a mixture of European and North American lineages (Seton 1929). Despite historical translocations from Europe, all of the modern red fox populations we sampled in North America were derived from matrilines that are native to North America. We found no European haplotypes, or any that clustered with European haplotypes, among North American red foxes in this study or in previous ones (Aubry et al. 2009; Perrine et al. 2007; Sacks et al. 2010). Furthermore, the Southeastern United States population clustered closely with those in eastern Canada, which are native to North America (Aubry et al. 2009). We cannot differentiate whether individual haplotypes in the East originated via natural range expansion or fur farms given the shared ancestry of these 2 sources (and both influences might be present). However, because red foxes predated the fur-farm industry in this region, they must have originated either from a natural expansion or from introductions from Europe. Given the large number of red foxes we sampled throughout Eurasia ($n = 247$) and North America ($n = 353$), the absence of European haplotypes in North America demonstrates that introduced European red foxes have not displaced native North American red foxes in any major portion of the continent.

An important caveat of our findings is that they only reflect matrilineal ancestry and, therefore, do not rule out the possibility that some degree of nuclear introgression (selective or random) has occurred. Moreover, our sample size in the east was too small to conclude that matrilineal European ancestry is absent from that region. Future sampling may yet reveal mitochondrial traces of European introductions in lowland portions of the Eastern Seaboard, particularly those with a long tradition of red fox hunting (e.g., Virginia). However, morphological patterns, which reflect the nuclear genome, are concordant with our mtDNA findings (Churcher 1959). If native red foxes exclude nonnative ones in the East, as has been observed in other areas (Norén et al. 2009; Sacks et al. 2011), then the Appalachian region, which was apparently colonized by native red foxes in the 18th and

TABLE 2.—Occurrence of 23 D-loop haplotypes[a] among recently established red fox populations[b] in the contiguous United States and a sample of red foxes from fur farms based on 342 base pairs from 136 individuals. The clade and subclade to which haplotypes belong is indicated.

		Nearctic clade																		Holarctic clade				
		Mountains subclade					Widespread subclade				Eastern subclade									Alaskan subclade				Eurasian subclade
Population	*n*	19	24	26	43	87	36	37	63	65	9	12	17	76	79	81	85	86	88	7	38	61	73	57
ES	15	—	—	—	—	1	—	—	—	—	3	—	—	8	—	1	—	—	—	—	2	—	—	—
CS	7	—	—	—	—	—	1	1	—	—	2	2	—	—	—	—	—	—	—	—	—	1	—	—
GB	26	17	1	—	2	—	—	—	—	1	2	—	2	—	—	—	—	—	—	—	1	—	—	—
WA	22	1	—	3	—	—	—	—	—	—	6	—	—	—	—	—	—	—	—	—	12	—	—	—
ORW	11	10	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—
CA	17	—	—	—	—	—	6	—	—	—	2	5	—	—	—	—	—	—	—	1	3	—	—	—
FF	38	—	—	—	—	—	2	—	1	—	7	1	13	—	1	—	2	4	3	—	—	—	1	3
Total	136	28	1	3	2	1	9	1	1	1	23	8	15	8	1	1	2	4	3	1	18	1	1	3

[a] Haplotypes 7, 9, 12, 17, 19, 24, 34, 36, 37, 38, 43, 57, 61, 63, 73, and 79 are as reported by Aubry et al. (2009); 65 is as reported by Sacks et al. (2010); 85 and 86 are as reported in Statham et al. (2011); and 26, 76, 81, 87, and 88 are from this study.

[b] CA = Southern California, CS = Central United States, ES = Southeastern United States, GB = Great Basin, ORW = Western Oregon, WA = Western Washington, FF = fur-farm samples.

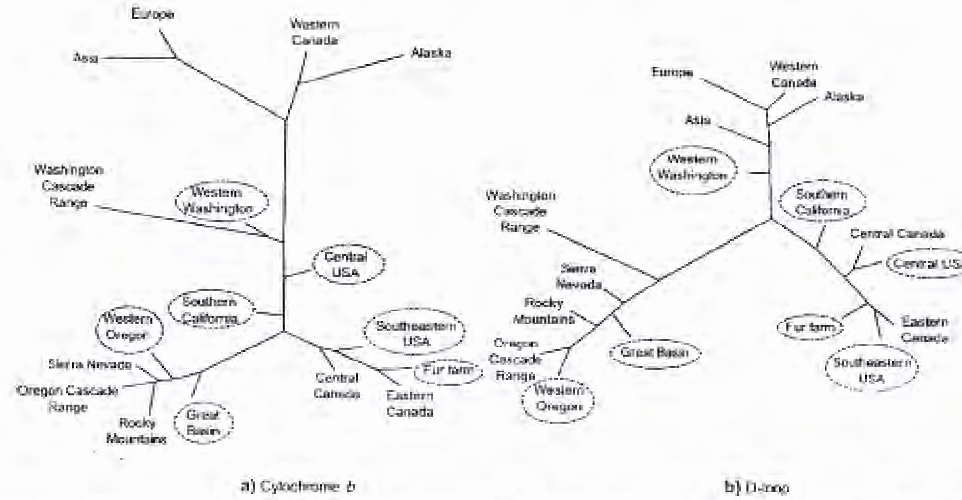

FIG. 3.—Unrooted neighbor-joining clustering tree based on pairwise Φ_{ST} values between 17 sampling localities (Appendix II). The lengths of the lines are proportional to the degree of genetic distance among sampling localities. a) Based on a 354-base pair (bp) segment of the cytochrome-*b* gene from 453 red foxes. b) Based on a 342-bp segment of the D-loop from 350 red foxes.

19th centuries (Audubon and Bachman 1849), could pose a barrier to the westward movement of nonnative foxes from coastal regions. Regardless of these caveats, and barring the unlikely possibility of systematic selection against European mitochondrial haplotypes in North America, it seems clear from our findings in this study and others of North American red fox mtDNA (Aubry et al. 2009; Perrine et al. 2007; Sacks et al. 2010, 2011) that contemporary North American red fox populations reflect primarily native ancestry. These findings clearly refute the conclusions of Kamler and Ballard (2002) that contemporary North American red foxes in lowland areas of the Pacific coastal states and throughout most of the historical range of native red foxes are of European ancestry.

The use of diagnostic nuclear markers will be needed to fully investigate the potential for traces of genetic introgression by introduced European red foxes into North American populations. However, several lines of evidence give reason to doubt that much of the genome will prove to be of European ancestry. For example, analyses of certain dental and cranial characteristics indicate greater divergence between European and eastern North American red foxes than between European and Alaskan red foxes (Churcher 1959). In addition, red foxes from the East are among the smallest in North America, and considerably smaller than those found in Sweden, England, and France (Cavallini 1995; Lloyd 1980; Merriam 1900), which were the 3 European sources of Colonial introductions to the United States (Long 2003). Moreover, Baird (1857) reported that red foxes from the southeastern and northeastern United States were similar morphologically, but differed substantially from European red foxes in muzzle length, pelage features, and other external characteristics. A series of climatic warming and cooling cycles occurred in North America during the Holocene (Dorf 1959), and fossils of the red fox have been found in the upper Midwest that date to the early and middle Holocene (10,000–4,000 years ago), and as far south as Georgia that date to the late Holocene (500–4,000 years ago [Faunmap Working Group 1996]). These records suggest that the southern range boundary of native red

TABLE 3.—Within-population statistics for 6 recently established red fox populations in the contiguous United States and a sample of red foxes from fur farms, based on mitochondrial cytochrome-*b* and D-loop data sets. Tajima's (1989) *D*, and Fu and Li's (1993) D^* and F^* are neutrality statistics, where departures from zero can indicate expansion (negative) or secondary contact between 2 or more lineages (positive). Significant Strobeck's (1987) *S*-values indicate admixture from multiple source populations. The neutrality statistics and Strobeck's *S*-values were only given for the D-loop data set.

Population	Cytochrome *b*				D-loop							
	n	No. haplotypes	*h*	π	*n*	No. haplotypes	*h*	π	Tajima's *D*	Fu and Li's D^*	Fu and Li's F^*	Strobeck's *S*
Southeastern United States	16	7	0.83	0.0068	15	4	0.47	0.0107	−0.86	0.21	−0.51	0.14
Central United States	11	5	0.76	0.0083	7	5	0.90	0.0177	−0.49	−0.58	−0.65	0.68
Great Basin	27	5	0.48	0.0024	26	7	0.62	0.0131	−1.20	1.02	−1.26	0.25
Western Washington	20	4	0.67	0.0080	22	4	0.64	0.0183	2.16	1.52**	1.87**	0.004**
Western Oregon	11	2	0.18	0.0005	11	2	0.17	0.0030	−1.85**	−2.32*	−2.50	0.34
Southern California	18	5	0.75	0.0088	17	5	0.79	0.0192	1.44	1.52	1.73	0.041*
Fur-farm samples	38	6	0.63	0.0056	38	11	0.82	0.0106	−0.69	0.58	0.19	0.55

* Significant at $P < 0.05$; ** significant at $P < 0.01$.

Table 4.—Support values for grouping recently established red fox populations with reference native populations or fur-farm samples based on cytochrome-*b* and D-loop data sets using AMOVA (Excoffier et al. 1992). Reference population groupings are: (1) Eurasia (Europe and Asia), (2) Northwestern North America (Alaska and western Canada), (3) Southeastern Canada (central Canada, eastern Canada, and northeastern United States), and (4) the Western Mountains (Washington Cascade Range, Oregon Cascade Range, Sierra Nevada, and Rocky Mountains); and (5) fur-farm samples.

Reference population	European origins[a]			North American origins[a]		
	Eu only	Eu + FF	Eu + FF + Exp	FF only	Exp only	FF + Exp
Southeastern United States	1	1	1	5	3	3
Central United States	1	1	1	5	3	5
Western Oregon	1	5	4	5	4	4
Great Basin	1	5	4	5	4	4
Western Washington	1	5	5	5	4	5
Southern California	1	5	5	5	4	5
Cytochrome-*b* Φ_{CT}	0.23	0.37**	0.45**	0.51***	0.52***	0.53***
D-loop Φ_{CT}	—	—	—	0.30***	0.31***	0.40***

[a] Eu = Eurasia, FF = fur farm, Exp = range expansion from native populations.
* $P \leq 0.05$; ** $P \leq 0.01$; *** $P \leq 0.001$.

foxes in eastern North America may have shifted periodically in response to changing climatic conditions since the retreat of Wisconsin glaciers.

Although red foxes were historically absent or extremely rare in the central and western United States (with the exception of high-elevation areas in the western mountains and the Sacramento Valley of California), they became established in many lowland areas during the 1900s (Aubry 1983, 1984; Bailey 1936b; Sacks et al. 2010; Whitlow and Hall 1933). These recently established populations could have resulted from human translocations of fur-farm animals that subsequently escaped or were released (Aubry 1983, 1984; Lewis et al. 1999), continental-scale range expansions from the East (Kamler and Ballard 2002), natural range expansions by native montane populations (Bailey 1936a; Fichter and Williams 1967; Verts and Carraway 1998), or human translocations from native montane populations for fur farming.

In several putatively nonnative populations in the west and in the central United States, we found a few Eastern subclade haplotypes that were best explained by continental-scale translocations of fur-farmed foxes. Several haplotypes were common among our study populations but not necessarily common in the ancestral populations (i.e., consistent with origin from a common founder population). Although our sample size from the central United States was too low to rule out natural range expansions from the east, it is noteworthy

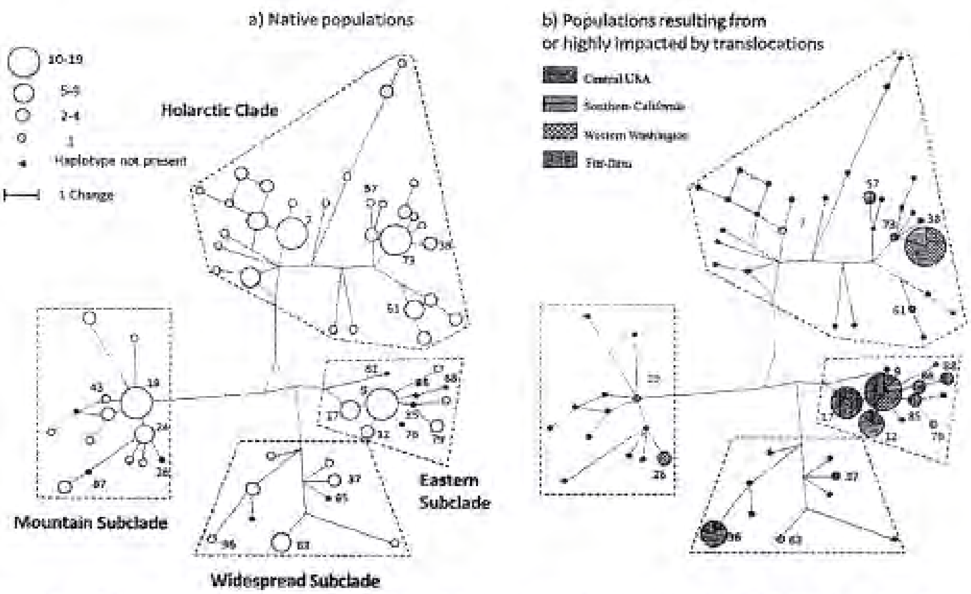

Fig. 4.—D-loop median joining network based on 342 base pairs with superimposed higher order clades and subclades as reported by Aubry et al. (2009). Branch lengths are proportional to the number of substitutions, and circle sizes are proportional to the number of individuals represented. Numbered haplotypes are those found in this study. Together, the Mountain, Eastern, and Widespread subclades comprise the Nearctic clade, which is restricted to North America. a) Network of haplotypes found in native populations (modified from Aubry et al. [2009]). b) Network of haplotypes present among populations resulting from or highly impacted by translocations.

FIG. 5.—Interpretation of the origin of red fox samples analyzed in this study; black triangles indicate samples with haplotypes that reflect intracontinental translocations, white triangles indicate samples with haplotypes that occur primarily in native populations, and gray triangles indicate samples of uncertain origin (i.e., samples with haplotypes that have a widespread distribution or incomplete sequences). Dotted lines encompass the populations analyzed. We consider the following haplotypes to have a signature of translocation, by region: Southeastern United States: G-38; Central United States, G-38, G-61, G-? (x2), and ?-36; Great Basin: F-17, F-?, and G-38; Western Washington: A-19, F-9 (x8), G-38 (x12), and O-26 (x3); Western Oregon: F-9; and Southern California: E-9, F-9, F-12 (x3), F-? (x3), ?-12 (x2), G-38 (x2), ?-38, K-36 (x6), N-7, and N-?.

that some of the Eastern subclade haplotypes found here also occurred in other isolated western populations that clearly originated from translocations (see below). In contrast, native populations in the western mountains were distinct from the Central United States and Eastern United States populations, indicating that Rocky Mountain red foxes did not expand their range eastward to lower-elevation habitats in the Great Plains (Fig. 5). Thus, midelevation areas along the eastern edge of the Rocky Mountains may represent a natural contemporary barrier between populations of native western and eastern red foxes.

In the West, we found evidence that some of these recently established populations were derived from native montane populations, whereas others clearly originated from translocations. Our samples from western Oregon and the Great Basin exhibited low mitochondrial diversity, significant negative neutrality statistics (Western Oregon population), and a high prevalence of the basal Mountain subclade haplotype A-19 (see Aubry et al. 2009), consistent with origins from native populations in the western mountains. Our findings provide support for previous hypotheses about natural range expansions by montane red foxes in these regions (Fichter and Williams 1967; Verts and Carraway 1998), but do not exclude the possibility that the recent establishment of these populations was human-mediated, nor that introgression of particular nonnative alleles could have facilitated a broadening of their habitat niche, enabling them to expand to habitats that were unsuitable previously. The widespread occurrence of the basal A-19 haplotype throughout most of the montane reference populations limited our resolution, enabling us only to trace the ancestry of these animals to the western mountains; however, previous microsatellite analyses of our samples from lowland Idaho and Nevada demonstrated that they were closely related to adjacent native Rocky Mountain populations (Sacks et al. 2010). Moreover, there is evidence that remnant populations of montane red foxes may have occurred in Nevada in some of the areas where we have now confirmed the presence of native genotypes (Hall 1946; Sacks et al. 2010). In the intermountain west, winter snowfall may create connectivity among otherwise distinct habitats during the peak dispersal period, which could facilitate natural range expansions. However, neither of these scenarios could explain the occurrence of native montane haplotypes among red foxes in western Oregon—winter snowpacks do not form there and the red fox clearly did not occur in the Willamette Valley until the 1940s (Bailey 1936a; Verts and Carraway 1998). Microsatellite analysis will be needed to isolate the region from which this population originated and genome-wide scans or selective sweep-mapping will be needed to assess the possibility of introgression by adaptive nonnative alleles in this and other populations (e.g., Great Basin).

In contrast to the Western Oregon and Great Basin populations, we found clear evidence of nonnative origins for recently established Western Washington and Southern California populations. Red fox populations in these regions had high mitochondrial diversity, consistent with a well-documented history of fur farming. Additionally, both populations had significant Strobeck's S-values (indicating admixture), clustered with the geographically distant Central United States population in the neighbor-joining tree, and contained similar mixtures of phylogenetically divergent haplotypes. Translocations or fur farms have been documented in or adjacent to all of the Washington counties where we detected these haplotypes (Aubry 1984), and throughout southern California (Lewis et al. 1999).

Relatively few haplotypes were common to >1 of these populations, making them useful indicators of nonnative stock. Most of these haplotypes were from the Eastern subclade and native to populations in southeastern Canada and the northeastern United States (E-9, F-9, F-12, and F-17), or in native Holarctic-clade populations in Alaska and western Canada (G-38, G-73, and N-7). Of the 38 samples we sequenced from red fox fur farms, most belonged to the Eastern subclade ($n = 31$), including those from Norway and Russia. Thus, these haplotypes also will be useful when screening for nonnative ancestry in Eurasian populations. According to historical records, most of the original breeding stock for the fur-farming industry came from Prince Edward Island in southeastern Canada, and consisted predominantly of locally caught foxes supplemented with those imported from southern Alaska (Balcom 1916; Laut 1921). Fur farmers on Prince Edward Island primarily raised the silver–black color phase, which had the greatest economic value. Farmed foxes from Prince Edward Island were subsequently used to stock fur farms in many areas of North America and Eurasia (Petersen 1914; Westwood 1989). At the same time, red fox breeders independently farmed other strains in Ontario, Quebec, and Maine (Balcom 1916). Given that silver fox breeders could charge as much as $1,500 each in the mid-1920s (Eugene Guard 1924), it is possible that fur farmers obtained their breeding stock from wild populations having high frequencies of the silver–black color phase, such as those in Alberta or British Columbia, Canada, or the Cascade Range in Washington (Butler 1945; Cowan 1938), as was done in Alaska until at least 1927 (Anchorage Daily Times 1927). Indeed, the presence of haplotype O-26 in a translocated population likely originated in the Washington Cascades (Aubry et al. 2009).

Contrary to previous interpretations, we found no matrilineal descendants of European red foxes anywhere in North America. Although more intensive sampling in the East may yet uncover evidence of limited or localized European red fox ancestry, the clear lack of European haplotypes found thus far in the east, and in a relatively large sample of nonnative foxes derived largely from eastern stock, clearly indicates that North American red foxes have retained primarily North American ancestry. However, many populations in the contiguous United States bear a genetic signature of translocations from other North American locations. Lowland populations in western Washington, southern California, and the central United States represent an unnatural admixture of clades and subclades translocated from disparate parts of North America. In contrast, recently established populations in western Oregon and the Great Basin had little genetic diversity and were not significantly differentiated from most native montane populations. Thus, it is clear that these recently established populations were derived, at least in part, from montane populations. Despite an extensive history of red fox translocations into and throughout North America, nonnative lineages apparently have persisted only in regions where native red foxes were absent historically. A focused study of microsatellite and single nucleotide polymorphism diversity in the native Sacramento Valley and adjacent nonnative red fox population in California suggested that native foxes may be able to competitively exclude nonnative foxes, hybridizing only on the margins of the native range (Sacks et al. 2011). Similar studies would be useful for understanding the ecological dynamics between native and nonnative red foxes in the intermountain west.

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Literature Cited

Anchorage Daily Times. 1927. Fur-farmers name officers; exchange ideas at banquet; and discuss needs of industry. Thursday, 8 September, Anchorage, Alaska.

Aubry, K. B. 1983. The Cascade red fox: distribution, morphology, zoogeography and ecology. Ph.D. dissertation, University of Washington, Seattle.

Aubry, K. B. 1984. The recent history and present distribution of the red fox in Washington. Northwest Science 58:69–79.

Aubry, K. B., M. J. Statham, B. N. Sacks, J. D. Perrine, and S. M. Wisely. 2009. Phylogeography of the North American red fox: vicariance in Pleistocene forest refugia. Molecular Ecology 18:2668–2686.

AUDUBON, J. J., AND J. BACHMAN. 1849. The viviparous quadrupeds of North America. Privately published by J. J. Audubon, New York. Vol. 2.

BAILEY, V. 1936a. The mammals and life zones of Oregon. North American Fauna 55:1–416.

BAILEY, V. 1936b. The red fox in America. Nature Magazine 28:269–272, 317.

BAIRD S. F. 1857. General report upon the zoology of several Pacific railroad routes. Pp. 331–334 in Reports of explorations and surveys. Vol. 8. Part 1. 33d Congress, 2d session, Executive Document 78. United States Government Printing Office, Washington, D.C.

BALCOM, A. B. 1916. Fox farming in Prince Edward Island: a chapter in the history of speculation. Quarterly Journal of Economics 30:665–681.

BANDELT, H. J., P. FORSTER, AND A. RÖHL. 1999. Median-joining networks for inferring intraspecific phylogenies. Molecular Biology and Evolution 16:37–48.

BUTLER, L. 1945. Distribution and genetics of the color phases of the red fox in Canada. Genetics 30:39–50.

CAVALLINI, P. 1995. Variation in the body size of the red fox. Annales Zoologici Fennici 32:421–427.

CHURCHER, C. S. 1959. The specific status of the New World red fox. Journal of Mammalogy 40:349–360.

COWAN, I. M. 1938. Geographic distribution of color phases of the red fox and black bear in the Pacific Northwest. Journal of Mammalogy 19:202–206.

CRONON, W. 1983. Changes in the land: Indians, colonists, and the ecology of New England. Hill and Wang, New York.

DORF, E. 1959. Climatic changes of the past and present. Contributions from the Museum of Paleontology, University of Michigan 8:181–210.

EUGENE GUARD. 1924. Silver foxes are received in city. Wednesday, 15 October, Eugene, Oregon.

EXCOFFIER, L., AND H. E. L. LISCHER. 2010. Arlequin suite ver 3.5: a new series of programs to perform population genetics analyses under Linux and Windows. Molecular Ecology Resources 10:564–567.

EXCOFFIER, L., P. E. SMOUSE, AND J. M. QUATTRO. 1992. Analysis of molecular variance inferred from metric distances among DNA haplotypes: application to human mitochondrial DNA restriction data. Genetics 131:479–491.

FAUNMAP WORKING GROUP. 1996. Spatial response of mammals to late Quaternary environmental fluctuations. Science 272:1601–1606.

FELSENSTEIN, J. 1989. PHYLIP—phylogeny inference package (version 3.2). Cladistics 5:164–166.

FICHTER, E., AND R. WILLIAMS. 1967. Distribution and status of the red fox in Idaho. Journal of Mammalogy 48:219–230.

FRATI, F., G. B. HARTL, S. LOVARI, M. DELIBES, AND G. MARKOV. 1998. Quaternary radiation and genetic structure of the red fox *Vulpes vulpes* in the Mediterranean Basin, as revealed by allozymes and mitochondrial DNA. Journal of Zoology (London) 245:43–51.

FREDSTED, T., M. H. SCHIERUP, L. F. GROENEVALD, AND P. M. KAPPELER. 2007. Genetic structure, lack of sex-biased dispersal and behavioral flexibility in the pair-living fat-tailed dwarf lemur, *Cheirogaleus medius*. Behavioral Ecology and Sociobiology 61:943–954.

FU, X. Y., AND W. H. LI. 1993. Statistical tests of neutrality in mutations. Genetics 133:693–709.

GRINNELL, J., J. S. DIXON, AND J. M. LINSDALE. 1937. Fur-bearing mammals of California. University of California Press, Berkeley. Vols. 1 and 2.

HALL, E. R. 1946. Mammals of Nevada. University of California Press, Berkeley.

HALL, E. R., AND K. R. KELSON. 1959. The mammals of North America. Ronald Press, New York.

INOUE, I., ET AL. 2007. Mitochondrial DNA phylogeography of the red fox (*Vulpes vulpes*) in northern Japan. Zoological Science 24:1178–1186.

KAMLER, J. F., AND W. B. BALLARD. 2002. A review of native and nonnative red foxes in North America. Wildlife Society Bulletin 30:370–379.

KAMLER, J. F., AND W. B. BALLARD. 2003. Range expansion of red foxes in eastern Nevada and western Utah. Journal of the Arizona–Nevada Academy of Sciences 36:18–20.

KIDD, A. G., J. BOWMAN, D. LESBARRÈRES, AND A. I. SCHULTE-HOSTEDDE. 2009. Hybridization between escaped domestic and wild American mink (*Neovison vison*). Molecular Ecology 18:1175–1186.

KOLBE, J. J., R. E. GLOR, L. RODRÍGUEZ SCHETTINO, A. CHAMIZO LARA, A. LARSON, AND J. B. LOSOS. 2004. Genetic variation increases during biological invasion by a Cuban lizard. Nature 431:177–181.

LARIVIÈRE, S., AND M. PASITSCHNIAK-ARTS. 1996. *Vulpes vulpes*. Mammalian Species 537:1–11.

LARSEN, P. F., M. M. HANSEN, E. E. NIELSEN, L. F. JENSEN, AND V. LOESCHCKE. 2005. Stocking impact and temporal stability of genetic composition in a brackish northern pike population (*Esox lucius* L.), assessed using microsatellite DNA analysis of historical and contemporary samples. Heredity 95:136–143.

LAUT, A. C. 1921. The fur trade of America. Macmillan Company, New York.

LEWIS, J. C., K. L. SALLEE, AND R. T. GOLIGHTLY, JR. 1999. Introduction and range expansion of nonnative red foxes (*Vulpes vulpes*) in California. American Midland Naturalist 142:372–381.

LLOYD, H. G. 1980. The red fox. B. T. Batsford Ltd., London, United Kingdom.

LONG, J. 2003. Introduced mammals of the world: their history, distribution and influence. CSIRO Publishing, Melbourne, Australia.

MACPHERSON, A. 1965. The origin of diversity in mammals of the Canadian Arctic tundra. Systematic Zoology 14:153–173.

MERRIAM, C. H. 1900. Preliminary revision of the North American red foxes. Proceedings of the Washington Academy of Sciences 2:661–676.

NEI, M. 1987. Molecular evolutionary genetics. Columbia University Press, New York.

NEI, M., AND W. H. LI. 1979. Mathematical model for studying genetic variation in terms of restriction endonucleases. Proceedings of the National Academy of Sciences 76:5269–5273.

NEWBERRY, J. S. 1857. Report upon the zoology of the route [from the Sacramento Valley to the Columbia River]. Pp. 35–110, plates 26–29 in U.S. Pacific railroad exploration and survey 6, part IV, no. 2. Government Printing Office, Washington, D.C.

NORÉN, K., L. DALÉN, K. KVALØY, AND A. ANGERBJÖRN. 2005. Detection of farm fox and hybrid genotypes among wild arctic foxes in Scandinavia. Conservation Genetics 6:885–894.

NORÉN, K., ET AL. 2009. Farmed arctic foxes on the Fennoscandian mountain tundra: implications for conservation. Animal Conservation 12:434–444.

NOWAK, R. M. 1991. Walker's mammals of the world. 5th ed. Johns Hopkins University Press, Baltimore, Maryland. Vol. II.

PERRINE, J. D., J. P. POLLINGER, B. N. SACKS, R. H. BARRETT, AND R. K. WAYNE. 2007. Genetic evidence for the persistence of the critically endangered Sierra Nevada red fox in California. Conservation Genetics 8:1083–1095.

PETERSEN, M. 1914. The fur traders and fur bearing animals. Hammond Press, Buffalo, New York.

RHOADS, S. N. 1903. The mammals of Pennsylvania and New Jersey. Privately printed, Philadelphia, Pennsylvania.

RHYMER, J. M., AND D. S. SIMBERLOFF. 1996. Genetic extinction through hybridization and introgression. Annual Review of Ecology and Systematics 27:83–109.

RICE, W. R. 1989. Analyzing tables of statistical tests. Evolution 43:223–225.

ROZAS, J., J. C. SANCHEZ-DELBARRIO, X. MESSEGUER, AND R. ROZAS. 2003. DnaSP DNA polymorphism analysis by the coalescent and other methods. Bioinformatics 19:2496–2497.

SACKS, B. N., M. MOORE, M. J. STATHAM, AND H. U. WITTMER. 2011. A restricted hybrid zone between native and introduced red fox (*Vulpes vulpes*) populations suggests reproductive barriers. Molecular Ecology 20:326–341.

SACKS, B. N., M. J. STATHAM, J. D. PERRINE, S. M. WISELY, AND K. B. AUBRY. 2010. North American montane red foxes: expansion, fragmentation, and the origin of the Sacramento Valley red fox. Conservation Genetics 11:1523–1539.

SENN, H. V., AND J. M. PEMBERTON. 2009. Variable extent of hybridization between invasive sika (*Cervus nippon*) and native red deer (*C. elaphus*) in a small geographical area. Molecular Ecology 18:862–876.

SETON, E. T. 1929. Lives of game animals. Doubleday, Doran and Company, Garden City, New York.

SØNSTEBØ, J. H., R. BORGSTRØM, AND M. HEUN. 2008. Genetic structure in alpine brown trout *Salmo trutta* L. shows that indirect stocking affects native lake populations. Journal of Fish Biology 72:1990–2001.

STATHAM, M. J., ET AL. 2011. On the origin of a domesticated species: identifying the parent population of Russian silver foxes (*Vulpes vulpes*). Biological Journal of the Linnean Society 103:168–175.

STROBECK, C. 1987. Average number of nucleotide differences in a sample from a single subpopulation: a test for population subdivision. Genetics 117:149–153.

TAJIMA, F. 1989. Statistical method for testing the neutral mutation hypothesis by DNA polymorphism. Genetics 123:585–595.

VALIERE, N., ET AL. 2003. Long-distance wolf recolonization of France and Switzerland inferred from non-invasive genetic sampling over a period of 10 years. Journal of Animal Conservation 6:83–92.

VERTS, B. J., AND L. N. CARRAWAY. 1998. Land mammals of Oregon. University of California Press, Berkeley.

WESTWOOD, R. E. 1989. Early fur-farming in Utah. Utah Historical Quarterly 57:320–339.

WHITLOW, W. B., AND E. R. HALL. 1933. Mammals of the Pocatello region of southeastern Idaho. University of California Publications in Zoology 40:235–275.

WISELY, S. M., J. E. MALDONADO, AND R. C. FLEISCHER. 2004. A technique for sampling ancient DNA that minimizes damage to museum specimens. Conservation Genetics 5:105–107.

ZHU, Q., X. ZHENG, J. LUO, B. S. GAUT, AND S. GE. 2007. Multilocus analysis of nucleotide variation of *Oryza sativa* and its wild relatives: severe bottleneck during domestication of rice. Molecular Biology and Evolution 24:875–888.

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APPENDIX I

Accession numbers of museum specimens from which we acquired DNA for this study.

Fort Roosevelt Vertebrate Collection: FRC027, FRC061, FRC087; Museum of Vertebrate Zoology: MVZ175993, MVZ207041, MVZ208591, MVZ208595, MVZ222348, MVZ222369, MVZ222471, MVZ33635, MVZ33636, MVZ52099, MVZ52100, MVZ52101, MVZ52102, MVZ57149, MVZ57150, MVZ57151, MVZ57152, MVZ57153, MVZ84481, MVZ90621, MVZ90798, MVZ91097; National Museum of Natural History: USNM107765, USNM110812, USNM188069, USNM188070, USNM19969, USNM224077, USNM242343, USNM242921, USNM242922, USNM242924, USNM243681, USNM243682, USNM243683, USNM243745, USNM263367, USNM263368, USNM263369, USNM263372, USNM263373, USNM264977, USNM264979, USNMA03071, USNMA03707, USNMA03713, USNMA03714, USNMA21156, USNMA21157; University of Washington Burke Museum: UW20182, UW32526, UW32527, UW32530, UW32531, UW32532, UW32534, UW32540, UW32541, UW32543, UW32544, UW32545, UW32547, UW32563, UW32950, UW34306, UW41617, UW73061; Natural History Museum of Los Angeles County: LA2, LA5, LA85700, LA87624; Oregon State University Fisheries and Wildlife Mammal Collection: OSU1175, OSU5543, OSU8778, OSU8779, OSU9017; Santa Barbara Natural History Museum: SB-1, SB-2, SB-3, SB-4, SB-5, SB-6; Slater Museum of Natural History: UPS10841, UPS1252, UPS13382, UPS13383, UPS14885.

APPENDIX II

Pairwise Φ_{ST} values between 10 native and 6 recently established red fox populations[a] in North America, and a sample of red foxes from fur farms. Values in boldface type on the diagonal indicate the number of sequences compared (cytochrome *b*/D-loop). Below the diagonal, values are based on the cytochrome-*b* data set, whereas above the diagonal, values are based on the D-loop data set. Asterisks indicate statistical significance ($P < 0.05$) based on sequential Bonferroni correction for multiple tests (Rice 1989).

	AK	AS	CA	CC	CS	EC	ES	EU	GB	ORW	ORC	RM	SN	WA	WAC	WC	FF
AK	**69/49**	0.25*	0.34*	0.52*	0.40*	0.53*	0.46*	0.24*	0.56*	0.61*	0.62*	0.57*	0.56*	0.21*	0.65*	0.17*	0.47*
AS	0.40*	**21/13**	0.28*	0.45*	0.33*	0.51*	0.41*	0.19	0.56*	0.63*	0.64*	0.58*	0.55*	0.22	0.70*	0.25*	0.42*
CA	0.59*	0.64*	**18/17**	0.14	−0.04	0.19*	0.12	0.38*	0.42*	0.47*	0.47*	0.46*	0.42*	0.19*	0.56*	0.29*	0.17*
CC	0.73*	0.82*	0.06	**6/9**	−0.02	0.13	0.14	0.56*	0.53*	0.64*	0.67*	0.56*	0.52*	0.33*	0.75*	0.41*	0.12*
CS	0.50*	0.60*	0.03	0.11	**11/7**	0.04	0.01	0.46*	0.45*	0.56*	0.57*	0.50*	0.45*	0.22	0.69*	0.34*	0.03
EC	0.73*	0.81*	0.20	0.07	0.20	**26/22**	0.00	0.65*	0.55*	0.65*	0.70*	0.59*	0.55*	0.37*	0.75*	0.49*	0.00
ES	0.68*	0.73*	0.11	0.02	0.09	0.07	**16/15**	0.56*	0.46*	0.58*	0.62*	0.53*	0.50*	0.26*	0.69*	0.40*	0.02
EU	0.42*	0.11*	0.55*	0.63*	0.48*	0.67*	0.61*	**57/8**	0.66*	0.75*	0.77*	0.65*	0.62*	0.21	0.80*	0.16	0.53*
GB	0.73*	0.83*	0.16*	0.04	0.23*	0.30*	0.21*	0.66*	**27/26**	−0.03	0.00	0.02	0.05	0.39*	0.27*	0.52*	0.46*
ORW	0.74*	0.86*	0.15	0.24	0.26*	0.37*	0.23*	0.64*	−0.04	**11/11**	−0.06	0.01	0.04	0.44*	0.42*	0.57*	0.53*
ORC	0.73*	0.85*	0.13	0.33	0.23	0.40*	0.23*	0.63*	−0.03	−0.05	**7/6**	−0.02	0.02	0.44*	0.50	0.58*	0.57*
RM	0.74*	0.84*	0.22*	0.22*	0.31*	0.43*	0.32*	0.67*	0.02	−0.02	−0.06	**30/30**	0.03	0.44*	0.20*	0.54*	0.52*
SN	0.75*	0.85*	0.25*	0.21*	0.34*	0.45*	0.35*	0.69*	0.02	0.01	−0.05	0.00	**37/35**	0.42*	0.23*	0.52*	0.50*
WA	0.37*	0.50*	0.12	0.25*	−0.03	0.34*	0.22*	0.43*	0.33*	0.33	0.30*	0.37*	0.40*	**20/22**	0.52	0.06	0.32*
WAC	0.77*	0.87*	0.39*	0.64*	0.46*	0.61*	0.47*	0.69*	0.51*	0.71*	0.73*	0.51*	0.52*	0.46*	**15/16**	0.63*	0.64*
WC	0.16*	0.40*	0.34*	0.51*	0.19	0.55*	0.46*	0.38*	0.53*	0.53*	0.51*	0.54*	0.57*	0.07	0.62*	**43/28**	0.42*
FF	0.69*	0.73*	0.14*	0.04	0.15	−0.02	0.06	0.64*	0.23*	0.26*	0.28*	0.34*	0.36*	0.29*	0.49*	0.51*	**38/38**

[a] AK = Alaska, AS = Asia, CA = Southern California, CC = Central Canada, CS = Central United States, EC = Eastern Canada and Northeastern United States, ES = Southeastern United States, EU = Europe, GB = Great Basin, ORW = Western Oregon, ORC = Oregon Cascade Range, RM = Rocky Mountains, SN = Sierra Nevada, WA = Western Washington, WAC = Washington Cascade Range, WC = Western Canada, FF = fur-farm samples.

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SURVIVAL AND NATAL DISPERSAL OF JUVENILE SNOWY PLOVERS (*CHARADRIUS ALEXANDRINUS*) IN CENTRAL COASTAL CALIFORNIA

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Abstract.—Juvenile survival and dispersal rates are important demographic parameters in predicting the viability of avian populations, but estimates are seldom available because mortality is usually confounded with permanent natal dispersal in analyses of live-encounter data. We used the Barker model for combined captures, recoveries, and resightings to estimate juvenile survival in fledgling Snowy Plover (*Charadrius alexandrinus*) for the 6.5-to-10.5-month period between fledging at 28 days and 1 April the following year, on the central California coast, for a 16-year period, 1984–1999. By using a large body of year-round sighting data from throughout the species' Pacific-coast range, we estimated true survival and quantified natal dispersal rates and distances. Juvenile survival estimates varied annually between 0.283 ± 0.028 (mean ± SE) and 0.575 ± 0.061 with no trend over the study, and paralleled higher adult survival in our most parsimonious models. In comparison, annual survival of banded chicks from hatching to fledging at age 28 days was 0.285–0.483 ($\bar{x} = 0.382 \pm 0.014$ SE) for those 16 years. Males were more likely to disperse from Monterey Bay for winter and females were more likely to disperse for breeding. Dispersal distances to breeding sites were usually within 10 km of natal sites (64%) and seldom >50 km (16%). The present study provides the first estimate of true survival for a juvenile shorebird and new information on survival and dispersal rates that will be useful for modeling Snowy Plover population viability. Studies of local winter residents, focused on predator pressure and weather conditions, could further advance our understanding of factors determining Snowy Plover survival.
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Key words: Barker model, *Charadrius alexandrinus*, demography, endangered–threatened species, fledging rate, philopatry, program MARK, shorebird, Snowy Plover.

Supervivencia y Dispersión Natal de Juveniles de *Charadrius alexandrinus* en la Costa Central de California

Resumen.—La supervivencia y la tasa de dispersión de los juveniles son parámetros demográficos importantes para la predicción de la viabilidad de las poblaciones. Sin embargo las estimaciones de estos parámetros casi nunca están disponibles debido a que en los análisis de datos de avistamiento, la mortalidad es confundida con procesos de dispersión natal permanente. Utilizamos el modelo de Barker con datos de capturas combinadas, recapturas y avistamientos repetidos en la costa central de California

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para estimar la supervivencia de juveniles de *Charadrius alexandrinus* para un periodo de 6.5 a 10.5 meses entre el emplumamiento a los 28 días y el primer día de abril del año siguiente, durante un periodo de 16 años (1984-1999). Utilizando una gran base de datos de avistamientos en el rango de distribución de esta especie a lo largo de la costa Pacífica, estimamos tanto las tasas de supervivencia verdaderas como las tasas y distancias de dispersión natal. Los estimados de supervivencia juvenil variaron anualmente entre 0.283 ± 0.028 (media ± EE) y 0.575 ± 0.061, sin un patrón determinado durante el periodo estudiado, pero fluctuando de modo paralelo a las tasas de supervivencia más altas de los adultos según nuestros modelos más parsimoniosos. Comparativamente, la tasa de supervivencia anual de los polluelos anillados, desde la eclosión hasta el emplumamiento a los 28 días, fue de 0.285–0.483 (= 0.382 ± 0.014 EE) para los 16 años de datos. Los machos presentaron una mayor probabilidad de dispersarse desde la Bahía Monterrey para invernar, mientras que las hembras presentaron mayor probabilidad de dispersarse para reproducirse. Generalmente, la distancia de dispersión a los sitios de cría no fue más de 10 km desde el lugar natal (64%) y raramente más de 50 km (16%). Este estudio presenta la primera estimación de supervivencia verdadera de juveniles de aves playeras así como información nueva sobre las tasas de supervivencia y dispersión, las cuales serán útiles para modelar la viabilidad de poblaciones de *C. alexandrinus*. Nuevos estudios sobre los individuos residentes de invierno enfocados en las presiones por parte de los depredadores y en las condiciones climáticas podrían contribuir aún más para el entendimiento de los factores que determinan la supervivencia de esta especie.

UNBIASED AND PRECISE estimates of demographic parameters are essential for understanding the population dynamics of small or imperiled bird populations (Beissinger and Westphal 1998). Demographic parameters are usually age-structured and often difficult to estimate. Juvenile survival is particularly difficult to estimate, because natal dispersal co-occurs with juvenile mortality, thus confounding estimates of both parameters (Greenwood and Harvey 1982, Larson et al. 2000). These problems are significant for shorebirds, with some species demonstrating considerable vagility (Stenzel et al. 1994, Clarke et al. 1997). Information on juvenile survival rates is lacking for most shorebird species (Sandercock 2003).

The population of Snowy Plovers (*Charadrius alexandrinus*) nesting along the Pacific coast of the United States is designated as threatened by the U.S. Fish and Wildlife Service (1993). Habitat loss, predation, and human disturbance are major threats to this population, which nests primarily on coastal beaches (Page and Stenzel 1981). The lengthy nesting season of Snowy Plovers extends from mid-March to mid-September (Page et al. 1995b), enabling pairs to renest after egg failure, females to nest again after eggs hatch, and males to renest after chicks fledge or perish (Warriner et al. 1986, Page et al. 1995b). Although both sexes share incubation, the female typically deserts the brood soon after chicks hatch, leaving the male to rear them alone. Many Snowy Plovers occupy the same coastal site year-round, but some disperse to other coastal sites for winter. Since 1993, there have been extensive management efforts to increase the size of the population. Although information on Snowy Plover reproductive success is available (Page et al. 1995b, Powell et al. 2002, Ruhlen et al. 2003, Neuman et al. 2004), much less is known about survival rates, especially for juveniles (Paton 1994, Sandercock et al. 2005).

Standard mark–recapture models for live encounter data, such as the Cormack-Jolly-Seber (CJS) model, are based on encounter histories of individually marked animals captured or resighted in focal study areas. The CJS models estimate only apparent survival (ϕ), because mortality is confounded with permanent emigration (Lebreton et al. 1992). Snowy Plovers in western North America were monitored year-round (Page et al. 1986, 1991, 1995a; PRBO unpubl. data) and could be detected throughout their range during survival intervals, providing additional data that cannot be included in encounter histories for standard CJS models. Consequently, we used a joint model for live encounters (on encounter occasions and in survival intervals) and dead recoveries developed by Barker (1999) to examine 16 years of data on Snowy Plover fledglings. This model permits estimation of true survival (S), site fidelity (F), and other demographic parameters. To date, for birds, Barker's (1999) model has been used primarily for waterfowl (e.g., Sedinger et al. 2002) but also for an oystercatcher (Sagar et al. 2002).

The objectives of this long-term field study were five-fold. The first was to estimate true juvenile survival for a shorebird of conservation concern. The second was to examine the relationship of juvenile, chick, and adult survival for evidence that juvenile survival was affected by factors in common with other age classes. The third was to examine the potential effects of predator control on juvenile survival. Management activities commencing in 1991 and fully underway by 1993 to protect Snowy Plover eggs and, to a lesser extent, chicks in the Monterey Bay area included nest exclosures and mammalian predator removal (Neuman et al. 2004). One of the main predators, red fox (*Vulpes vulpes*), is known to depredate adult shorebirds (Brunton 1986, L. Feeney unpubl. data). We examined the effect of these management efforts by looking for a trend in juvenile survival over the study or for a change after the commencement of these efforts. The fourth objective was to examine the potential effect of winter climate conditions on juvenile survival. Although winters in coastal California generally are mild, severe El Niño–La Niña events can disrupt the coastal environment for both the prey and avian predators of Snowy Plovers (Holmgren et al. 2001, PRBO unpubl. data). We were unable to directly examine the influence of avian predators on survival, because data on predator distribution and abundance are lacking. The last objective was to compare philopatry rates and natal dispersal distances between the sexes. Philopatry and natal dispersal are parameters shaping population dynamics that are often sex-biased and associated with a species' mating system (Greenwood 1980). For species like the Snowy Plover that employ a resource-defense mating system, the male, the sex that defends the resources, is hypothesized to be more philopatric than the female. Conversely, females are hypothesized to disperse more frequently or farther than males (Greenwood 1980, Clarke et al. 1997).

Methods

Study area.—The study was conducted over 18 years (1984–2001) at Monterey Bay, on the central California coast. The study area included 40 km of contiguous sandy beach of Monterey Bay in Santa Cruz and Monterey counties (122°17′W, 37°6′N to 121°52′W, 36°36′N); retired salt ponds at Elkhorn Slough, Monterey County, 1 km inland of the center of the beach (121°47′W, 36°49′N); and five small creek mouths in northern Santa Cruz County. Individual Snowy Plovers moved regularly among these areas (hereafter "Monterey Bay area"). The nearest major nesting areas were 48 km to the north and 160 km to the south. Small beaches, 10–44 km north and 32–151 km south of Monterey Bay, were used irregularly by five or fewer pairs (Page and Stenzel 1981, PRBO unpubl. data; Fig. 1). In the study area, the distribution of breeders varied among years, with the largest concentrations near the Pajaro (121°49′W, 36°51′N) and Salinas (121°48′W, 36°45′N) river mouths and at the salt ponds. The greatest linear distance between potential breeding beaches in the Monterey Bay area was 65 km.

Data collection.—We attempted to find all Snowy Plover nests in the study area and banded chicks at hatch with individual color band combinations, mostly at or near nest sites. Unmarked parents attending chicks were also captured and marked with individual color band combinations. All birds received an aluminum federal band and one to three Darvic plastic color bands. For increased durability, all bands were wrapped with automobile pinstriping tape (color-matched to plastic bands) and the ends of plastic bands and tapes were heat soldered. Parents were monitored for broody behavior (alert posture, ground distraction displays, and aerial alarm displays). When these behaviors were not apparent, we searched for chicks and watched for broody behavior on subsequent visits to ascertain whether broods had been lost. Fledging was defined as the survival of chicks to 28 days, when they begin to fly and males are usually still in attendance. Males usually abandon or decrease their attendance of young shortly after fledging (Page et al. 1995b). We usually did not attempt to view the chicks until 28 days after hatch, because of concerns that we could be cueing predators to broods. Once young had fledged, we observed the male

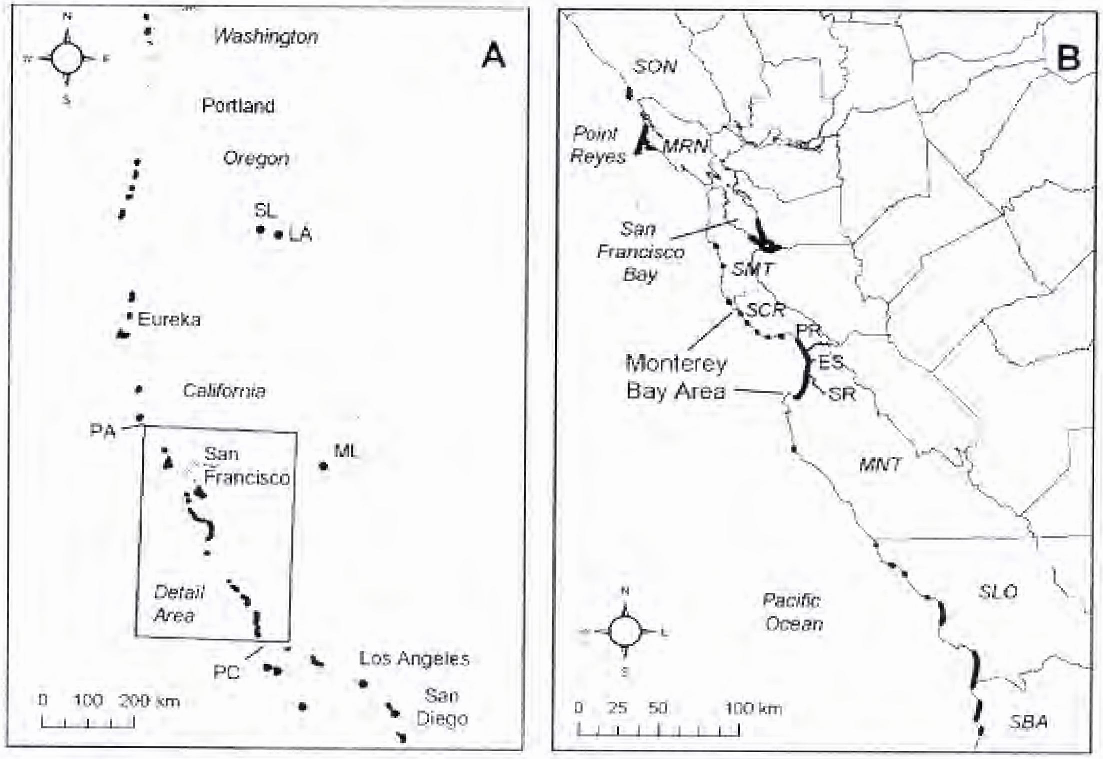

FIG. 1. (A) U.S. Pacific coast breeding range of Snowy Plovers, identifying interior locations (Lake Abert = LA, Summer Lake = SL, and Mono Lake = ML) where plovers hatched at Monterey Bay have been reported. Thickened coastlines indicate nesting areas (PA = Point Arena and PC = Point Conception). (B) Detail area of central California coast, showing county boundaries and Monterey Bay study area, including Pajaro River mouth (PR), Elkhorn Slough salt ponds (ES), and Salinas River mouth (SR). Coastal counties are Sonoma (SON), Marin (MRN), San Mateo (SMT), Santa Cruz (SCR), Monterey (MNT), San Luis Obispo (SLO), and Santa Barbara (SBA).

and brood for up to several hours to determine the identity of chicks that had fledged. Sex could be determined only for birds in alternate plumage, as early as December for juvenile males and March for juvenile females. Males were distinguished by a lack of brown feathers in the black forehead, ear covert, and foreneck markings, and females by some brown feathers in these areas. Males also exhibited bright rusty caps early in the breeding season, whereas female caps were pale brown (Page et al. 1995b).

We searched for pairs and nests beginning 1 March and monitored nests from mid-March to mid-August and chicks from mid-April to mid-September; we scanned local flocks for marked juveniles until 31 October. Detections of banded Snowy Plovers during the survival intervals came from four sources: (1) intensive year-round observations of banded birds in our study area, 1984–2001; (2) a volunteer-based program of site surveys, ongoing since 1979 (Page et al. 1986); (3) breeding-season sightings by Snowy Plover and Least Tern (*Sterna albifrons*) monitors; and (4) recoveries of dead banded Snowy Plovers. All color-band observations were screened for accuracy, and project personnel were sent to correct or verify implausible or unexpected sightings. Questionable sightings were not included in any analyses.

The volunteer-based surveys covered most California coastal locations used by Snowy Plovers outside our study area during the nonbreeding season (Page et al. 1986). We defined major sites as those holding >14 individuals on at least half the survival intervals in which they were checked. Although surveys were focused on the nonbreeding season, many sites were covered year-round. The authors supplemented this effort to ensure winter coverage of the most remote coastal sites between the study area and Point Conception. Survival-interval coverage from 1979 to 1986 is reported in Page et al. (1986). Subsequently, observers conducted 560–1,066 (median = 849) total surveys annually from 1986 to 2001, with 17,400–51,500 (median = 29,500) total birds checked for bands (including multiple checks of the same flocks); 60–84% (median = 69%) of the 95 major California sites were covered by observers annually. Overall, 14% of the surveys were in May or June, 35% in July–October, 40% in November–February, 8% in March, and 4% from 16–30 April. Because Snowy Plovers often move locally in winter (Page et al. 1986), some marked individuals were detected at more than one site. Other researchers conducted an annual comprehensive winter survey of Oregon beaches. We also obtained limited information from the Washington coast (where <20 Snowy Plovers winter) and Baja California, Mexico. In Baja California, we checked several hundred Snowy Plovers each winter, 1991–1994, while surveying other shorebirds (Page et al. 1997). Researchers studying Brant (*Branta bernicla*) in Baja California, 1990–1993 and 1996–1999, also contributed to sightings of marked Snowy Plovers.

During the breeding season, sightings of our banded birds outside the Monterey Bay area were obtained from other researchers monitoring Snowy Plovers at specific sites and from broad-scale surveys. Comprehensive coastal breeding surveys in May or June were conducted in Washington: 1994–2001; Oregon: 1984–2001; and California: 1989 (Page et al. 1991), 1991, 1995 (excluding San Francisco Bay), and 2000. In coastal California, north of Point Arena, comprehensive surveys were conducted from 1992 to 1994, but coverage was limited to fewer sites in other years. North of Monterey Bay to Point Arena, Marin County sites were surveyed or monitored, 1986–2001; coastal San Mateo County sites, 1987–1992 and 1994–2001; and San Francisco Bay sites, 1984, 1986–1989, 1991–1997, 1999, and 2001. South of Monterey Bay to Point Conception, most major nesting beaches were surveyed or monitored, 1986–1992 and 1994–2001. South of Point Conception to the Mexican Border, most major sites were surveyed or monitored, 1989–1992 and 1994–2001. Additionally, researchers monitoring Least Terns located some banded Snowy Plovers nesting in association with Least Terns in and south of Santa Barbara County. Comprehensive inland breeding surveys were made of Oregon sites in 1985–1990 and of California sites in 1988. Plovers also were checked for bands on breeding surveys in Baja California in 1991 and 1992 (Palacios et al. 1994).

Juvenile survival rate from fledging.—Survival of banded fledglings to the following April (hereafter "juvenile survival") was estimated from >66,000 live encounters and 35 dead recoveries from April 1984 to March 2001. Our "encounter occasion" was 1–15 April; by then, breeding was well underway in almost all years. Bearhop et al. (2003) identify methodological factors that can introduce heterogeneity into a mark–encounter sample and violate key model assumptions. For precocial shorebirds, survival and its key explanatory variables can be expected to vary among four periods: egg stage, chick stage, juvenile stage, and adult stage. Pooling survival estimates over two stages, and even within one stage (e.g., banding chicks at various ages), may introduce sample heterogeneity (Sandercock et al. 2005). To control for this source of heterogeneity, we started the survival interval for all juveniles at 28 days of age. Because chicks fledged from mid-May through mid-September, we controlled for the varying lengths of the first (juvenile) survival interval by including date of fledging as an individual covariate of the juvenile survival and first re-encounter parameters. To minimize heterogeneity caused by differing site fidelities, this sample is used only to estimate juvenile survivorship.

We considered individual and annual covariates of juvenile survival. Individual covariates were linear and quadratic terms for the date of fledging; both covariates were included to allow for midseason extrema in survival. Annual covariates were a trend variable, the overall prior fledging rate, predator management, and winter climate extremes. Because the progeny of Monterey Bay breeders may winter from Oregon to Baja California Sur, we examined the effect of broad-scale winter climate extremes on annual survival. We used the sum of the monthly multivariate El Niño–Southern Oscillation indices (MEIs) for September–March, 1984–2001 (available from the National Oceanographic and Atmospheric Administration [NOAA] Climate Diagnostics

Center; see Acknowledgments) as a proxy variable for broad-scale climate conditions. We considered possible effects from La Niña events (low-negative MEIs, associated with low temperatures), El Niño events (high-positive MEIs, associated with high precipitation), or both extremes (high MEI absolute values).

We explored models and estimated demographic parameters using MARK, version 3.1 (White and Burnham 1999) and procedures suggested by Lebreton et al. (1992). To include information on live- and dead-marked Snowy Plovers between encounter occasions, we employed Barker's (1999) model. All models were created with design matrices, using the logit-link function. It was not possible to assess the fit of the global model, because the bootstrap method is not currently recommended because of bias in the $\hat{c}$ estimate (White 2002, G. C. White pers. comm.). Nonetheless, the sensitivity of model selection to potential overdispersion was examined by adjusting $\hat{c}$ in increments of 0.01 up to 10. To rank the candidate models, we used the Akaike Information Criterion (AIC) corrected for small sample size (AIC_c, or $QAIC_c$ for $\hat{c} > 1$). We identified models with the strongest support as those with normalized Akaike weights (w_i; Table 1) >0.01 and ΔAIC_c (differences between AIC_c or $QAIC_c$ of the model with lowest AIC_c or $QAIC_c$ and the model under consideration) values <2 for some value of $\hat{c}$. We used the variance components procedure in MARK to remove sampling variance from the overall estimate of true survival in our global model.

The Barker model estimates the following seven parameters: (1) S_i is the probability that an individual alive at i is alive at $i + 1$ (survival to 1 April). All models considered were time-since-marking (two age-classes, S^1 and S^{2+}, and time-dependent, t). The survival interval for S^1 extended from age 28 days (fledging) to the following April. We also examined models in which survival was constrained to be additive for age class within years; to be a function of the observed proportion of chicks fledged that season (f), premanagement (1984–1992) or management (1993–2001) years (m), or the MEI (e or $|e|$, its absolute value); or to follow an annual trend (T) over the study. We also modeled first-year survival with individual covariates for date of hatch as a linear trend (d) or as a quadratic function (d and $d2$ [d^2]). Specific

TABLE 1. Barker models under $\hat{c} = 1.00$ for survival of Snowy Plovers from fledging to the following April, 1984–1999. All models with AIC_c weights (w_i) > 0.01 and $\Delta AIC_c < 2$ under any values of $\hat{c}$ are shown. Models are ranked out of the 22 considered under $\hat{c} = 1.00$. Survival and detection probabilities are two age-class (S^1 and p^1, first year, and S^{2+} and p^{2+}, after first year). Subscripts are t (time, year), R (sighting probability of birds that survive the interval), c (constant), d (date of hatch), and $d2$ (date of hatch squared). Resighting of surviving birds is a function of time (R_t) for models shown. For all models, recovery and return parameters are modeled as constants (r_c, F'_c). Model 10 is the global model.

Model rank	Model parameterization	AIC_c	ΔAIC_c	AIC_c weight (w_i)	Model likelihood	Number of parameters	Deviance
1	$S^1_t + S^{2+}_t \; p^1_{t+d+d2} + p^{2+}_t \; R'_R F_t$	8,918.14	0.00	0.312	1.000	72	8,771.76
2	$S^1_t + S^{2+}_t \; p^1_{d+d2} + p^{2+} \; R'_R F_t$	8,918.63	0.50	0.243	0.780	59	8,799.04
3	$S^1_t + S^{2+}_t \; p^1_{d+d2} + p^{2+} \; R'_t F_t$	8,919.40	1.26	0.166	0.532	75	8,766.82
8	$S^1_t + S^{2+}_t \; p^1_{t+d+d2} + p^{2+}_t \; R'_R F_c$	8,925.92	7.78	0.006	0.020	57	8,810.43
12	$S^1_t + S^{2+}_t \; p^1_t + p^{2+}_t \; R'_R F_c$	8,952.05	33.92	0.000	0.000	55	8,840.67
10	$S^1_{t+d+d2} * S^{2+}_t \; p^1_{t+d+d2} * p^{2+}_t \; R'_t F_t$	8,928.41	10.27	0.002	0.005	104	8,715.45

survival terms for candidate models were $S^1_{t+d+d2} * S^{2+}_t$, $S^1_{t+d} * S^{2+}_t$, $S^1_t * S^{2+}_t$, $S^1_t + S^{2+}_t$, $S^1_f * S^{2+}_f$, $S^1_m * S^{2+}_m$, $S^1_T * S^{2+}_T$, $S^1_e * S^{2+}_e$, and $S^1_{|d|} * S^{2+}_{|d|}$ with d and $d2$ considered in the latter terms if warranted, based on results from fitting terms in the first three models. (2) p_i is the probability that an individual at risk of detection at (encounter occasion) i is detected at i. Because many year-old birds do not begin occupying territories and breeding as early as most older adults (PRBO unpubl. data), all models we considered were time-since-marking (two age-class, p^1 and p^{2+}, and time, t). Detection for first year of re-encounter was constrained to be additive for age class and date of hatch in some models examined. Specific detection terms considered in candidate models were $p^1_{t+d+d2} * p^{2+}_t$, $p^1_t * p^{2+}_t$, $p^1_t + p^{2+}_t$, and $p^1 + p^{2+}$, with d and $d2$ considered in the latter terms if warranted, as above for S^1. (3) r_i is the the probability that an individual that dies in interval $(i, i + 1)$ is found dead and the band reported. We had few recoveries and only considered r_c, a constant recovery rate term. (4) R_i is the probability that an individual that survives the interval $(i, i + 1)$ is sighted some time in interval $(i, i + 1)$. For survivors, we considered the terms R_t and R_c. (5) R'_i is the probability that an individual that dies in interval $(i, i + 1)$ without being found dead is sighted alive in $(i, i + 1)$ before it dies. For nonsurvivors, we considered the terms R'_t, R'_R (resighting of nonsurvivors constrained as a linear function of resighting of survivors), and R'_c. (6) F_i is the probability that an individual at risk of encounter at i and alive at $i + 1$ is at risk of encounter at $i + 1$ (study-site fidelity). We considered fidelity terms F_t and F_c. And (7) F'_i is the probability that an individual not at risk of encounter at i is at risk of encounter at $i + 1$ (return of temporary emigrants). For returning emigrants, we considered only F'_c.

Fledging rates and juvenile survival rates from hatch.—The annual chick fledging rates, f_i, were calculated as the proportion of banded chicks that survived from hatch to 28 days. We estimated annual juvenile survival from hatch to the following April as the product of annual fledging rates and juvenile survival estimates, $f_i\,\hat{S}_i$; mean rates of fledging and survival from hatch were calculated by weighting years equally.

Natal dispersal.—We compared the proportions of each sex employing different first-year dispersal patterns. The four primary patterns were (1) remaining in the natal area for the first winter and breeding season, (2) remaining in the natal area for winter but dispersing to breed, (3) dispersing from the natal area for winter but returning to breed, and (4) dispersing from the natal area for winter and subsequent breeding season. Patterns for 16 Snowy Plovers of undetermined sex that emigrated for nesting were apportioned in relation to the ratio of males and females with the same patterns. "Corrected" dispersal patterns were derived by augmenting the observed Snowy Plover numbers by the estimated number that survived but were never detected after their first March; this was calculated as (true survival rate × total fledglings in the sample) minus the number detected after March. We added the estimate into the totals for the two dispersal patterns in which nesting was away from the Monterey Bay area, based on the ratio of identified males and females in those categories.

Natal dispersal distances.—Natal dispersal distances were calculated for birds nesting in the Monterey Bay area in their first breeding season or seen elsewhere in their first or a subsequent breeding season. We included all individuals with confirmed (observed attending eggs or chicks) or behavioral evidence of breeding and May and June sightings of birds unsupported by breeding evidence. Sightings at other times, without evidence of breeding, were excluded to avoid including birds engaged in pre- or post-breeding movements. Mean distances moved were used for Snowy Plovers nesting at more than one site. For juveniles absent from the Monterey Bay area in their first breeding season and found breeding elsewhere in a subsequent breeding season, we assumed breeding-site fidelity and used that location for distance calculations. All estimates are reported as means ± SE, unless otherwise noted.

Results

Juvenile survival rate from fledging.—For the five models we identified with $w_i > 0.01$ and ΔAIC_c (or $\Delta QAIC_c$) < 2 for some value of $\hat{c}$, survival probabilities were a function of time (t, year) and juvenile and adult rates were additive ($S^1_t + S^{2+}_t$; Table 1). Detection probabilities were a function of time, hatch date, or both for the top five models. Survival interval sighting probabilities were a function of time, with probabilities for surviving Snowy Plovers paralleling

TABLE 2. Overall parameter estimates at $\hat{c} = 1$ for the global model. Estimates (± SE) with only process variance, taken from the variance components procedure of MARK, except where modeled as a constant. $\hat{S}^1$ is survival from fledging (at age 28 days) to the following April.

Parameter	Estimate
$\hat{S}^1$ (juvenile survival)	0.463 ± 0.018
$\hat{S}^{2+}$ (adult survival)	0.691 ± 0.033
$\hat{p}^1$ (juvenile occasion detection)	0.711 ± 0.056
$\hat{p}^{2+}$ (adult occasion detection)	1.000 ± 0.000
$\hat{r}$ (recovery)	0.007 ± 0.002 [a]
$\hat{R}$ (interval sighting, survivors)	0.861 ± 0.023
$\hat{R}'$ (interval sighting, nonsurvivors)	0.562 ± 0.047
$\hat{F}$ (fidelity)	0.766 ± 0.038
$\hat{F}'$(return of emigrants)	0.173 ± 0.020 [a]

[a] Modeled as constant.

those that did not survive the intervals in all but one of the top models. Emigration probabilities were a function of time in three and constant in two of the top models. We constrained recovery and return probabilities to be constant in all models. We did not find a relationship between survival and broad-scale winter climate conditions or predator management. There also was no support for a relationship between chick survival and postfledging survival or for a trend in survival during the study. All the latter models ranked below the global model in AIC_c value. At all overdispersion levels examined, the sums of w_i for models in which survival was time- and age-dependent, with juvenile paralleling adult rates ($S_t^1 + S_t^{2+}$), were ≥0.84 out of a possible total weight of 1.00. Models 1, 2, 3, and 8 were the most highly weighted through the most typical levels of overdispersion ($\hat{c} < 3$).

Overall estimated juvenile survival was $\hat{S}^1 = 0.463 \pm 0.018$ (Table 2); model averaging produced annual estimates between 0.283 ± 0.028 and 0.575 ± 0.061; three-quarters were between 0.422 and 0.552 (Fig. 2). Encounter-occasion detection estimates for juveniles ($\hat{p}^1$) and survival interval sighting estimates for all birds ($\hat{R}$ and $\hat{R}'$) were relatively high (≥0.56), but the recovery rate of dead Snowy Plovers was quite low ($\hat{r} < 0.01$; Table 2). Estimates of site fidelity ($\hat{F}$) were relatively high, and the return rate of temporary emigrants ($\hat{F}'$) was low (Table 2); however, they did not reflect actual rates of philopatry or return for temporary emigrants, because they were based on a brief encounter occasion (1–15 April) rather than on the lengthier nesting season.

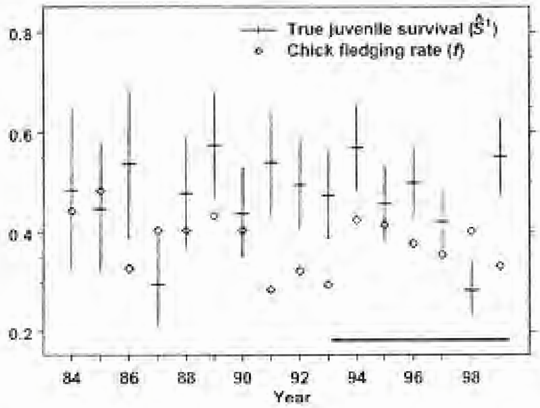

FIG. 2. Annual fledging rates (survival from hatch to age 28 days), f_i, and estimates of true juvenile survival ($\hat{S}_i^1$) for subsequent 6.5–10.5 months, 1984–1999. Juvenile survival estimates are from model averaging under $\hat{c} = 1.00$; vertical lines show 95% confidence intervals. The period of mammalian predator management is indicated by the horizontal line.

Fledging rate and juvenile survival from hatch.—We banded 161–434 chicks per year from 1984 to 1999 at Monterey Bay ($\bar{x} = 242 \pm 20$, $n = 16$ years, 3,873 total chicks). Of these, 0.285–0.483 survived to fledging at 28 days ($\bar{x} = 0.382 \pm 0.014$, 1,466 total fledglings). Only four chicks, initially recorded as not fledging, were later discovered alive. These rates differ slightly from those in Neuman et al. (2004), who reported only on the portion of the study area where predator management was concentrated. The fledging rate (f_i) was particularly low from 1991 to 1993, just as predator management was becoming fully implemented in parts of the study area (Fig. 2). No long-term trend was observed in the fledging rate (nonparametric test for trend, Spearmann's $D = 406$, $P = 0.118$, $n = 16$). The proportion of 124–234 clutches annually producing ≥1 fledgling declined from 0.379 in 1984 to a low of 0.190 in 1991, then increased to 0.329–0.446 per year with predator management ($\bar{x} = 0.329 \pm 0.019$ for the 16 years considered). Overall, about one-third of the 2,813 clutches produced ≥1 fledgling. We rarely determined the sex of Snowy Plovers not surviving to their first breeding season, but of 642 fledglings seen after 31 March of the year following hatch, 48.6% were females, 48.6% males, and 2.8% were of unknown sex.

Juvenile survival is usually reported for the 12-month period from hatching to the following year. Our juvenile survival estimate was for the 6.5–10.5 month period following fledging. Mean annual survival from hatch to April of the first breeding season was 0.179 ± 0.010 for $\hat{c} < 4$, on the basis of an annual fledging rate (f_i) and estimates of juvenile survival ($\hat{S}_i^J$).

Natal dispersal.—We relocated 642 first-winter survivors, including 31 Snowy Plovers without breeding evidence that were never seen again after 6 May. The remainder included 297 females, 294 males, 16 Snowy Plovers of undetermined sex that survived long enough to be assigned to a first-year dispersal pattern, and 4 Snowy Plovers that did not fall into one of the four primary dispersal patterns. For three patterns, involving some residency in our study area, we believe that relative detection probabilities were similar for the sexes. Assuming that our detection of permanent emigrants was also similar between sexes, the proportions of females and males employing the four primary dispersal patterns differed ($\chi^2 = 27.89$, df = 3, $P < 0.0001$; Table 3), with females slightly more likely than males (56% vs. 46%) to winter in the study area (odds ratio = 1.5, 95% confidence interval [CI]: 1.1 to 2.1) and males more likely than females (78% vs. 64%) to breed there (odds ratio = 2.0, 95% CI: 1.4 to 3.0). Thus, dispersal for wintering was slightly more common for males and dispersal for breeding more common for females. Eleven percent of locally banded chicks and 29% of fledglings recruited into the study area's breeding population.

The above proportions are probably biased toward birds spending some time in the Monterey Bay area because some permanent emigrants were not seen again after leaving. Given an overall juvenile survival rate of $\hat{S}^J = 0.463$, an estimated 679 ± 34 fledglings survived to the following April. Adding the estimated 37 additional birds (679–642) to those known to have bred away from Monterey Bay, the estimate of breeding and permanent emigrants increased by 12% for females and 17% for males (Table 3). Philopatry rates for Monterey Bay declined to 59% for females and to 74% for males, but the sexual difference was maintained (odds ratio = 2.0, 95% CI: 1.4 to 2.8; Table 3).

Natal dispersal distances.—We determined natal dispersal distances for 44 females and 30 males that spent their entire first breeding season away from Monterey Bay. Of these, 37 females and 29 males were found at breeding sites by their first breeding season; 28 of the females and 26 of the males also met our criteria for nesting by then.

The mean distance between the natal site and site of first breeding was greater for 238 females (median = 6.9 km, maximum = 790 km) than for 259 males (median = 4.2 km, maximum = 360 km; one-tailed Z-test, $Z_n = 1.890$, $P = 0.029$; Fig. 3; Reed 1993). Overall, observed natal dispersal distances were usually within 10 km of natal sites (64%) but were occasionally >50 km (16%). Among the local fledglings recruiting into the study area, 35% of the females and 27% of

TABLE 3. Observed and estimated proportions of Snowy Plovers, using four dispersal patterns with respect to the Monterey Bay area from winter to their first breeding season.

	Females		Males	
	Observed	Estimated	Observed	Estimated
Sample size (n)	306	328	301	316
Breed and winter in Monterey Bay area	0.428	0.399	0.399	0.380
Breed in Monterey Bay area, winter away	0.209	0.195	0.382	0.364
Breed away, winter in Monterey Bay area	0.131	0.137	0.056	0.063
Breed and winter away	0.232	0.268	0.163	0.193

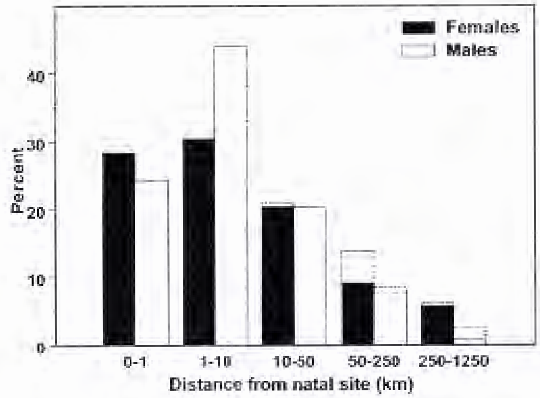

FIG. 3. Natal dispersal distances for 238 females and 259 males fledged in the Monterey Bay area. Birds without evidence of breeding are indicated by broken line.

the males bred within 1 km, and 73% of females and 76% of males within 10 km, of natal sites. Both sexes dispersed north and south to breed. All 74 first-year dispersers were found only at coastal sites, including San Francisco Bay.

DISCUSSION

SURVIVAL

Potential sources of variability in juvenile Snowy Plover survival.—During the present study, Snowy Plovers exhibited annual variability in juvenile survival rates from 0.283 to 0.575, with no long-term trend. The parallel relationship between juvenile and adult survival rates suggests that important annual mortality factors for the two age classes were similar, but either these factors had a greater effect on juveniles or juveniles experienced an additional period of elevated mortality, possibly directly after fledging. There was no evidence that juvenile survival was affected by mammalian predator management midway through the study or that it was correlated to chick survival to fledging. Because predator management was focused on protecting eggs and unfledged chicks, a positive effect would be expected if the predators also were causing postfledging mortality. Conversely, a negative effect might be expected if management successfully increased fledgling numbers and if mortality after fledging were density-dependent (Côté and Sutherland 1997). The success of mammalian predator management at increasing the fledging rate was modest in our study area (Neuman et al. 2004), and there was no evidence that mammals were affecting postfledging survival. The lack of correlation between annual fledging and juvenile survival rates suggests that factors affecting survival during chick rearing differed from those during the subsequent fall and winter.

We did not find an effect of broad-scale climate extremes on juvenile survival. Mortality may be more strongly correlated with local (e.g., weather) than broad-scale (e.g., winter climate extremes) conditions, but it was not possible to determine dispersal patterns for most juveniles that did not survive their first winter and, thereby, account for local factors in our models. We believe that there could have been severe weather-related mortality, as reported for other shorebirds (Baillie 1980, Davidson and Clark 1985), but effects of climate on survival were masked because other factors, such as avian predation, also were important. For example, in 1987, one of the years of lowest survival (Fig. 2), 30 pairs of Snowy Plovers moved from beaches to nearby riverine islands where they produced 26–29 fledglings. Subsequently, after a Northern Harrier (*Circus cyaneus*) began hunting over the islands, 16 of 23 banded fledglings were never seen again and feather remains characteristic of harrier kills were located. Such postfledging events may introduce variability to annual juvenile survival that could mask the effects of other factors, such as winter climate extremes. We suspect that avian predators may be important determinants of Snowy Plover survival, but we lacked adequate data on predation pressure to examine this factor. Studies of winter residents focused on local predator pressure and weather conditions may further our understanding of the factors determining Snowy Plover survival. Because it takes a year to establish a nonbreeding residency pattern, adults may provide better subjects for such studies.

The time of fledging and, therefore, the length of the first survival interval were not related to survival, which suggests that mortality was not occurring at a steady rate after fledging. Prewinter mortality may have occurred soon after fledging and before fledglings had developed competent flight, such as described above. Weather-related winter mortality also may be episodic. For example, of 170 marked Snowy Plovers with established winter residency patterns between Monterey Bay and Point Reyes, 19% were last seen in November or December 1990, coincident with a week-long period of freezing temperatures in December (PRBO unpubl. data).

We could not control for sex in our analysis of juvenile survival, because it was unknown at hatching and fledging. Sexual bias in detection would be a factor primarily during the breeding season when sexual roles differ (Warriner et al. 1986); however, our overall estimate of adult detection was 1.0 ($\hat{p}^{2+}$; Table 2). Therefore, we believe that sexual bias in detecting birds was negligible. Székely et al. (2004) report a hatchling sex ratio not different from 1:1 for Kentish Plovers (*C. a. alexandrinus*) in Turkey. If the hatchling sex ratio for our study was also 1:1, because of the 1:1 sex ratio for 624 fledglings seen after their first March, we found no evidence to suggest that juvenile survival (from hatch) differed between the sexes.

Overall juvenile survival.—Using Barker's (1999) model with extensive range-wide coverage, our estimated overall juvenile survival rate of $\hat{S}$ = 0.463 for the Snowy Plover is the first estimate of true survival for any shorebird. Previous survival estimates for plovers from mark–encounter models vary according to the estimation technique used and the birds' ages at the beginning of the survival interval. Although our estimate is considerably higher than a mark–encounter survival estimate reported for fledgling Kentish Plovers in Turkey, it is similar to mark–encounter survival estimates for two other plover species. Apparent first-winter survival ($\hat{\phi}$) estimates are 0.15 for Kentish Plover fledglings in Turkey (Sandercock et al. 2005), 0.47 for Mountain Plovers (*C. montanus*) in Montana (Dinsmore et al. 2003), and 0.48 for Piping Plovers (*C. melodus*) on the Atlantic coast (Melvin and Gibbs 1996), but none of these estimates distinguishes permanent emigration from mortality. Sandercock et al. (2005) report that their apparent first-winter survival estimate fell 40%, to 0.09, when they pooled four age groups of chick and fledgling Kentish Plovers. The effect of such pooling may account in part for the lower apparent survival rates reported by Paton (1994) for Snowy Plovers at Great Salt Lake (0.385) and Larson et al. (2000) for Piping Plovers in central North America (0.318).

Barker's (1999) model was suitable for this study, because it allowed the use of a large body of data from outside encounter occasions and outside our study area. Of 642 first-winter survivors detected, 79% were seen in the study area on at least one encounter occasion after original capture, 9% in the study area only during survival intervals, and 11% only outside the study area during survival intervals. Thus, we could estimate survival from all information on 99% of all birds known to have survived, compared with only 79% that would have been used in a CJS model. Further, it permitted use of a brief encounter occasion (4% of the survival interval length) without sacrificing most individual detections.

Dispersal

In a review of vertebrate dispersal studies, Greenwood (1980) hypothesized that the class of mating system—resource-defense versus mate-defense—should predict the direction of sexual bias in philopatry or dispersal. The Snowy Plovers we studied exhibited male-biased philopatry and female-biased natal dispersal, a pattern characterizing other avian species in which males defend resources rather than females (Greenwood 1980, Clarke et al. 1997). Other researchers reported male-biased philopatry (or female-biased natal dispersal) in five studies of resource-defense shorebird species, but failed to find a sexual bias in philopatry or dispersal in six other studies (Clarke et al. 1997 and citations therein, Robinson and Oring 1997, Kruk et al. 1998, Flynn et al. 1999). Reed and Oring (1993) and Jackson (1994) suggest that the lack of sexual bias reported for some shorebirds may be an artifact of study methods, particularly relatively small study plots within large areas of suitable breeding habitat. If limited area of search was a contributing factor to the lack of observed sexual bias in philopatry in the former studies, the pattern of male-biased philopatry reported by our study and 5 of 11 studies of other shorebirds may be more typical of shorebirds employing a resource-defense mating system than previously indicated.

We found that the probability that a Snowy Plover will breed in a location is inversely related to the distance from its natal site, which is consistent with other shorebirds. Most birds (64%) settled <10 km, and only 16% >50 km, from natal sites. Although search effort may have created some downward bias in dispersal distances outside the study area, even within the Monterey Bay area ~75% of the juveniles settled <10 km from natal sites. Documentation of natal dispersal distances beyond study sites is available for few species. Haig and Oring (1988) reported considerable variability for Piping Plovers, with ~70% of detected natal dispersal within 10 km at Minnesota and New York study sites, but <40% within 10 km at a Manitoba study site; however, these dispersal distances were not all from unequivocal breeding-season months or confirmed breeding sites. For the area within 40 km of natal sites, Jackson (1994) found that ~95% of Common Redshank (*Tringa totanus*), Dunlin (*Calidris alpina*), and Ringed Plover (*Charadrius hiaticula*) dispersing <8 km. Thompson et al. (1994) reported that 61% of Lapwings (*Vanellus vanellus*) settled <10 km from natal sites. Kruk et al. (1998) reported that breeding-season recoveries of Black-tailed Godwit (*Limosa limosa*) were 66% within 5 km, 77% within 10 km, and 90% within 23 km. Cramp and Simmons (1983) reported that half the Little Ringed Plovers (*C. dubius*) tracked in Germany settled <10 km and none were found >250 km from natal sites. They suggested that the ephemeral nature of Little Ringed Plover breeding habitat imposes dispersal on that species; we believe that this is also true for Snowy Plovers nesting in coastal strand habitat.

If dispersal is regulated by locally fluctuating habitat quality, population density, or distribution of suitable habitat, as suggested for other birds (Reed and Oring 1993, Paradis et al. 1998, Altwegg et al. 2003), natal dispersal rates of Snowy Plovers could vary temporally and spatially. We did not examine these variables for Snowy Plovers because we lacked data on breeding-habitat extent for most years, though it clearly varied considerably. Population viability analysis for the Snowy Plover would benefit from improved information on patterns of natal dispersal and factors affecting this demographic parameter.

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Literature Cited

Altwegg, R., A. Roulin, M. Kestenholtz, and L. Jenni. 2003. Variation and covariation in survival, dispersal, and population size in Barn Owls *Tyto alba*. Journal of Animal Ecology 72:391–399.

Baillie, S. 1980. The effect of the hard winter of 1978/79 on the wader populations of the Ythan Estuary. Wader Study Group Bulletin 28:16–17.

Barker, R. J. 1999. Joint analysis of mark–recapture, resighting and ring-recovery data with age-dependence and marking-effect. Bird Study 46 (Supplement):82–91.

Bearhop, S., R. M. Ward, and P. R. Evans. 2003. Long-term survival rates in colour-ringed shorebirds—Practical considerations in the application of mark–recapture models. Bird Study 50:271–279.

Beissinger, S. R., and M. I. Westphal. 1998. On the use of demographic models of population viability in endangered species management. Journal of Wildlife Management 62:821–841.

Brunton, D. H. 1986. Fatal antipredator behavior of a Killdeer. Wilson Bulletin 98:605–607.

Clarke, A. L., B.-E. Sæther, and E. Røskaft. 1997. Sex biases in avian dispersal: A reappraisal. Oikos 79:429–438.

Côté, I. M., and W. J. Sutherland. 1997. The effectiveness of removing predators to protect bird populations. Conservation Biology 11:395–405.

Cramp, S., and K. E. L. Simmons, Eds. 1983. Handbook of the Birds of Europe, the Middle East and North Africa: The Birds of the Western Palearctic, vol. III: Waders to Gulls. Oxford University Press, New York.

Davidson, N. C., and N. A. Clark. 1985. The effects of severe weather in January and February 1985 on waders in Britain. Wader Study Group Bulletin 44:10–16.

Dinsmore, S. J., G. C. White, and F. L. Knopf. 2003. Annual survival and population estimates of Mountain Plovers in southern Phillips County, Montana. Ecological Applications 13:1013–1026.

Flynn, L., E. Nol, and Y. Zharikov. 1999. Philopatry, nest-site tenacity, and mate fidelity of Semipalmated Plovers. Journal of Avian Biology 30:47–55.

Greenwood, P. J. 1980. Mating systems, philopatry and dispersal in birds and mammals. Animal Behaviour 28:1140–1162.

Greenwood, P. J., and P. H. Harvey. 1982. The natal and breeding dispersal of birds. Annual Review of Ecology and Systematics 13:1–21.

Haig, S. M., and L. W. Oring. 1988. Distribution and dispersal in the Piping Plover. Auk 105: 630–638.

Holmgren, M., M. Scheffer, E. Ezcurra, J. R. Gutiérrez, and G. M. J. Mohren. 2001. El Niño effects on the dynamics of terrestrial ecosystems. Trends in Ecology and Evolution 16:89–94.

Jackson, D. B. 1994. Breeding dispersal and site-fidelity in three monogamous wader species in the Western Isles, U.K. Ibis 136: 463–473.

Kruk, M., M. A. W. Noordervliet, and W. J. Ter Keurs. 1998. Natal philopatry in the Black-tailed Godwit *Limosa limosa* L. and its possible implications for conservation. Ringing and Migration 19:13–16.

Larson, M. A., M. R. Ryan, and B. G. Root. 2000. Piping Plover survival in the Great Plains: An updated analysis. Journal of Field Ornithology 71:721–729.

Lebreton, J.-D., K. P. Burnham, J. Clobert, and D. R. Anderson. 1992. Modeling survival and testing biological hypotheses using marked animals: A unified approach with case studies. Ecological Monographs 62:67–118.

Melvin, S. M., and J. P. Gibbs. 1996. Viability analysis for the Atlantic coast population of Piping Plovers. Pages 175–186 *in* Piping Plover (*Charadrius melodus*) Atlantic Coast Population Revised Recovery Plan (A. Hecht, D. Avrin, S. Melvin, J. Nicholls, C. Raithel, and K. Terwilliger, Eds.). U.S. Fish and Wildlife Service, Hadley, Massachusetts.

Neuman, K. K., G. W. Page, L. E. Stenzel, J. C. Warriner, and J. S. Warriner. 2004. Effect of mammalian predator management on Snowy Plover breeding success. Waterbirds 27:257–263.

Page, G. W., F. C. Bidstrup, R. J. Ramer, and L. E. Stenzel. 1986. Distribution of wintering Snowy Plovers in California and adjacent states. Western Birds 17:145–170.

Page, G. W., E. Palacios, L. Alfaro, S. Gonzalez, L. E. Stenzel, and M. Jungers. 1997. Numbers of wintering shorebirds in coastal wetlands of Baja California, Mexico. Journal of Field Ornithology 68:562–574.

Page, G. W., and L. E. Stenzel. 1981. The breeding status of the Snowy Plover in California. Western Birds 12:1–40.

Page, G. W., L. E. Stenzel, W. D. Shuford, and C. R. Bruce. 1991. Distribution and abundance of the Snowy Plover on its western North American breeding grounds. Journal of Field Ornithology 62:245–255.

Page, G. W., M. A. Stern, and P. W. C. Paton. 1995a. Differences in wintering areas of Snowy Plovers from inland breeding sites in western North America. Condor 97:258–262.

Page, G. W., J. S. Warriner, J. C. Warriner, and P. W. C. Paton. 1995b. Snowy Plover (*Charadrius alexandrinus*). *In* The Birds of North America, no. 154 (A. Poole and F. Gill, Eds.). Academy of Natural Sciences, Philadelphia, and American Ornithologists' Union, Washington, D.C.

Palacios, E., L. Alfaro, and G. W. Page. 1994. Distribution and abundance of breeding Snowy Plovers on the Pacific coast of Baja California. Journal of Field Ornithology 65: 490–497.

Paradis, E., S. R. Baillie, W. J. Sutherland, and R. D. Gregory. 1998. Patterns of natal and breeding dispersal in birds. Journal of Animal Ecology 67:518–536.

PATON, P. W. C. 1994. Survival estimates for Snowy Plovers breeding at Great Salt Lake, Utah. Condor 96:1106–1109.

POWELL, A. N., C. L. FRITZ, B. L. PETERSON, AND J. M. TERP. 2002. Status of breeding and wintering Snowy Plovers in San Diego County, California, 1994–1999. Journal of Field Ornithology 73:156–165.

REED, J. M. 1993. A parametric method for comparing dispersal distances. Condor 95: 716–718.

REED, J. M., AND L. W. ORING. 1993. Philopatry, site fidelity, dispersal, and survival of Spotted Sandpipers. Auk 110:541–551.

ROBINSON, J. A., AND L. W. ORING. 1997. Natal and breeding dispersal in American Avocets. Auk 114:416–430.

RUHLEN, T. D., S. ABBOTT, L. E. STENZEL, AND G. W. PAGE. 2003. Evidence that human disturbance reduces Snowy Plover chick survival. Journal of Field Ornithology 74:300–304.

SAGAR, P. M., R. J. BARKER, AND D. GEDDES. 2002. Survival of breeding Finsch's Oystercatchers (*Haematopus finschi*) on farmland in Canterbury, New Nealand. Notornis 49:233–240.

SANDERCOCK, B. K. 2003. Estimation of survival rates for wader populations: A review of mark–recapture methods. Wader Study Group Bulletin 100:163–174.

SANDERCOCK, B. K., T. SZÉKELY, AND A. KOSZTOLÁNYI. 2005. The effects of age and sex on the apparent survival of Kentish Plovers breeding in southern Turkey. Condor 107:583–596.

SEDINGER, J. S., N. D. CHELGREN, M. S. LINDBERG, T. OBRITCHKEWITCH, M. T. KIRK, P. MARTIN, B. A. ANDERSON, AND D. H. WARD. 2002. Life-history implications of large-scale spatial variation in adult survival of Black Brant (*Branta bernicla nigricans*). Auk 119:510–515.

STENZEL, L. E., J. C. WARRINER, J. S. WARRINER, K. S. WILSON, F. C. BIDSTRUP, AND G. W. PAGE. 1994. Long-distance breeding dispersal of Snowy Plovers in western North America. Journal of Animal Ecology 63:887–902.

SZÉKELY, T., I. C. CUTHILL, S. YEZERINAC, R. GRIFFITHS, AND J. KIS. 2004. Brood sex ratio in the Kentish Plover. Behavioral Ecology 15:58–62.

THOMPSON, P. S., D. BAINES, J. C. COULSON, AND G. LONGRIGG. 1994. Age at first breeding, philopatry and breeding site-fidelity in the Lapwing *Vanellus vanellus*. Ibis 136:474–484.

U.S. FISH AND WILDLIFE SERVICE. 1993. Endangered and threatened wildlife and plants; determination of threatened status for the Pacific coast population of the western Snowy Plover; final rule. Federal Register 58:12864–12874.

WARRINER, J. S., J. C. WARRINER, G. W. PAGE, AND L. E. STENZEL. 1986. Mating system and reproductive success of a small population of polygamous Snowy Plovers. Wilson Bulletin 98:15–37.

WHITE, G. C. 2002. Discussion comments on the use of auxiliary variables in capture–recapture modelling: An overview. Journal of Applied Statistics 29:103–106.

WHITE, G. C., AND K. P. BURNHAM. 1999. Program MARK: Survival estimation from populations of marked animals. Bird Study (Supplement) 46:120–139.

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Home range, habitat selection and diet of foxes (*Vulpes vulpes*) in a semi-urban riparian environment

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Abstract

Between 2000 and 2002 the home range, habitat selection and diet of foxes were examined in the Dandenong Creek Valley, Melbourne. The mean home range was 44.6ha (range 19.2 – 152.6 ha). A significant selection towards blackberry and gorse used as diurnal shelter was found during the day with an active avoidance of less structurally complex vegetation types. While there was obvious selection of certain habitats, the diet of urban foxes is highly generalistic and opportunistic and offers little potential as a factor to manipulate in order to reduce fox abundance. Given the strong preference for blackberry and gorse as a shelter resource a habitat manipulation strategy is suggested by where patches of blackberry and gorse are removed and replaced with less structurally complex vegetation. Such a habitat manipulation strategy has the potential to significantly influence the density of foxes in semi-urban riparian environments such as those discussed in this study.

Keywords habitat selection, habitat manipulation, fox, *Vulpes vulpes*, pest, control, home range, diet **Running Title:** Habitat use and diet of urban foxes

Introduction

Red foxes (*Vulpes vulpes*) have established over most of mainland Australia, possibly following the spread of the European rabbit (*Oryctolagus cuniculus*) and brown hare (*Lepus capensis*) (Jarman 1986) and are now considered a serious threat to many different groups of native species (e.g. Olsson *et al*, 2005; Priddel and Wheeler 1997; Spencer and Thompson 2005) and agricultural productivity (Saunders *et al*. 1995). The management of foxes in urban areas and at the urban agricultural interface is becoming increasingly difficult, primarily due to the lack of safe and fox-specific management options (Hegglin *et al*. 2004; Marks *et al*, 1996). In most cases, traditional mortality based control strategies such as baiting and shooting are not possible with den fumigation being one of the few practical control options available to managers (Hart *et al*. 1996). More recently, research has focussed on developing fecundity based control strategies (Seamark 2001) which may have potential applications in controlling foxes in urban environments. These strategies primarily rely on the delivery of baits containing abortive compounds such as cabergoline (Marks 2001; Marks *et al*. 2002) or immunocontraceptives (Bradley *et al*. 1997; Seamark 2001). An alternative method of control that could be implemented in the urban environment is habitat manipulation. This type of strategy relies on manipulating and reducing the availability of key resource/s rather than attempting to manipulate the mortality of the population, as would be the case with traditional poison based control methods (Caughley 1977). The development of such strategies is dependant on a sound understanding of the relationship between the animal, its habitat and its resources (White *et al*. 1998). Understanding what habitats or dietary items are selected or favoured by wildlife has aided in the development of both pest and conservation strategies. A number of these strategies have been based on habitat manipulation, where favoured habitats are modified to less favourable habitats in the case of pest management (eg: Sullivan *et al.* 1998; White *et al.* 1997,1998) or where habitats are modified to make them more favourable to wildlife in the case of conservation management, such as in the provision of nest boxes to replace hollows after logging (Lindenmayer *et al.* 2003). Whilst the home range and diet of foxes are reasonably well understood (e.g. Meek and Saunders 2000; Saunders *et al.* 2004), relatively few studies have been designed to examine the potential of developing habitat manipulation as a control method. Urban and semi-urban areas have relatively high fox densities, probably as a consequence of having favourable resources. In Melbourne urban fox populations have been reported at densities as high as 16 foxes per km^2 (Marks and Bloomfield 1999), compared with rural areas of Victoria where densities of 3.5 – 7 foxes per km^2 have been estimated (Coman *et al.* 1991). In the United Kingdom, urban areas have been estimated as having fox densities of 20 foxes per km^2 (Harris 1981). If we can develop a better understanding of how these urban and semi-urban populations of foxes utilize resources and reach such high densities we may be able to use this information to develop more effective management strategies. This paper examines the home range and habitat selection (both diurnal and noctumal) of foxes in a semi-urban environment and also examines the diet of urban foxes and the influence of season on dietary composition. A potential control strategy for foxes based on is discussed based on the habitat use and diet results.

Materials and methods S*tudy sites*

The Dandenong Creek Valley is a semi-urban riparian corridor in Melbourne's outer eastern suburbs, comprising a mix of parklands, farmlands, golf courses and waste refuse stations bordered on both sides by residential and commercial factory developments. The study area was 13 km long and ranged from 1-3 km wide. The riparian zone and floodplains of the creek consist of wetlands, ponds and small lakes and runs throughout the study zone. Some remnants of native vegetation remain although they are often severely degraded and heavily invaded by weeds such as blackberry (*Rubus fruticosus*) and Gorse (*Ulex europaeus*). Prior and current land use of the area involves a variety of farming enterprises such as sheep, cattle and goat farming and the area also has many fruit orchards and horse adjistment paddocks. The eastern side is designated as a reserve for a proposed freeway development and has extensive weed infestations, cattle and horse paddocks. The entire perimeter is bordered by residential areas, caravan parks and sporting clubs.

Live capture and handling

Foxes were captured over a 17 month period from November 2000 to April 2002 using Victor Soft-Catch™ traps (Woodstream Corporation: Lititz, USA), that were set just below ground level and tethered to a peg. The traps were set along tracks, against fallen trees and fence posts and at other locations considered suitable for capturing foxes. Trap sets were baited with chicken, beef or salami baits or anal gland or tuna oil lures, or a combination of both. To avoid undue stress to the foxes during handling, all foxes were anaesthetized with an intramuscular injection of Zoletil 100 (100mg/ml) (a tiletamine and zolazepam combination) at a dose rate of up to 10 mg (active) kg^{-1}. Each fox was fitted with a radio tracking collar (150 -151 MHz; Sirtrack™ Ltd: Havelock North, New Zealand). The transmitters had a duty cycle of 24 hours on and 24 hours off, potentially yielding a battery life of 2 years. The sedated animals were placed in under the nearest dense cover (generally blackberry thickets) and allowed to recover (the animals were often coming out of sedation as they were placed in the shelter). Released animals were then routinely checked, from a distance, until they fully recovered and moved away to a new location. All animals were checked again during the evening and were seen moving throughout their home range.

Telemetry

Radio collared foxes were tracked on foot using a Regal 2000Titley™ (Ballina: NSW) radio receiver with a three element Yagi antennae. Locations of foxes were recorded on an aerial photo and the type of habitat the animal was using was also recorded. To avoid autocorrelation of locations (Swihart and Slade 1985) only one fix was taken each day, hence a maximum of one diurnal fix was acquired every two days. We were able to take more night fixes as the risk of autocorrelation was reduced and the maximum number of night fixes taken was four with a minimum of 1 hour between each fix. Whilst more nocturnal fixes were able to be taken on any night, the number of nocturnal and diurnal fixes taken overall were kept relatively even.

Home range estimation

Fixes (diurnal and nocturnal) were entered into the Biotas™ (Ecological Software Solutions. Schwägalpstrasse 2, 9107 Urnäsch, Switzerland. Version 1.03.) home range analysis software package. Both diurnal and nocturnal locations were used to estimate home range area because foxes have diurnal and nocturnal range shifts, and therefore any estimate of home range must incorporate the entire activity cycle of the animal (Harris *et al.* 1990). Home range areas were determined using the minimum convex polygon (MCP) method (Mohr 1947; Southward 1966). This method was utilised because it is the most commonly reported method in the literature (Harris *et al.* 1990) and therefore allows for some comparison with other studies. The harmonic mean (HM) home range estimator (Dixon and Chapman 1980) was also used to estimate home range size (95% and 75% activity isopleths), shape and core areas of activity (50% activity isopleths). This method of estimation, showed the best performance in simulation trials of five estimators which also included the MCP (Boulanger and White 1990).

Habitat assessment

To determine the availability of different habitat types within a home range four habitat types were generated based on vegetation structure as: 1) patches of blackberry and gorse; 2) Dense native vegetation); 3) long unmanaged grass and reed beds; and 4) areas of short grass and paddock. Blackberry and gorse patches formed thickets offering high structure from the ground to a height of 2 m. Areas of native vegetation with dense understorey also had high structure from the ground up to 2 m. This structure was largely associated with native grasses and shrubs. Long grass and reed beds provided some structure at the ground level, however many of these areas were temporally inundated by water during some winter months. The short grass and paddock habitat type was the broadest habitat type and represented areas with almost no structure to a height of three metres. Other than paddocks, this habitat type also included areas of bare ground and managed wind breaks with sparse ground based vegetation. All areas where radio-tracking was conducted were mapped for habitat types and then entered into a Geographic Information System (GIS). Once the home range analysis had been conducted this GIS was utilised to estimate the proportion of each habitat type within in each fox's home range (95% Harmonic Mean). To determine whether foxes were displaying preference to particular habitat types in their home range, Johnson's (1980) rank based preference technique was used. The proportional use of habitats both during the day and at night were compared to the proportion of available habitats in the animal's home range, described by Johnson (1980) as third order habitat selection. The analysis was conducted using Prefer© (Dakota, USA) (Pankratz and Schwartz 1994) and the Waller and Duncan (1969) method was used to determine the nature of these differences.

Dietary studies

Five 1 km^2 sites were selected across the study area. These sites represented a variety of land uses including managed parklands, golf courses, farmland used for horse and cattle grazing, bike and walking paths, a waste disposal landfill and a recreational field. Monthly for one year the sites were searched on foot for fox scats which were identified by shape and size as described by Triggs (1996). The contents were sorted using a dissecting microscope and grouped into eight main categories: mammal remains, bones, invertebrates, feathers, blackberry, seeds, vegetation and unidentifiable items. An estimate of the volume of each category in the scat was recorded to the nearest 5% of composition. Hair present in the scat was identified using whole mount and cross section techniques as described by Brunner and Coman (1974).

Results

Home range and habitat use

The ranging behaviour of foxes was determined from nine individuals with a mean of 94 fixes (SE = 20) per fox (Table 1). The mean home range size was 44.6ha ± 13.2 (SE) for the MCP. Home range analysis using the harmonic mean 95% isopleth revealed a mean home range size of 23.9 ha ± 5.7 (SE). The core component of the home range (HM = 50%) was 1.8 ha ± 0.4 (SE) (Table 1). The availability of different habitat types within the home range of foxes differed significantly ($F_{3,32} = 52.485$, $P < 0.01$), with areas of short managed grass being the most abundant habitat type. Habitats containing blackberry and gorse, long grass and reeds, and dense native vegetation did not vary significantly within home ranges (SNK $P > 0.05$). Foxes were not found to select any of the habitat categories preferentially at night ($F_{3,6} = 2.214$, $P > 0.05$). During the day, foxes exhibited a significant preference for blackberry and gorse over other habitat types, with the least favoured habitat being paddocks or areas of short grass ($F_{3,6} = 31.658$, $P < 0.01$) (Table 2). If the 95% home range was compared to the proportion of habitats available in the core areas (50% HR), a significant change in composition occurred ($F_{3,32}$ = 25.350, P < 0.001). The resulting change in composition indicated blackberry and gorse became more prevalent in the core areas and suggests that these weeds are providing a critical resource for foxes in this area.

Dietary studies

A total of 1317 fox scats were collected and analysed across four seasons from all five sites. The number of scats collected varied according to season ($F_{3,16} = 6.889$, $P = 0.003$) with significantly more scats occurring in summer and autumn than in winter and spring (SNK $P <$ 0.05). Common brushtail possum (*Trichosurus vulpecula*), common ringtail possum (*Pseudocheirus peregrinus*), European rabbit, black rat (*Rattus rattus*), house mouse (*Mus domesticus*) and the sugar glider (*Petaurus breviceps*) were all detected in the scats (Table 3). Mammalian prey formed 21.8 % of the diet and did not differ significantly between seasons although a non-significant trend suggests that mammals may be utilised more during the winter and spring. No significant trends occurred in the presence of these species in the diet across seasons. Bone fragments were found to constitute 12% of the scats, yet this did not differ significantly between seasons ($F_{(3,16)}=0.659$, $P = 0.589$). Bird remains contributed to 5.2% of the content of scats and not differ significantly across seasons ($F_{(3,16)}=1.466$, $P = 0.261$) although it was not possible to determine which species of birds had been consumed.

Invertebrates contributed a significant amount to the content of scats (17.9%) and this differed significantly across seasons ($F_{3,16} = 3.257$, $P = 0.049$), with more occurring in the spring diet than in the winter diet (SNK $P < 0.05$). The proportion of blackberry seeds in the diet differed with season ($F_{(3,16)}=30.515$, $P < 0.001$) and these were absent from the diet in winter and spring, but contributed significantly to the summer and autumn diet. Other seeds (plums apples and pears) contributed very little to the diet (1.8%) and differed significantly between seasons ($F_{(3,16)}=3.706$, $P = 0.034$) and were more common in the summer than winter and spring (SNK $P < 0.05$).

Discussion

The mean MCP home range sizes reported in this study (44.6) are small in comparison to those others reported in Australia. Coman *et al.* (1991) reported home range sizes in the order of 90 ha in suburban areas, and 600 ha in agricultural areas of Victoria. Home range estimates from Saunders *et al.* (2002) in agricultural areas of NSW were approximately 300 ha. The small home ranges of the foxes in this study are likely to be the result of extremely high resource loads in the semi-urban riparian environment, as is suggested for foxes in Jervis Bay (Meek and Saunders 2000). This is consistent with an established negative relationship between home range size and resource availability for many species (e.g. Damuth 1981; Fridell and Litvaitis 1991; Harestad and Bunnell 1979). We found a random use of our habitat categories at night, but diurnally foxes show a strong preference to patches of blackberry or gorse over all other habitat types and it is likely that this type of habitat is providing structure for 'safe' diurnal resting sites. Given the strong selection for this type of habitat it may be a critical resource that could limit population sizes in this area. The fox's diet appears highly variable throughout the year and is composed of many different food items. Consistent with many other studies these semi-urban foxes appear to be opportunistic predators and scavangers (e.g. Molsher *et al.* 2000; Ryan and Croft 1974). The main food items were mammalian prey as has been found in most fox diet studies (e.g. Catling 1985; Mitchell and Banks 2005). Due to the urban nature of this area there were very few mammalian species represented in the diet with considerable reliance on introduced rodents, the European rabbit and the common ringtail possum and common brushtail possum. This is in contrast to diets in non-urban areas where there is considerably more variety in the mammalian prey taken by foxes (e.g. Mitchell and Banks 2005). Whilst Invertebrates play an important seasonal role in the diet they appear to be eaten more frequently when invertebrates are more likely to be available in the system (i.e. spring). This trend has been observed by numerous authors (e.g. Coman 1973). Likewise, while blackberry fruits are seasonally important food resources, they are utilized as a food resource when they are in abundance in the environment. Given the opportunistic nature of the fox diet in semi-urban environments, manipulation of food resources may be of limited value as a primary control strategy in this area, given that animals can exploit a vast variety of foods. Foxes made a strong active selection of blackberry and gorse for diurnal resting areas. The high availability of these two species of weeds suggests that a habitat manipulation strategy could be developed on the basis of intensive weed control. It is most likely that removal of these weeds would have a significant effect on the availability of safe diurnal resting resources. A reduction of this critical resource may force foxes to increase their home range sizes to include less frequent diurnal resting habitats and may reduce the density of foxes in these areas due to increased intra-specific competition for a depleted resource. This process has been described as a population following a negative feedback loop (Caughley and Sinclair 1994). Such habitat manipulation could cause the population to be maintained at a lowered density, provided the resource is maintained at the reduced levels. This is conceptually different to mortality based control strategies where the population, once reduced in density, has the capacity to rebound towards the density that the resources in the system are dictating (Caughley and Sinclair 1994). Integrating pest and weed management into one strategy, as is suggested here, not only encourages good land use practices but is also likely to be economically beneficially because weeds and pests are targeted at the same time. Such a strategy may have further flow on effects for other pest species such as rabbits and the black rat, both of which are likely to utilise blackberry and gorse. A reduction in these two prey species and the absence of blackberry as a summer/autumn food resource may further enhance any density reduction associated with the removal of these habitats. If the density of foxes is associated with the availability of patches of dense structural vegetation it is likely that this strategy could be applied to many agricultural areas. Other than blackberry and gorse, which are widely spread in southern Australia, plants such as box thorn (*Lycium ferocissimum*) and lantana (*Lantana camara*) may also be capable of providing a similar structural resource in other areas.

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References

Boulanger, J.G. and White, G.C. (1990) A comparison of home-range estimators using Monte Carlo simulation. *Journal of Wildlife Management* **54**, 310-315.

Bradley, M.P., Hinds, L.A. and Bird, P.H. (1997) A bait-delivered immunocontraceptive vaccine for the European red fox (*Vulpes vulpes*) by the year 2002? *Reproduction, Fertility and Development* **9**, 111-116.

Brunner, H. and Coman, B.J. (1974) *The Identification of Mammalian Hair.* (Inkata Press: Melbourne)

Catling, P.C. (1988) Similarities and contrasts in the diets of foxes, *Vulpes vulpes*, and cats, *Felis catus*, relative to fluctuating prey populations and drought. *Australian Wildlife Research* **15**, 307-317.

Caughley, G. (1977) Analysis of vertebrate populations. Wiley, New York, 234 pp.

Caughley, G. and Sinclair, A.R.E (1994) Wildlife ecology and management. Blackwell Sciences, Cambridge, Massachusetts, USA.

Coman, B.J. (1973) The diet of red foxes, *Vulpe vulpes* L., in Victoria. *Australian Journal of Zoology* **21**, 391-401.

Coman, B.J., Robinson, J. and Beaumont, C. (1991) Home range, dispersal and density of Red Foxes (*Vulpes vulpes* L.) in Central Victoria. *Wildlife Research* **18**, 215-23.

Damuth, J. (1981) Home range, home range overlap, and species energy use among herbivorous mammals. *Biological Journal of the Linnean Society* **15**, 185-193.

Dixon, K.R. and Chapman, J.A. (1980) Harmonic mean measure of animal activity areas. *Ecology* **61**, 1040-1044.

Fridell, R.A. and Litvaitis, J.A. (1991) Influence of resource distribution and abundance on home-range characteristics of southern flying squirrels. *Canadian Journal of Zoology* **69**, 2589-2593.

Harestad, A.S. and Bunnell, F.L. (1979) Home range and body weight – a reevaluation. *Ecology* **60**, 389-402.

Harris, S. (1981) An estimation of the number of foxes (*Vulpes vulpes* L.) in the City of Bristol, and some possible factors affecting their distribution. *Journal of Applied Ecology* **18**, 455-465.

Harris, S., Cresswell, W.J., Forde, P.G., Trewella, W.J., Woollard, T. and Wray, S. (1990) Home-range analysis using radio-tracking data – a review of problems and techniques particularly as applied to the study of mammals. *Mammal Review,* **20** 97-123.

Hart, S., Marks, C.A. and Staples, L. (1996) Den-Co-Fume – Humane control of foxes (*Vulpes vulpes*) in natal dens. In: Fisher, P.M and Marks, C.A. (Eds.)

Humaneness and vertebrate pest contol. Ropet Printing: Tynong North pp 58
61.

Hegglin, D., Bontadina, F., Gloor, S., Swild, J.R., Muller, U., Breitenmoser, U. and Deplanzes, P. (2004) Baiting red foxes in an urban area: a camera trap study. *Journal of Wildlife Management* **68**, 1010-1017.

Jarman, P. (1986) 'The Red Fox – an exotic large predator. In *The Ecology of Exotic Animals and Plants: some Australian case studies*. Ed RL Kitching. pp 45-61. (John Wiley and Sons: Brisbane)

Johnson, D.H. (1980). The comparison of usage and availability measurements for evaluating resource preference. *Ecology* **61**, 65-71.

Lindenmayer, D.B., MacGregor, C.I., Cunningham, R.B., Incoll, R.D., Crane, M., Rawlins, C. and Michael, D.R. (2003) The use of nest boxes by arboreal marsupials in the forests of the Central Highlands of Victoria. *Wildlife Research* **30**, 259-264.

Marks, C.A. (2001) Bait-delivered cabergoline for the reproductive control of the red fox (*Vulpes vulpes*): estimating mammalian non-target risk in southeastern Australia. *Reproduction, Fertility and Development* **13**, 499-510.

Marks, C.A. and Bloomfield, T.E. (1999) Distribution and density estimates for urban foxes (*Vulpes vulpes*) in Melbourne: implications for rabies control. *Wildlife Research* **26**, 763-775.

Marks, C.A., Brzozowski, M., Zurek, H. and Clark, M. (2002) Control of fertility in the red fox (*Vulpes vulpes*): effect of a single oral dose of cabergoline in early pregnancy. *Reproduction, Fertility and Development* **14**, 29-33.

Marks, C.A., Nijk, M., Gigliotti, F., Busana, F. and Short, R.V. (1996) Preliminary field assessment of a Cabergoline baiting campaign for reproductive control of the red fox (*Vulpes vulpes*). *Wildlife Research* **23**, 161
168.

Meek, P.D. and Saunders, G. (2000) Home range and movement of foxes (*Vulpes vulpes*) in coastal New South Wales, Australia. *Wildlife Research* **27**, 663-668.

Mitchell, B.D. and Banks, P.B. (2005) Do wild dogs exclude foxes? Evidence for competition from dietary and spatial overlaps. *Austral Ecology* **30**, 581
591.

Mohr, C.O. (1947) Table of equivalent populations of north American small mammals. *American Midland Naturalist* **37**, 223-249.

Molsher, R.L., Gifford, E.J. and McIlroy, J.C. (2000) Temporal, spatial and individual variation in the diet of red foxes (*Vulpes vulpes*) in central New South Wales. *Wildlife Research* **27**, 593-601.

Olsson, M., Wapstra, E., Swan, G., Snaith, E., Clarke. And Madse, T. (2005) Effects of long-term fox baiting on species composition and abundance in an Australian lizard community. *Austral Ecology* **30**, 899-905.

Prankratz, C. and Schwartz, M. (1994) *Prefer: Preference Assessment.* Northern Prairie Science Center, Jamestown, Norht Dakota, USA.

Priddel, D. and Wheeler, R. (1997) Efficacy of fox control in reducing the mortality of released captive-reared Malleefowl, *Leipoa ocellate*. *Wildlife Research* **24**, 469-482.

Ryan, G.E. and Croft, J.D. (1974) Observations on the food of the fox, *Vulpes vulpes* (L.), in Kinchega National Park, Menindee, N.S.W. *Australian Wildlife Research* **1**, 89-94.

Saunders, G., Berghout, M., Kay, B., Triggs, B., van de Ven, R. and Winstanley, R. (2004) The diet of foxes (*Vulpes vulpes*) in south-eastern Australia and the potential effects of rabbit haemorrhagic disease. *Wildlife Research* **31**, 13-18.

Saunders, G., Coman, B., Kinnear, J. and Braysher, M. (1985) Managing Vertebrate Pests: Foxes. Australian Government Publishing Service, Canberra.

Saunders, G., McIlroy, J., Berghout, M., Kay, B., Gifford, E., Perry, R. and Van de Ven, R. (2002) The effects of induced sterility on the territorial behaviour and survival of foxes. *Journal of Applied Ecology* **39**, 56-66.

Seamark, R.F. (2001) Biotec prospects for the control of introduced mammals in Australia. *Reproduction, Fertility and Development* **13**, 705-711.

Seebeck, J.H. (1977) Mammals in the Melbourne Metropolitan Area. *The Victorian Naturalist* **94**, 165-171.

Southwood, T.R.E. (1966) *Ecological Methods: with particular reference to the study of insect populations.* Chapman and Hall, London.

Spencer, R. and Thompson, M.B. (2005) Experimental analysis of the impact of foxes on freshwater turtle populations. *Conservation Biology* **19**, 845-854.

Sullivan, T.P., Sullivan, D.S., Hogue, R.A. and Wagner, R.G. (1998). Population dynamics of small mammals in relation to vegetation management in orchard agroecosystems: compensatory responses in abundance and biomass. *Crop Protection* **17**, 1-11.

Swihart, R.K. and Slade, N.A. (1985). Testing for independence of observations of animal movements. *Ecology* **69**, 1176-1184

Triggs, B (1996) *Tracks, Scats and Other Traces: a field guide to Australian mammals.* (Oxford University Press: Melbourne).

Waller, R.A.. and Duncan, D.B. (1969) A Bayles rule for the symmetric multiple comparisons problem. *Journal of the American Statistical Association* **64**, 1484-1503.

White, J., Horskins.K. and Wilson, J. (1998) The control of rodent damage in Australian macadamia orchards by manipulation of adjacent non-crop habitats. *Crop Protection* **17**, 353-359.

White, J., Wilson, J. and Horskins, K. (1997) The role of adjacent habitats in rodent damage levels in Australian macadamia orchard systems. *Crop Protection* **16**, 727-732.

I Table 1 Home range estimates for all foxes. Estimates are derived from the minimum 2 convex polygon method (MCP) and the

Fox	Number of locations: Diurnal	Nocturnal	Duration (Days)	Home range estimates (ha): MCP	HM 95%	HM 75%	HM 50%
F1	100	104	520	47.9	37.1	8.9	2.9
F2	87	94	485	21.9	20.5	9.1	1.8
F3	36	43	472	28.1	17.8	3.9	1.4
M1	35	42	98	19.2	14.5	3.6	0.5
M2	44	53	202	30.7	26.7	6.1	1.0
M3	31	40	113	22.3	11.6	3.1	1.5
M4	29	37	74	152.6	63.5	14.6	4.4
M5	14	24	35	29.6	11.7	8.0	1.8
M6	12	22	39	49.0	12.1	3.1	0.5
		Mean ± 1SE		44.6±13.2	23.9±5.7	6.7±1.3	1.8±0.4

S** S** S** 3

-- NS S* 2

-- NS S** 2

-- - -- 1

Season / Species	Autumn	Winter	Spring	Summer	% total for year	Total No. of scats
Common ringtail possum	22	24	20	28	26.3	135
Common brushtail	14	17	33	16	17.3	89

harmonic mean method (HM) at 95%, 75% and 50% 3 utilisation isopleths.

Table 2. Ranking matrix for diurnal habitat selection by foxes, comparing proportions of radio locations of each fox in each habitat with the proportion of each habitat available in the 95% harmonic mean home range of each fox. Differences are based on the Waller and Duncan (1969) multiple comparison procedure. Habitats were ranked according to their importance from one (the least important habitat) to three (the most important). (*Significant at $P < 0.05$, **Significant at $P < 0.01$).

Blackberry or Dense native Long grass Paddock or

Rank

Gorse Vegetation or reeds short grass

Blackberry or GorseDense native Vegetation Long grass or reeds Paddock or short grass

Fox	Number of locations Diurnal	Nocturnal	Duration (Days)	Home range estimates (ha) MCP	HM 95%	HM 75%	HM 50%
F1	100	104	520	47.9	37.1	8.9	2.9
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F3	36	43	472	28.1	17.8	3.9	1.4
M1	35	42	98	19.2	14.5	3.6	0.5
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M3	31	40	113	22.3	11.6	3.1	1.5
M4	29	37	74	152.6	63.5	14.6	4.4
M5	14	24	35	29.6	11.7	8.0	1.8
M6	12	22	39	49.0	12.1	3.1	0.5
		Mean ± 1SE		44.6±13.2	23.9±5.7	6.7±1.3	1.8±0
S**		S**		S**	3		

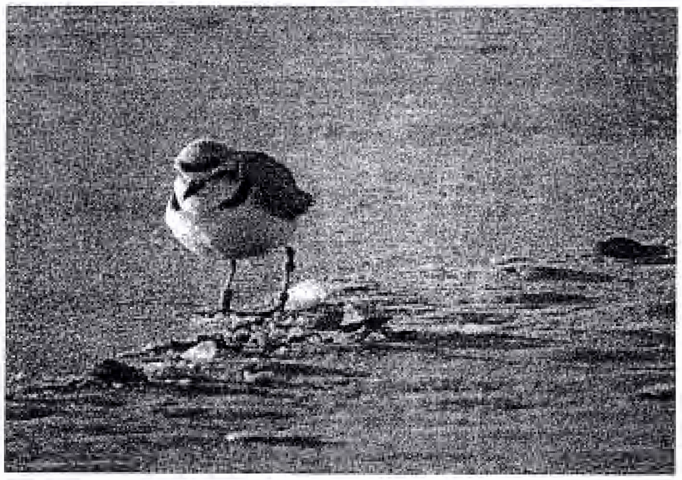
Table 3. Percentage presence of mammalian hair in scats by season. All values are the percentage of scats

Fox	Number of locations Diurnal	Nocturnal	Duration (Days)	Home range estimates (ha) MCP	HM 95%	HM 75%	HM 50%
F1	100	104	520	47.9	37.1	8.9	2.9
F2	87	94	485	21.9	20.5	9.1	1.8
F3	36	43	472	28.1	17.8	3.9	1.4
M1	35	42	98	19.2	14.5	3.6	0.5
M2	44	53	202	30.7	26.7	6.1	1.0
M3	31	40	113	22.3	11.6	3.1	1.5
M4	29	37	74	152.6	63.5	14.6	4.4
M5	14	24	35	29.6	11.7	8.0	1.8
M6	12	22	39	49.0	12.1	3.1	0.5
		Mean ± 1SE		44.6±13.2	23.9±5.7	6.7±1.3	1.8±0.4
S**		S**		S**	3		
--		NS		S*	2		

containing mammalian hair. Values are not independent as the same scat can contain remains of more than one species.

Attachment 4

NESTING OF THE CALIFORNIA LEAST TERN AND WESTERN SNOWY PLOVER AT OCEANO DUNES STATE VEHICULAR RECREATION AREA, SAN LUIS OBISPO COUNTY, CALIFORNIA 2015 SEASON



Prepared for
California Department of Fish and Wildlife
United States Fish and Wildlife Service

Prepared by
California Department of Parks and Recreation
Off-Highway Motor Vehicle Division
Oceano Dunes District

November 2015

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Necropsy examination report: one least tern juvenile

Medical examination record: one snowy plover adult

SUMMARY

Staff of Oceano Dunes State Vehicular Recreation Area (Oceano Dunes SVRA, ODSVRA) and Point Blue Conservation Science (Point Blue) monitored breeding California least terns (*Sternula antillarum browni*) (least tern, tern) and western snowy plovers (*Charadrius nivosus nivosus*) (snowy plover, plover) at ODSVRA, San Luis Obispo County, California, in 2015.

There were an estimated 44-49 least tern breeding pairs, similar to the 47-48 pairs in 2014 and above the average of 40-43 pairs (range=23-66) for the 10-year period 2005-14. There were 54 known nesting attempts, all within the large seasonally fenced exclosure in the southern portion of the vehicle riding area. The nest hatching rate was 88.9% (48/54). Of the six nests that failed, one was abandoned pre-term (prior to the expected hatch date); one abandoned post-term; one abandoned, unknown if pre- or post-term; one depredated by raccoon; and two failed to unknown cause. Eighty-four chicks hatched and 69 were color-banded to individual. Sixty-nine of the 84 chicks (including 12 unbanded chicks) are known to have fledged (seen when 21 days old or older), for a chick fledging rate of 82.1% and an estimated 1.41-1.57 chicks fledged per pair. For the 10-year period 2006-15, average productivity was 1.21-1.28 chicks fledged per pair. Mortality was documented for two juveniles in the seasonal exclosure; one found as a carcass and one observed alive with serious injuries that would have prevented survival.

There was a minimum of 205 breeding snowy plovers (113 males and 92 females), compared to 226 in 2014. One hundred and twelve banded birds were documented as breeding, and the banding history was known for 105 of these birds. Of the known origin birds 87.6% (92/105) were banded as chicks and fledged from ODSVRA. There were 217 known nesting attempts, including 15 identified only by detection of brood (unknown nest location). Of the 202 nests from known locations, 182 (90.1%) were in the southern riding area seasonal exclosure (Southern Exclosure) and 20 (9.9%) in Oso Flaco. Of the 195 nests with known location and fate, 167 hatched for a nest hatching rate of 85.6%. Twenty-eight nests failed, attributed to the following causes: abandoned pre-term (12); abandoned post-term (1); abandoned unknown pre- or post-term (4); abandoned, suspected due to wind (1); unknown cause (3); raven (4); unidentified predator (1); and unidentified avian predator (2). Of the 494 hatching chicks, 331 were color-banded to brood (183 fledged) and the fate of the 163 unbanded chicks is believed known (94 fledged). A total of 277 chicks fledged (seen when 28 days old or older) for a fledging rate of 56.1%. One chick fledged per breeding male is the estimated number needed to prevent the population of snowy plovers from declining and productivity of 1.2 chicks fledged per male should provide for moderate population growth (assuming approximately 75% annual adult survival and 50% juvenile survival) (U.S. Fish and Wildlife Service 2007). In 2015, an estimated 2.45 juveniles fledged per male at ODSVRA and will promote population growth. For the 14-year period 2002-15, average productivity was 1.47 juveniles fledged per breeding male.

INTRODUCTION

Oceano Dunes SVRA, located in southern coastal San Luis Obispo County, California, is a popular park with high attendance and was visited by over 1.6 million people in 2014 for a variety of recreational opportunities, including driving vehicles on the beach and dunes.[1] In 2014, an estimated 317,949 street-legal vehicles and 154,943 off-highway vehicles were driven on the shoreline and dunes in the designated riding area of the park.[2]

Within ODSVRA there is extensive breeding habitat for two special-status ground-nesting birds, the state and federally endangered California least tern and the federally threatened Pacific coast population of the western snowy plover. Monitoring of the least tern and snowy plover at ODSVRA during the breeding season began in 1991 and 1992, respectively. Least terns are present at ODSVRA only during the breeding season, migrating to wintering areas well south of California. The snowy plover population at the park is comprised partly of birds present year-round and partly of migrant birds present only during the breeding or wintering season.

This report summarizes the results of the 2015 nesting season for least terns and snowy plovers at ODSVRA. Maps in figures and appendices use digital satellite photos taken in 2007 by DigitalGlobe © 2008, unless otherwise noted.

State park staff conducts monitoring activities at ODSVRA under U.S. Fish and Wildlife Service (USFWS) permit 10(a)(1)(A) TE-815214-7 and California Department of Fish and Wildlife (CDFW) Scientific Collecting Permits. Predator removal activities are conducted under USFWS Depredation Permit MB25976A-0. Point Blue conducts monitoring and banding activities under USFWS permit 10(a)(1)(A) TE-807078-15, Federal U.S. Geological Survey Bird Banding Laboratory Banding Permit 09316, CDFW Scientific Collecting Permit SC-006691, and a CDFW Memorandum of Understanding.

[1] ODSVRA 2014 Annual Attendance figures (source ODSVRA)
[2] ODSVRA 2014 Monthly Carrying Capacity Summaries (source ODSVRA)

SITE DESCRIPTION

ODSVRA is part of the 18-mile-long Guadalupe-Nipomo Dunes complex. The Oceano Dunes District, California Department of Parks and Recreation, manages approximately 4,900 acres with approximately 9.1 miles of ocean shoreline on the western edge. On the northern border of the park is the city of Pismo Beach. Located to the east of the park are Phillips 66 Refinery, the cities of Grover Beach and Oceano, and private lands that consist of dunes, coastal scrub, and agricultural fields. The southern border of the park abuts the Guadalupe-Nipomo Dunes National Wildlife Refuge (NWR). Inside the park, dunes that are open to vehicles extend inland in some areas for over one mile. Eight numbered marker posts, located approximately 0.5 miles apart, are located along the coastal strand of the riding area to orient park visitors and staff. Street-legal vehicles are allowed throughout the riding area. Off-highway vehicles, as well as overnight camping, are allowed along the beach and dunes south of marker post 2 (approximately one mile south of Pier Avenue). In the southern portion of ODSVRA is Oso Flaco Lake area (Oso Flaco) with a shoreline of approximately 1.7 miles. Pedestrians are allowed at Oso Flaco but it is closed to camping, equestrian, dog, and vehicle use. The beach at Oso Flaco west of the foredunes is narrower than in the riding area.

The following are descriptions of sites and terms as used in this report (Figure 1, Figure 2).

ODSVRA: All areas that are administered by the Oceano Dunes District, including the Oceano Dunes SVRA, Pismo State Beach, Pismo Dunes Natural Preserve (Dunes Preserve), Pismo Lake, and Oso Flaco Lake area. Management of the Dunes Preserve and Pismo State Beach was transferred to the Oceano Dunes District in December 2004. The Pismo Lake property was acquired from the California Department of Fish and Wildlife in 2007 and is currently closed to the public. ODSVRA provided tern and plover monitoring for the Dunes Preserve prior to 2004 and continues to do so. Pedestrian and equestrian use is permitted in the Dunes Preserve, but vehicles and dogs are not allowed.

Riding area: The area within ODSVRA that is open to recreational vehicles. This area changes in size based on seasonal restrictions. Street-legal vehicles are allowed along approximately 5.3 miles of beach, from the Grand Avenue park entrance south to the southern boundary of the riding area (approximately 0.4 miles south of marker post 8). Off-highway vehicles are only allowed south of marker post 2.

Open riding area: The area within ODSVRA open to recreational vehicle use during the nesting season.

Southern Exclosure: A single contiguous area within the southern portion of the riding area that is fenced and closed to entry during the breeding season to protect nesting terns and plovers. The adjoining shoreline is also part of the Southern Exclosure and is closed to public entry during the nesting season. From 2001 to 2004, the amount of seasonally protected nesting habitat in the riding area periodically increased in size. Subsequent to 2004 there has been no increase in size of this protected area. The area of the Southern Exclosure (including the area at and above the high tide line on the closed shoreline) for 2015 was approximately 297 acres, compared to a range of 271-301 acres (and an average of 288 acres) between 2004 and 2014. Although the basic configuration of the Southern Exclosure has remained consistent since 2004, changes in dune topography and public safety issues impact the placement of the east fence, resulting in small variations in acreage from year to year. Individually identified areas (Figure 2) within the Southern Exclosure include the following:

> *6 exclosure*: The area from marker post 6 to marker post 7, (approximately 0.5 miles of shoreline and approximately 61 acres), first incorporated into the Southern Exclosure for a full season in 2004. Vegetation within the exclosure is overall very sparse with limited areas of vegetated hummocks.

7 exclosure: The area from marker post 7 to the south side of 7.5 revegetation area (approximately 0.4 miles of shoreline and approximately 62 acres). Habitat includes extensive areas of bare sand, limited areas of vegetated hummocks, limited areas of organic surface debris (shells, driftwood, dried algal wrack), and moderate to heavy vegetation in the small 7.5 revegetation area located within the 7 exclosure.

8 exclosure: The area from the south side of the 7.5 revegetation area to the North Oso Flaco fencing south of marker post 8 (approximately 0.5 miles of shoreline and approximately 83 acres). Habitat includes extensive areas of bare sand, limited areas of vegetated hummocks, and limited areas of organic surface debris (shells, driftwood, and algal wrack).

Boneyard exclosure: The area east of the North Oso Flaco dunes. Habitat is primarily bare sand and active sand dunes. This inland area does not have a shoreline component and is approximately 92 acres. A portion of the west side (12.5 acres) has been closed year-round since 2005 due to the presence of a cultural resource area. In September 2014, this area increased in size by 6 acres. Portions of this area have developed small vegetated hummocks. Straw bales, placed within the protected cultural area in 2004, to build up sand to cover and protect cultural resources, persist. The east fence is not maintained as predator fencing due to the rapidly shifting open sand dunes in the area. Instead, beginning in 2003, a two-inch by four-inch mesh interior fence (six-foot-tall predator fencing) has bisected Boneyard exclosure during the nesting season, resulting in 42 acres in the western portion (contiguous with 6, 7, and 8 exclosures) and 50 acres in the eastern portion.

<u>Oso Flaco</u>: The shoreline and dunes in ODSVRA located south of the riding area. The approximately 1.7 miles of beach length is narrow in width, and the dunes are typically heavily vegetated, relative to the riding area. The area is part of the Oso Flaco Lake area, open to pedestrian use but closed to vehicles. Beginning in 2006, an additional 0.4 miles of shoreline at the southern end of the park were included in the ODSVRA (a survey conducted by the Guadalupe-Nipomo Dunes NWR in 2005 determined this area was part of ODSVRA and not the NWR, as was previously thought). For purposes of discussion in this report, Oso Flaco is divided into North Oso Flaco and South Oso Flaco (Figure 2).

North Oso Flaco: The area extending south from 8 exclosure to the pedestrian boardwalk access trail to the Oso Flaco shoreline (approximately 0.5 miles of shoreline and approximately 68 acres). Beginning in 2002, the upper beach and dunes were closed to pedestrians during the nesting season with symbolic fencing. Since 2005, the North Oso Flaco area has been part of the seasonal exclosure and managed in a similar manner; predator fencing has replaced symbolic fencing and the shoreline has been closed to the public during the nesting season.

South Oso Flaco: Extends from the boardwalk to the ODSVRA southern boundary (approximately 1.2 miles shoreline length). Oso Flaco Lake drains through Oso Flaco Creek and the mouth of this creek is within the northern portion of South Oso Flaco. The shoreline is open to the public and symbolic fencing and signage have been used since 2002 to designate the seasonally closed upper beach and dune habitat. Snowy plover nests found in this area typically receive individual nest exclosures.

<u>Pipeline revegetation area</u>: Located adjacent to the east side of 8 exclosure. The area is heavily vegetated.

<u>Arroyo Grande Creek</u>: Seasonally flows into the Pacific Ocean approximately two miles north of the Southern Exclosure. The associated lagoon is variably located east of the area between marker post 1 and marker post 2. The upper creek area and lagoon are closed to vehicle use year-round to protect sensitive aquatic habitat. Pedestrian and equestrian entry is prohibited during the nesting season and permitted

during the nonbreeding season. Posts and signs delineate the closed area during the nonbreeding season; symbolic rope fence is added during the nesting season.

Carpenter Creek: Seasonally flows into the Pacific Ocean approximately 4.5 miles north of the Southern Exclosure. No vehicles are allowed in the area as it is approximately 0.4 miles north of the riding area. The area receives a high level of pedestrian use.

Pismo Creek lagoon: Seasonally flows into the Pacific Ocean approximately 4.8 miles north of the Southern Exclosure. Standing water persists all year, with low vegetated hummocks west of the lagoon and tall vegetated dunes and housing to the east. No vehicles are allowed in the area as it is approximately 0.75 miles north of the riding area. The area receives a high level of pedestrian use. Only a small portion of the lagoon is part of state park property.

MONITORING AND MANAGEMENT ACTIONS

MONITORING

Daily monitoring occurs from 1 March – 30 September. At a minimum, ODSVRA maintains three monitors during morning and early afternoon hours. As the season progresses, monitoring increases to include the late afternoon and early evening hours. Monitoring involves walking to assess or find new nests as well as scanning nests and broods from parked vehicles (a proven and effective blind). Monitoring occurs in a manner to minimize disturbance or adverse effects to adult birds, nests, and chicks.

Open riding area

Monitoring of the open riding area by vehicle occurs daily along defined transects, as any nests initiated or chicks in this area require immediate protection from recreational activities. Areas along transects with plover activity indicating potential nesting interest (scraping or copulating) are checked more thoroughly on foot and with increased frequency using binoculars or spotting scope. When staff finds chicks in the open riding area, the area is closed to vehicles and chicks are slowly directed back into the protected Southern Exclosure. Staff continues to monitor chicks to confirm they do not move back into the open riding area.

Breeding least terns and snowy plovers

Finding and monitoring nests: The least tern and snowy plover management program documents size of breeding populations and attempts to find, monitor, and determine all tern and plover nest and chick fates. Staff checks most nests daily and conducts regular nest searches using binoculars and spotting scopes from parked vehicles outside of the seasonal fencing. Additional nest searches are conducted on foot. Staff maps nest locations using a Global Positioning System (GPS). Egg-laying dates provide estimates for least tern and snowy plover clutch hatching dates; for nests found at full clutch, floating the eggs (snowy plovers only) provides an estimate.

Nest fates:
The following categorizes nest fates used in this report:

> *Hatch*: Nest hatched at least one egg. Nesting attempts known only by detection of brood are referred to as "unknown location nests" and egg numbers from such nests are minimums derived from the number of chicks first observed.
>
> *Abandoned pre-term*: Nest abandoned prior to the expected hatch date; causes may include, but are not limited to, disturbance or adult mortality.
>
> *Abandoned, suspected due to wind*: Nest abandoned pre-term during periods of high wind, with eggs typically found almost or completely buried.
>
> Beginning in 2010, the category of "abandoned, suspected due to wind" was added to nest fates. Prior to this, nests lost where wind may have been the cause were included in the broader category of "abandoned pre-term." For the 2010 report, least tern nests in the abandoned pre-term category for the previous eight years were reviewed and a limited number were reassigned to the category of abandoned, suspected due to wind. Tables in this report include the reassigned tern nest fates for years prior to 2010.
>
> *Abandoned post-term*: Nest abandoned after the expected hatch date, and includes nests with nonviable eggs.

Abandoned, unknown if pre- or post-term: Nest abandoned, but unknown if pre- or post-term.

Depredated: Nest lost to a predator. If possible, staff identifies the predator to species or group (mammalian, avian), or describes the nest as lost to an unidentified predator.

Flooded: Nest overwashed by tide, or flooded by a shifting creek or expanding lagoon.

Failed to unknown cause: Nests that disappeared before expected hatch date with cause of failure undetermined.

Unknown fate: Nests where eggs disappear around the estimated hatch date, but not enough evidence exists to determine whether they hatched or failed. To decrease disturbance to chicks, access to nests with nearby young tern and plover broods is limited, and may result in nests with unknown fate.

<u>Banding chicks</u>: In 2015, least tern chicks received a single size 1A blank aluminum band (covered with yellow over green vinyl tape) on the right leg, and a size 1A numbered aluminum federal band on the left leg. Color tape placed on the federal band creates color band combinations unique to each individual chick. Weighing chicks occurs immediately prior to banding, typically at one to three days old.

Banding of plover chicks was inconsistent prior to 2001. Since 2002, the goal has been to band all chicks to brood, with all chicks within one brood given the same color band combination. Since 2010, some ODSVRA band combinations on birds that may be alive have been reused due to the limited number of combinations available. Therefore, the age of adult plovers with certain ODSVRA band combinations is sometimes unknown. Some chicks are left unbanded in areas with nearby young tern and plover broods to reduce disturbance to chicks. The fates of unbanded chicks are tracked with intense monitoring of broods. In some instances the associated male or sibling chicks may be color banded.

<u>Assignment of broods to nests</u>: Most chicks are banded at the nest. Chicks found outside of the immediate nest area can often be assigned to a specific hatched nest as one or both of the parents are color banded. For some broods with unbanded adults the brood location and age of chicks allow nest determination. However, circumstances can occur with several nearby nests hatching at the same time (chicks confirmed from distance with spotting scope) and banding at the nests is not possible. The resulting broods, with chicks the same age, may appear on the same section of shore and it is not possible to assign each brood to a specific nest. Such broods are referred to as "unassigned broods."

<u>Chick monitoring</u>: Chick observations are recorded during daily monitoring activities. In addition, focused searching for broods occurs multiple times each week from vehicle surveys on the shoreline of the Southern Exclosure and Oso Flaco. Staff records band combinations, chick numbers, adults present, location and direction of movement, and any interaction or aggression with nearby broods.

<u>Fledging success</u>: At ODSVRA, juvenile terns can be widely dispersed over a large area. Monitoring efforts directed specifically for terns are needed in estimating the number of juveniles produced as well as identifying threats to survival. Tern chicks surviving to 21 days or older are considered fledged (21 days after the hatch date, which counts as day zero). Tracking of juvenile terns occurs on park property (in the Southern Exclosure, at Oso Flaco Lake, Pismo Creek lagoon, and roosting areas such as south of Pier Avenue) and at nearby sites.

The fledgling tern counting method varies among years as follows: single day high counts for 1991-97, and 2000-01; a single day high count at Oso Flaco Lake for 1998; count method for 1999 unknown; and three-week interval day count conducted from 2002-04 (chicks banded to site 2003-04). In 2005, chicks were color-banded to brood and from 2006-15 most chicks were color-banded to individual, resulting in more accurate documentation of fledge rate than previous methods. Earlier estimates prior to banding to individual may represent substantial undercounts or overcounts.

Plover chicks surviving to 28 days or older from the time of hatch are considered fledged (28 days after the hatch date, which counts as day zero). Prior to 2001, monitoring in Oso Flaco and Pismo Dunes Natural Preserve was intermittent, and fledgling information was not obtained.

Measures describing breeding success:
The following categorizes measures describing breeding success used in this report:

Hatch rate: Total number of hatching known location and fate nests divided by total number of nests with known location and fate.

Percentage chicks fledging: Total number of chicks fledging divided by total number of chicks (includes chicks fledged from unknown location nests).

Number of chicks fledging per nest: Total number of chicks fledging divided by total number of nests.

Productivity: Number of least tern fledglings per breeding pair (consistent with the annual statewide California least tern report produced by CDFW). Number of snowy plover fledglings per breeding male (consistent with USFWS Pacific coast western snowy plover recovery plan).

Banded adults: Documenting banded least terns and snowy plover adults can provide detailed information on history of birds including: origins, age, breeding status, and movement between sites. Staff attempts to record all band combinations of adult least terns and snowy plovers.

Number of breeding adults: For least terns the number of breeding pairs is represented as a range. The estimated minimum number of pairs is equal to the maximum number of concurrently active nests and broods. The estimated maximum number of pairs is equal to the minimum number of pairs plus one-half of the value of the minimum number of pairs subtracted from the total number of nests. (This assumes nests in addition to those accounted for by the minimum number of pairs are equally divided between renesting pairs and new pairs.):

Max. no. pairs = min. no. pairs + [(total no. nests - min. no. pairs) / 2]

Banding least tern chicks to brood in 2005, and to individual since 2006, provides for increased accuracy in counting the number of active broods on a given date. From 1991 to 2001, the estimated number of breeding pairs was not always reported or was based only on the number of concurrent nests. These reports were reviewed in 2005, looking at both nests and the limited brood information. For some years this resulted in identifying an increase in the minimum number of pairs and this revised information has been provided in annual reports since 2005.

Individually banded snowy plover adults provide the most accurate means to identify breeding population size but currently at ODSVRA too few adults are banded to rely solely on this method. A minimum number of breeding females is derived from the maximum number of nests active on the same day plus any additional nests hatching one day before or initiated one day after this date. A minimum number of breeding males is estimated from the highest same day count of active nests and broods (males typically raise the chicks; males with broods three weeks of age or older are not included if they could be associated with a new nest) and number of nests initiated the day after the high count. Beginning in 2009, numbers of color-banded adults confirmed breeding are compiled, and any number of this group that could not be accounted for on the same day high count, including nests or broods with unknown adults, are added to the same day high count for the appropriate sex.

ODSVRA also participates in the annual U.S. Pacific coast snowy plover breeding season window survey coordinated by USFWS.

Least tern night roost: During the breeding season terns may assemble in a night roost. Monitors record the night roost location and total numbers of individuals present as the terns arrive at dusk. Night vision goggles are available and used for this task, but they have a limited range for distance viewing. There are occasions when terns are not seen, but are heard vocalizing as they arrive to roost after it is too dark to see. Counts are considered a minimum due to the inherent limited visibility of the night roost. It is typically too dark to distinguish between adults and juveniles.

Least tern use of freshwater lakes: Freshwater lakes can provide a source of prey fish in addition to the near-shore ocean. Periodically surveying nearby small freshwater lakes documents tern use and gives a better understanding of local food resources. An important component of this monitoring is to determine if lakes provide additional appropriately-sized fish to feed chicks (chicks require fish small enough that they can be swallowed whole). Observations of adults in flight provide information about the direction of foraging sources and, occasionally, fish size.

Wind speed monitoring

Beginning in 2011, ODSVRA monitors wind speed from a tower (S1 tower) located approximately 375 feet east of 6 exclosure, with anemometers at two, seven and ten meters high. In 2010-11, a portable anemometer with data logger (from WindLog Rainwise, Inc.) was placed in the breeding habitat. Before 2010, wind speeds were periodically measured by handheld weather gauges (Kestrel 2000 Weather Meter by Kestrel Meters).

Predator activity

Monitoring predator activities: Park staff and contractors (Ventana Wildlife Society, U.S. Department of Agriculture (USDA) Wildlife Services, and Point Blue) collect information on predator presence at ODSVRA from February through September. From direct observation of mammalian and avian predators or their sign (e.g., tracks, scats, regurgitated pellets, prey remains, depredated nests), monitors record species, type of sign, behavior, duration of observation, direction of travel, and characteristics that may identify an individual. Summarizing these observations by count of days detected, location of animal sighting or sign, and observation duration allows for comparison across years. For additional details, see section titled Predators and predator management on page 41.

Gull monitoring: Gulls may depredate snowy plover and least tern eggs, chicks, and juveniles. Gulls are of particular concern because they can be a subsidized predator attracted to food resources associated with human activity. Conducting daily and more detailed monthly surveys during the nesting season, in addition to general predator monitoring, documents flock locations and numbers within the park. Gull numbers are counted at the trash dumpster area daily and the full park is surveyed monthly.

Nonbreeding season monitoring of snowy plovers

Beginning in 2009, more consistent weekly surveys for snowy plovers occurs during the months of October through February. During these surveys staff divides the shoreline into the following five sections, listed from north to south:

1) approximately 0.5 miles north of Pismo Pier to Grand Avenue (pedestrian use only, no vehicle use allowed);

2) Grand Avenue south to marker post 2 (street-legal vehicles and day use only, no camping);
3) marker post 2 south to marker post 6 (street-legal vehicles, off-highway vehicles, and camping allowed year-round);
4) marker post 6 south to the southern shoreline riding area boundary (shore and portion of upper beach closed to public use during 1 March to 30 September and open to all activities during the rest of the year); and
5) Oso Flaco (southern shoreline riding area boundary to ODSVRA's southern boundary with pedestrian use only and portion of shore and upper beach closed to pedestrian use 1 March to 30 September).

ODSVRA also participates in the annual U.S. Pacific coast snowy plover winter window survey coordinated by USFWS.

Investigation of least tern and snowy plover carcasses
ODSVRA sends fresh carcasses of least terns or snowy plovers to an approved facility (CDFW Office of Spill Prevention and Response, Marine Wildlife Veterinary Care and Research Center, Santa Cruz, California) for necropsy. Fresh carcasses must be immediately refrigerated and then sent by overnight delivery service within one day to preserve the integrity of tissues to be tested to determine cause of death.

MANAGEMENT ACTIONS

ODSVRA manages for least terns and snowy plovers to optimize breeding success and reduce the potential for take. To reduce visitor disturbance to breeding birds, ODSVRA installs fence around seasonally closed areas to visitors and posts signage. Staff augments existing habitat with branches, woodchips, wrack (surf-cast kelp), plants and seed. An active predator management program reduces disturbance and depredation by mammalian and avian predators.

Informational signage and enforcement of regulations
Interpretive panels at access points and signs identifying closed areas serve to increase public awareness of threats to nesting terns and plovers. The public can access a low wattage radio station with a repeated recording of park information, including information about protection of sensitive species. State Park rangers enforce park regulations enacted to protect terns and plovers.

Seasonal closure and fencing
Every year from 1 March through 30 September, ODSVRA closes least tern and snowy plover breeding habitat to vehicle and pedestrian use with wire or symbolic fencing. The wire fencing of the seasonal exclosure (see details below), provides a higher level of protection when compared to symbolic fencing, composed of rope with signs, to keep visitors from entering sensitive areas. When nesting occurs outside of the seasonal exclosure, staff may choose an alternative wire exclosure type with consideration for the species, topography, proximity to recreational activities, predator threats, and duration of disturbance to the area during exclosure construction. The seasonal exclosure and large single nest exclosures are collectively referred to as seasonal fencing in this report.

ODSVRA uses the following exclosure types:

Seasonal exclosure (Southern Exclosure and North Oso Flaco) protected area: ODSVRA fences this approximately 350-acre area during the nesting season to limit vehicle and human trespass into protected nesting and brood-rearing habitat. Wire fencing five feet high (bottom eight inches buried) with two-inch by four-inch mesh discourages coyote (*Canis latrans*) entry. Beginning in 2006, an additional layer of fence material was attached to overlap the top of the fence, increasing fence height above the surface to approximately six feet as a further deterrent to coyotes. Staff attaches bird barrier spikes to the wood posts in an effort to discourage perching by avian predators. Tall posts with large stop signs extend into the intertidal area at marker post 6 and the south end of North Oso Flaco. Rope with additional signage extends between the shoreline posts to clearly designate a closed shoreline to visitors.

Symbolic fencing (South Oso Flaco): Symbolically fencing approximately 1.2 miles of nesting and brood-rearing habitat in South Oso Flaco identifies the closure area (lower shore remains open to public). Nests in this area typically receive some type of individual nest exclosure.

Large single nest exclosure: Staff installs a minimum 200-foot-diameter circular single nest exclosure with height of five feet (bottom eight inches buried) around any least tern or snowy plover nest found in the open riding area. Single nest exclosures of differing sizes may also be used to protect snowy plover nests in areas where vehicles are not permitted (Oso Flaco, Southern Exclosure shoreline, Arroyo Grande Creek area, and areas north of Grand Avenue).

10-foot by 10-foot exclosure, circular exclosure, and mini-exclosure: Staff selectively uses a small circular or one of two small square nest exclosures (made of two-inch by four-inch wire) around snowy plover nests inside or outside of seasonal fencing for protection from predators, including roosting gull flocks. Staff uses different exclosures based on a variety of factors including, but not limited to, weather, topography, predator threats, and proximity of young broods.

The 10-foot by 10-foot exclosure (used since 2003) and seven-foot-diameter circular exclosure (used since 2012) are built with five-foot-high sides and the bottom eight inches buried when outside of the seasonal exclosure protected area. A 1/2-inch by 1/2-inch mesh net top is added when avian predation is a concern.

Mini-exclosures (used since 2010) are three feet by three feet by three feet with a wire mesh top, staked into the ground, and buried four to eight inches when appropriate. Of the three types, mini-exclosures take the least amount of time and staff to install.

Bumpout: A nest in the Southern Exclosure located less than 100 feet from the east or north fence requires temporary additional fencing extending into the open riding area to allow an adequate buffer between recreational activities and the nest. This type of extended fence is termed "bumpout." Staff extends bumpouts when recreational activities continue to cause disturbance to nesting birds. ODSVRA maintains a safe vehicle corridor adjacent to the east fence and any bumpouts. Nests on the shoreline that are close to the west fence may be exclosed by two-inch by four-inch mesh fencing extending from the Southern Exclosure fence; this type of single nest exclosure is also given the term bumpout.

Habitat enhancement
Following the nesting season, and for the five-month period October through February, camping, street-legal vehicles, and off-highway vehicles use portions of the Southern Exclosure. This recreational use results in large areas of flattened terrain and barren sand with very limited scattered natural debris and vegetation.

Each year, staff place material in 6, 7, and 8 exclosures to offer more areas of disruptive cover for terns and plovers, providing shelter from wind and blowing sand, reducing exposure to predators, and augmenting potential nesting substrate. Beginning in February or March, and prior to nest initiation, natural materials such as driftwood, woodchips, and wrack are added to the exclosures and shoreline areas, to enhance habitat features. No habitat enhancement occurs within 100 feet of the fence that borders the open riding area to discourage nesting near recreation that may cause disturbance to breeding birds.

Wrack and talitrids: Results from studies conducted by Drs. Jenny Dugan and Mark Page, researchers from the Marine Science Institute at the University of California Santa Barbara, suggest that the seven-month seasonal closure (March through September) is not a sufficient period of time for invertebrates to effectively recover species diversity and abundance on the Southern Exclosure shoreline following five months of recreational vehicle use.

ODSVRA collects wrack in the open riding area and disperses it in the Southern Exclosure. Collection and distribution is done by hand and moved using a truck and trailer. In addition to providing cover, wrack on the shoreline provides a food resource supporting invertebrates, which in turn are prey for plover chicks, juveniles, and adults. Talitrids (commonly called beach hoppers) are collected from outside the vehicle use area north of Grand Avenue. Staff inoculates the wrack addition areas of the Southern Exclosure shoreline with talitrids in order to establish a breeding population, thus increasing the food resources available for plover chicks and juveniles during the breeding months.

Woodchips, branches and driftwood: Staff adds woodchips to supplement the existing assorted debris that snowy plovers often choose as nesting substrate. Woodchips are spread in patches of less than a quarter-acre in size in the 6, 7, and 8 exclosures in areas of barren sand and over thinning woodchip patches remaining from the previous year(s). OSDVRA heavy equipment assists in loading woodchips to be distributed.

Staff distributes cut branches and driftwood in patches from the mid-portion of 6 and 7 exclosures to the west fence and upper shoreline west of the exclosure. Staff collects the branches and driftwood from the exclosures at the end of each season and stores them for use in the following season.

Plants and seeds: Prior to expected rain, staff may broadcast seed and install container plants grown on-site, as available, in an effort to provide scattered plants in 6 and 7 exclosures. All seed for dispersal and container plants are collected from local foredune species. The seeding and planting is within 6 and 7 exclosures because these areas have the least amount of vegetative cover during the nesting season compared to other areas of the seasonal exclosure. Seed or plants are of foredune species such as sea rocket (*Cakile maritima*), beach bur (*Ambrosia chamissonis*), and sand verbena (*Abronia maritima*). Scattered plants, and the associated development of small hummocks, can benefit plovers and terns during the breeding season.

Predator management

In addition to preventative measures such as fencing, individual nest exclosures, and cover provided by habitat enhancement, ODSVRA park staff and contractors monitor predator activity to assess impacts on breeding terns and plovers (as discussed in Monitoring). Staff removes animal carcasses (which attract scavengers) in or adjacent to nesting and brood-rearing habitat and harass predators to flush them from sensitive areas. Hazing techniques used include firing a bird whistler and waving arms and making noise while approaching an avian predator on foot or by vehicle. A bird whistler is a handheld launcher that fires a projectile 250 to 300 feet and makes a loud "screech" sound, hazing predatory birds without harming them. The bird whistler can be fired from a vehicle, which can limit disturbance to plovers and terns when it would be disruptive to approach an avian predator on foot in the breeding habitat. When additional options for managing predators are needed, selective live-trapping and relocation of avian predators is conducted by Ventana Wildlife Society and selective live-trapping and relocation or lethal removal of mammalian and avian predators is conducted by USDA Wildlife Services. See section titled Predators and predator management on page 41 for additional information.

Figure 1. ODSVRA site map.

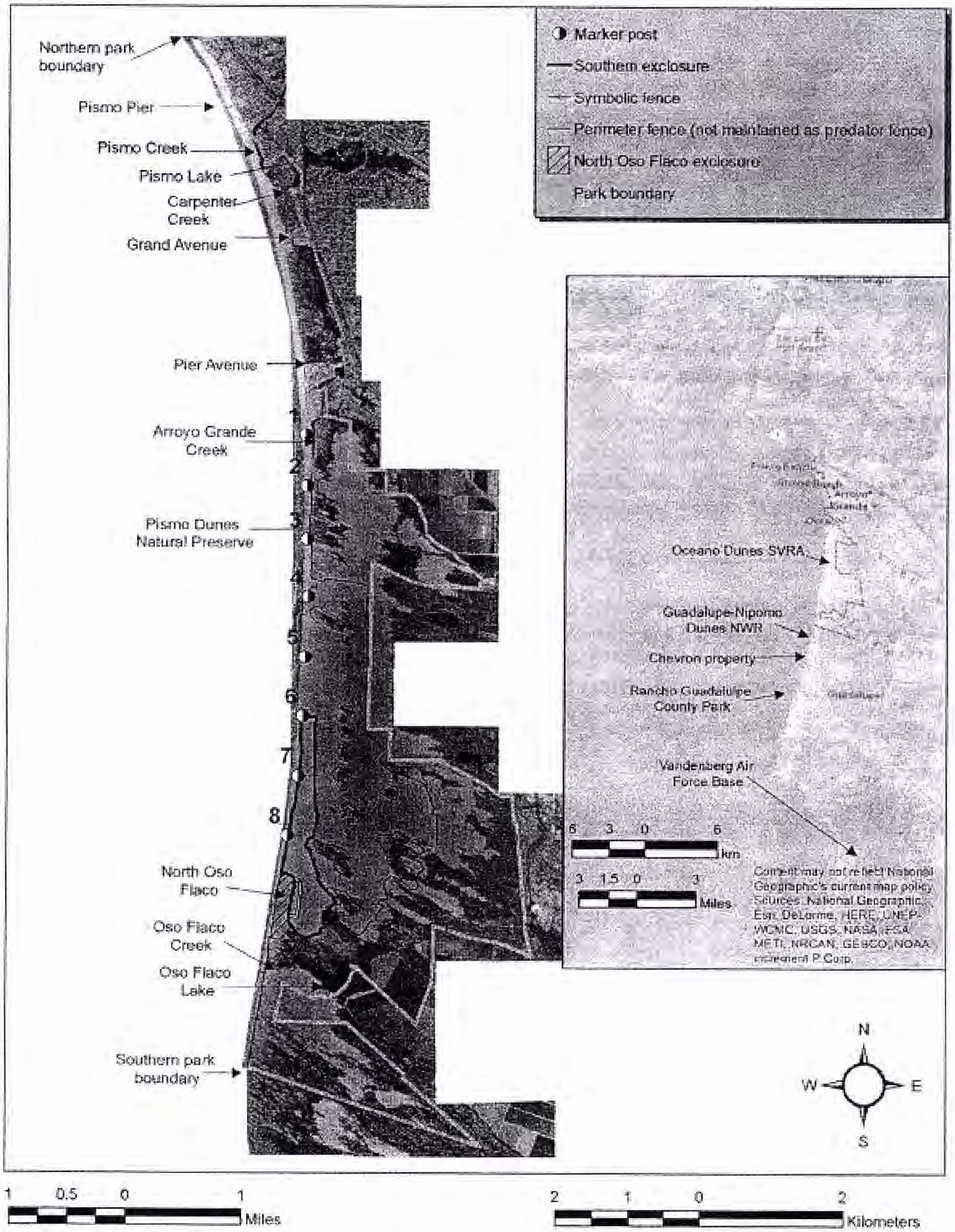
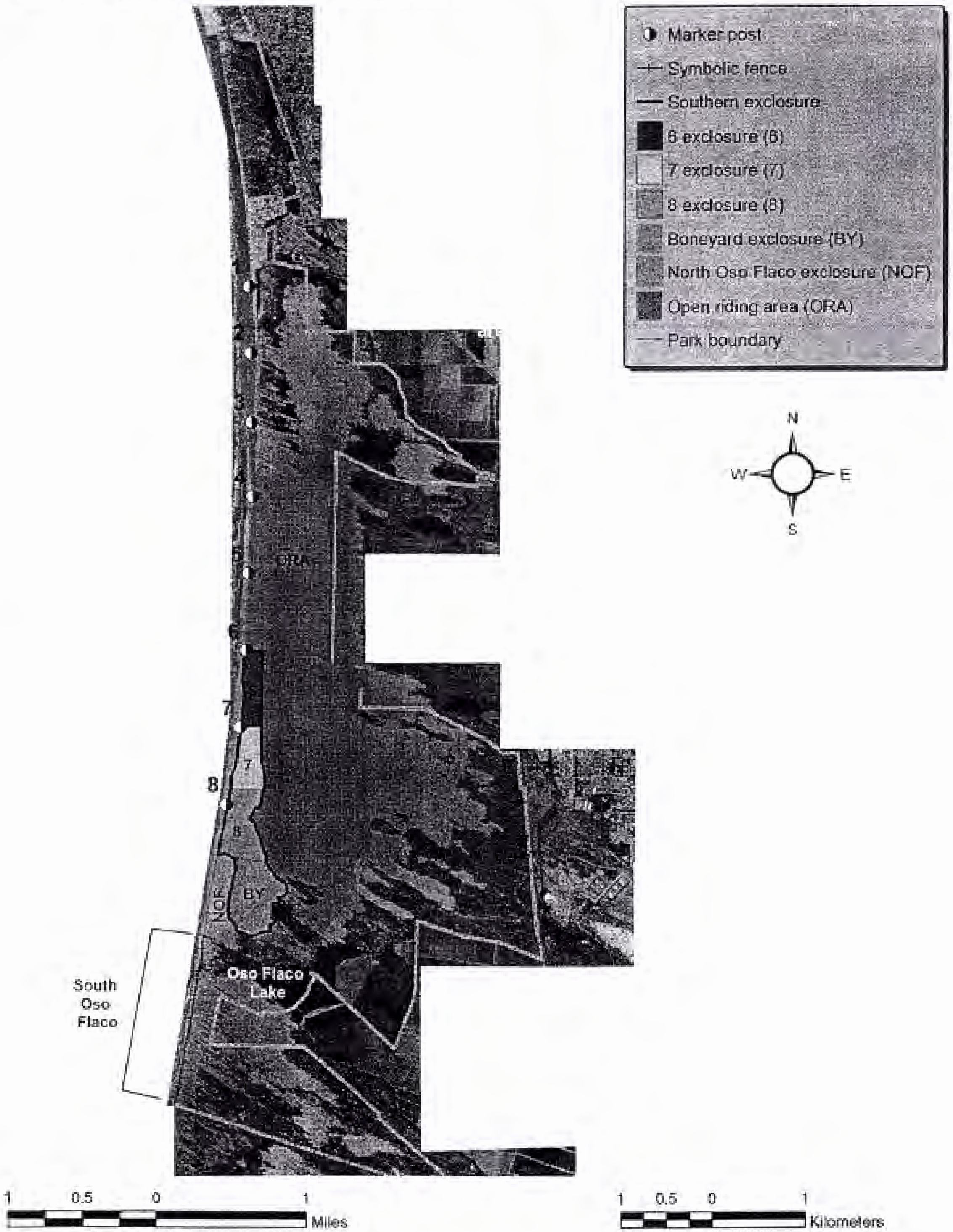


Figure 2. ODSVRA Southern Exclosure and Oso Flaco seasonally protected areas for breeding California least terns and snowy plovers in 2015.



RESULTS AND DISCUSSION

CALIFORNIA LEAST TERN

Number of breeding pairs

In 2015, least terns were first seen at ODSVRA on 28 April with three flying over the exclosure, and from this date onward terns were seen or heard daily. Terns were last seen on 17 August with two adults over 8 exclosure shoreline. During the previous 10 years, first sightings occurred between 8 April and 13 May (median=6 May) and last sightings occurred between 10 August and 25 September (median=31 August). There were an estimated 44-49 breeding pairs. This is similar to the 47-48 pairs in 2014 and above the average of 40-43 pairs (range=23-66) from 2005-14 (Table 1, Figure 3).

Number, clutch size, and distribution of nests

There were 54 nesting attempts documented, with the first nest initiated approximately 18 May and the last 12 July (Appendix A). During the ten-year period 2005-14, there were an average of 46 nests per year (range=23-66) with initiation dates for first nests ranging from 16 May to 8 June (median=4 June). In 2015, the maximum number of nests active at the same time was 44 on 7 June. Of the 45 nests with known complete clutch size seven had one egg, 37 had two eggs, and one had three eggs, with an average clutch size of 1.87 eggs. This compares to an average of 1.89 for 2005-14 (range=1.55-2.05), and a reported statewide average of 1.71 from 2007-14 (range=1.60-1.82) (Marschalek 2008-12; Frost 2013-15). Nests were located in 6 exclosure (38 nests), 7 exclosure (15 nests), and 8 exclosure (1 nest) (Figure 4).

Clutch hatching rate

All nests had a known fate and 88.9% (48/54) hatched. This compares to an average hatching rate of 83% (range=66-91%) during the period 2005-14 (Table 1). The hatching rate was 92.1% (35/38) in 6 exclosure, 80.0% (12/15) in 7 exclosure, and 100% (1/1) in 8 exclosure. Sixty-one chicks hatched from a minimum of 71 eggs in 6 exclosure, 21 chicks hatched from a minimum of 25 eggs in 7 exclosure, and two chicks hatched from a single two-egg nest in 8 exclosure. Causes of loss for six nests known to fail were abandoned pre-term (1); abandoned post-term (1); abandoned, unknown if pre- or post-term (1); depredated by raccoon (1); and failed, unknown cause (2) (Table 2).

Table 1. Nesting success of California least terns at ODSVRA from 1991-2015.
Percent nests hatched calculated using number of nests with known fate. Percent chicks fledged and juveniles fledged per nest may include fledges from unknown nest locations detected only by brood presence, but these are few. Chicks were banded to site in 2003 and 2004. In 2005, chicks were first banded to brood and from 2006-15, chicks were banded to individual.

Year	Estimated no. breeding pairs	No. nests (no. known fate)	No. hatched nests	Percent known fate nests hatched	No. chicks	Percent chicks fledged	No. juveniles	Juveniles fledged per nest	Estimated no. juveniles fledged per pair
1991	4-5	6 (6)	2	33	4	50	2	0.33	0.40-0.50
1992	3-4	4 (4)	1	25	2	50	1	0.25	0.25-0.33
1993	0	0	0	0	0	0	0	0	0
1994	2	2 (2)	0	0	0	0	0	0	0
1995	1	1 (1)	0	0	0	0	0	0	0
1996	0	0	0	0	0	0	0	0	0
1997	16-19	21 (10)	3	30	6	67	4	0.19	0.21-0.25
1998	33-37	40 (32)	26	81	40	60	24	0.60	0.65-0.73
1999	28-31	34 (30)	21	70	38	45	17	0.50	0.55-0.61
2000	4-5	5 (5)	4	80	8	50	4	0.80	0.80-1.00
2001	12-15	18 (18)	13	72	22	55	12	0.67	0.80-1.00
2002	20-21	22 (19)	15	79	27	37	10	0.45	0.48-0.50
2003	53-66	79 (77)	60	78	101	37	37	0.47	0.56-0.70
2004	47-55	63 (60)	44	73	69	36	25	0.40	0.45-0.53
2005	47-53	59 (59)	39	66	66	30	20	0.34	0.38-0.43
2006	31-35	38 (38)	28	74	45	80	36	0.95	1.03-1.16
2007	54-60	66 (66)	51	77	90	78	70	1.06	1.17-1.30
2008	55-56	56 (56)	50	89	99	71	70	1.25	1.25-1.27
2009	25-26	26 (26)	23	88	43	77	33	1.27	1.27-1.32
2010	23	23 (23)	20	87	35	83	29	1.26	1.26
2011	33-34	35 (35)	31	89	55	91	50	1.43	1.47-1.52
2012	41-44	46 (40)	33	83	52	81	42	0.91	0.95-1.02
2013	48-53	57 (52)	45	87	85	66	56	0.98	1.06-1.17
2014	47-48	49 (46)	42	91	76	76	58	1.18	1.21-1.23
2015	44-49	54 (54)	48	89	84	82	69	1.28	1.41-1.57

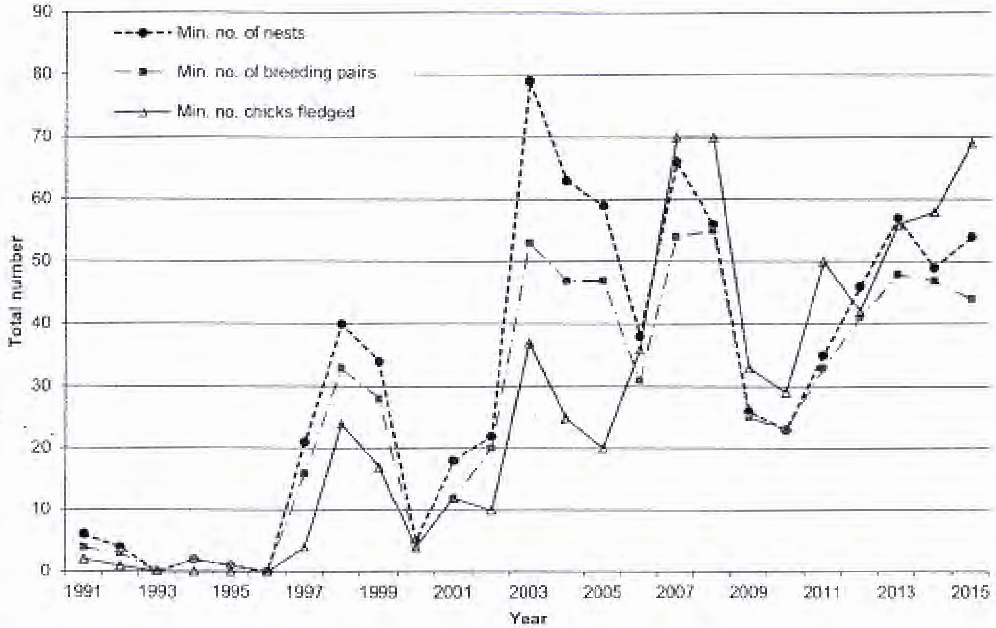


Figure 3. Number of California least tern nests, pairs, and fledglings at ODSVRA from 1991-2015.

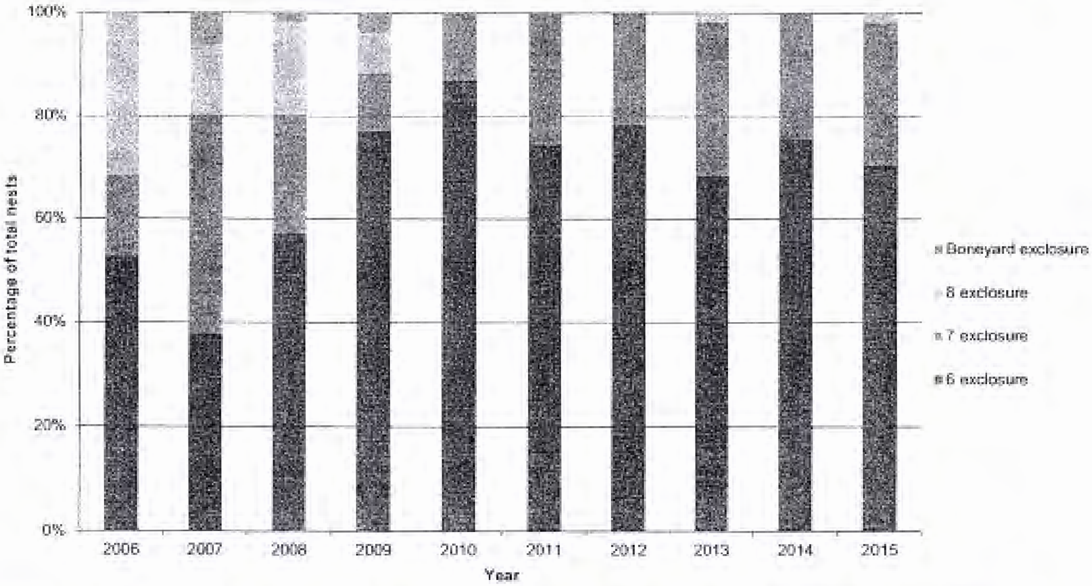


Figure 4. Distribution of least tern nests as a percent of total nests at ODSVRA from 2006-15.
6 exclosure was first incorporated into the Southern Exclosure for a full season in 2004.

Table 2. Causes of California least tern nest loss at ODSVRA from 2002-15.
Ab.=Abandoned

Year	Ab. pre-term	Ab. post-term	Ab., susp. wind	Ab., unknown if pre- or post-term	Failed, cause unknown	Coyote	Gull	Opossum	Raccoon	Unknown predator	Chick dies in egg at hatch	Total no. failed nests
2002	1	1				2						4
2003	6	3				1				2		12
2004	9	1				2				1		13
2005	7	3		4	4					1	1	20
2006	5	3		1						1		10
2007	1	4	4		6							15
2008	3	2					1					6
2009	1	1		1								3
2010		1			1			1				3
2011	2	2										4
2012	1	2		3	1							7
2013	2			2	1	1		1				7
2014	1	1		1	1							4
2015	1	1		1	2				1			6
Total 2002-15	40 (35.1%)	25 (21.9%)	4 (3.5%)	13 (11.4%)	16 (14.0%)	6 (5.3%)	1 (0.9%)	2 (1.8%)	1 (0.9%)	5 (4.4%)	1 (0.9%)	114

Chick fledging rate, juveniles produced per pair, and juvenile length of stay on-site
Sixty-nine of the 84 known hatching chicks were banded with a unique color combination. Sixty-nine of the 84 chicks were seen when 21 days old or older for a fledging rate of 82.1% (57 fledglings were banded and 12 were unbanded) (Appendix A). This fledging rate compares to an average of 78% (range=66-91%) during the previous nine years when most chicks were banded to individual. For two-chick broods, 59% (20/34) fledged both young. This compares to an average of 62% (range 43-86%) for 239 two-chick broods during the period 2006-14. In 2015, the estimated number of fledglings produced per pair ranged from 1.41-1.57. This is higher than the ten-year average of 1.11-1.17 for 2005-14 (range=0.38-1.52) and well above recent averages for all of California (Table 1). Estimated statewide fledgling rates for each year are reported as a range and averaged 0.26-0.38 fledglings per pair for the ten-year period 2005-14 (highest estimates in 2014 with range=0.37-0.68) (Marschalek 2007-13; Frost 2014).

From 2010-15, there have been six known occurrences of a least tern chick moving east of the exclosure into the open riding area (two in 2010, by the same chick on the same day; one in 2011; two in 2013; and one in 2015). These chicks were monitored and directed back into the exclosure. On 28 June 2015, one ten-day-old color-banded chick of the two-chick LT42 brood moved ten feet east of 7 exclosure and was picked up and placed back in the exclosure. This chick was documented to fledge (see Notes section).

Of the current or recent breeding sites in San Luis Obispo and Santa Barbara counties, only ODSVRA bands chicks. Marking least tern chicks with individual color band combinations has increased the ability to detect juveniles at ODSVRA and provides greater accuracy in documenting fledging rate than the three-week count method[3]. For the six-year period 2006-11, the three-week count method at ODSVRA consistently underestimated the minimum known number of juveniles produced each year, identifying an average of 49.0% (range=38.0-66.7%) of the known minimum number (see CDPR 2011 for greater

[3] High counts of juveniles that are seen on dates at intervals of three weeks are added together (Marschalek 2007). This is based on the assumption that juveniles typically depart the colony with their parents within two to three weeks of fledging (at 21 days old) and that any juveniles seen are not from other sites.

details). ODSVRA relies on color band resighting data to derive a more accurate fledging rate and did not conduct three-week counts in 2012-15.

Color banding chicks to brood in 2005 and to individual since 2006 has also provided information on juvenile length of stay at ODSVRA. In 2015, 21.4% (12/56) of the color-banded juveniles tracked were documented remaining at ODSVRA for 21 days or longer post-fledging, with one juvenile documented on-site for 45 days post-fledging. Over the 11-year period 2005-15, 483 color-banded fledglings were tracked at ODSVRA with 33.1% remaining 21 days or longer (Table 3, Figure 5).

Table 3. Number of days that color-banded California least tern juveniles hatched at ODSVRA continued to be seen on-site after reaching fledge age (21 days old) during the 11-year period, 2005-15.

During this period, 483 color-banded fledglings (21 days old or older) were tracked at ODSVRA (sightings outside the park are not included). Numbers in parentheses are percentages of all banded fledglings for the year. One banded chick in 2015 (LT9) was known to fledge based only on found carcass and is excluded from table.

Year	0 - 6 days post-fledge	7 - 13 days post-fledge	14 - 20 days post-fledge	21 - 27 days post-fledge	28 - 34 days post-fledge
2005	0 (0%)	4 (20%)	2 (10%)	10 (50%)	4 (20%)
2006	4 (12%)	5 (15%)	9 (26%)	14 (41%)	2 (6%)
2007	12 (17%)	14 (20%)	17 (25%)	21 (30%)	5 (7%)
2008	14 (21%)	30 (44%)	15 (22%)	9 (13%)	0 (0%)
2009	3 (10%)	14 (48%)	8 (28%)	3 (10%)	1 (3%)
2010	3 (11%)	4 (14%)	12 (43%)	9 (32%)	0 (0%)
2011	2 (4%)	5 (10%)	9 (18%)	31 (63%)	2 (4%)
2012	4 (11%)	6 (17%)	14 (39%)	10 (28%)	2 (6%)
2013	6 (12%)	12 (23%)	24 (46%)	10 (19%)	0 (0%)
2014	2 (5%)	7 (17%)	18 (43%)	14 (33%)	1 (2%)
2015	13 (23%)	9 (16%)	22 (39%)	9 (16%)	3 (5%)
TOTAL 2005-15	63 (13%)	110 (23%)	150 (31%)	140 (29%)	20 (4%)

Mortality (other than eggs)

There was a minimum of two documented tern mortalities (other than eggs) at ODSVRA during the 2015 breeding season; one unbanded juvenile observed 22 July with a broken wing in 7 exclosure and on 7 exclosure shoreline and assumed to not survive, and the intact carcass of one juvenile (L:Y/G from LT9) found on 21 July inside 7 exclosure 50 feet east of the western fence (see Appendix G and Necropsy report).

Least tern use of nearby small freshwater lakes

During the chick-rearing period, adult least terns are noted foraging and carrying fish from the ocean, but may also be seen at the following nearby small freshwater lakes: Pismo Lake, Oso Flaco Lake, Dune Lakes, and Cypress Ridge Lake. Of the freshwater sources noted, Oso Flaco Lake and Pismo Lake are located on State Park property. Pismo Lake was not actively monitored by staff from 2010-15 and tern use of this lake is suspected to be minimal. Use of Oso Flaco Lake in 2015 appeared to be minimal compared with previous years. Oso Flaco Lake is more accessible to monitors and in 2015 there were eight surveys (lasting an average of 45 minutes) conducted between 7 July and 15 August with an average of 4 birds seen (high count of five on 25 July). This compares with an average of 12 birds and a single day high count of 30 birds in 2014 (eight surveys conducted). Over the season, no banded juveniles and a minimum of two banded adults were documented at Oso Flaco Lake; one banded W/B:R/Y tern (fledged from ODSVRA in 2010), and the second banded Y/W/Y:- (missing band on right leg, one Y/W/Y:G/Y tern fledged from ODSVRA in 2007). The two banded adults were observed by a local birder and photos confirmed their band combinations. Adults were also seen feeding juveniles at Oso Flaco Lake and carrying fish northwest towards the Southern Exclosure. Terns were observed flying over Dune Lakes, but no detailed information is available because these lakes are only visible from a distance. There were many observations of adult terns carrying small fish flying into the exclosure from the east (the direction of Dune Lakes). In 2007, monitors first documented terns foraging at Cypress Ridge Lake, located approximately 3.2 miles east of the tern colony site. This lake had moderate levels of foraging documented in 2007-10, none in 2011, 2014, or 2015, and minimal use in 2012-13.

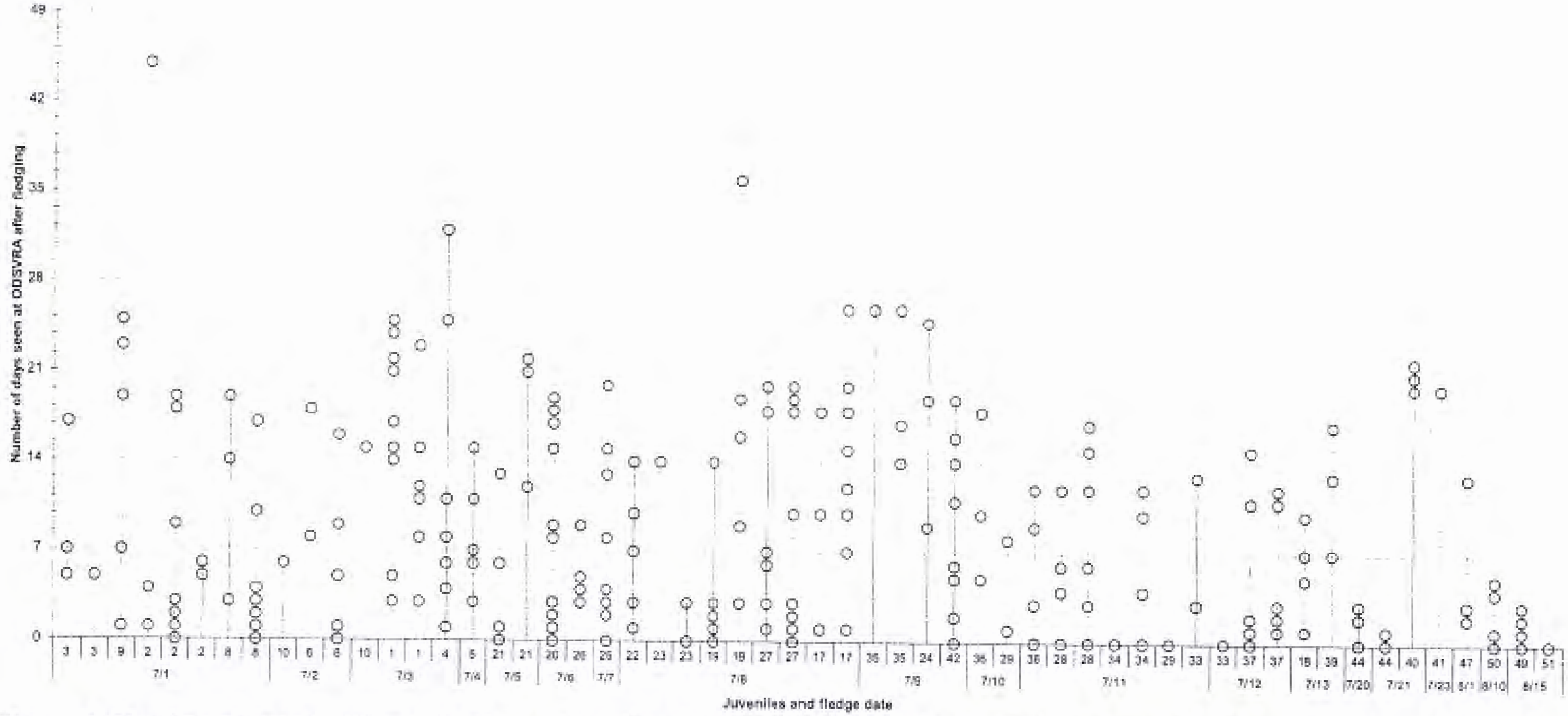


Figure 5. Number of days California least tern juveniles that hatched at ODSVRA in 2015 continued to be seen on-site after reaching fledge age (21 days old).

The horizontal axis provides the nest number from which each fledgling hatched and the date it fledged. All juveniles included in graph were color-banded to individual. One of the two LT9 fledglings (L:G/Y) was found dead on 21 July and is excluded from the figure because it was not observed alive since it was banded as a chick and it is not known how many days it survived past the fledge date.

Banded adult least terns at ODSVRA

Recording color combinations is more difficult for adult least terns than snowy plovers as the behavior of the terns provides fewer opportunities for observations. In 2015, there was a minimum of 39 banded adults documented at ODSVRA, based on observations with a spotting scope. Thirty-seven of these birds were identified as banded at this site as chicks (banding began in 2003). Origins of two banded birds could not be determined as they only had a federal aluminum band without tape. Breeding was documented for 15 of the 39 banded adults (13 banded as chicks at ODSVRA and two with undetermined origin) (Table D.1 in Appendix D). Over the last six years there has been one confirmed sighting of a banded tern from another site. This was an adult (S:A/O) seen 28 July to 11 August 2011 that was banded at the U.S. Navy North Island Maintenance and Training Facility in San Diego Bay.

Least terns typically first breed at three years old, with some breeding documented by two-year-old birds (Massey and Atwood 1981). A total of seven two-year-old banded terns have been documented as breeding at ODSVRA in 2012-14 (two in 2012, three in 2013, and two in 2014), and none were confirmed in 2015 (some band combinations were used in multiple years so age could not be confirmed). In 2005, a two-year-old tern banded as a chick at ODSVRA was documented breeding at Vandenberg Air Force Base, approximately 22 miles south of the park. The oldest confirmed breeding adult at ODSVRA in 2015 was a six-year-old tern (banded Y/O:W/B in 2009 at ODSVRA).

Terns banded at ODSVRA breeding at Vandenberg Air Force Base

In 2015, three terns that were banded as chicks at ODSVRA (B/R:B/W and P:B/W in 2012, and Y/R/Y:W/B in 2013) were documented breeding at Vandenberg Air Force Base.

Night roost

During the breeding season, adult least terns not engaged in incubation or chick care may assemble in a communal night roost and are often joined by fledglings later in the breeding season. Reduced exposure to disturbance from predators is likely an important factor in the selection of a night roost location. There can be a high degree of site fidelity, both within a breeding season and between years, with birds continuing to roost in the same location. Surveys of the night roost were conducted on 67 days between 6 May and 12 August in 2015. The night roost was initially located in the same area of northern 6 exclosure used since 2004, the year when 6 exclosure first became available as protected habitat for a complete season (Figure C.2 in Appendix C). In early July the roost location appeared to move to an area in mid-7 exclosure and was sometimes not visible or not located during surveys after this time. Counts at the night roost are minimums, as some or all birds would often arrive after it was too dark to count individuals. In 2015, there was a high count of 74 birds at the night roost on 16 May (Figure 6). This compares to an average night roost high count of 57 (range=35-95) from 2007-14. Both adults and juveniles were seen but it typically was too dark to distinguish plumage and age class.

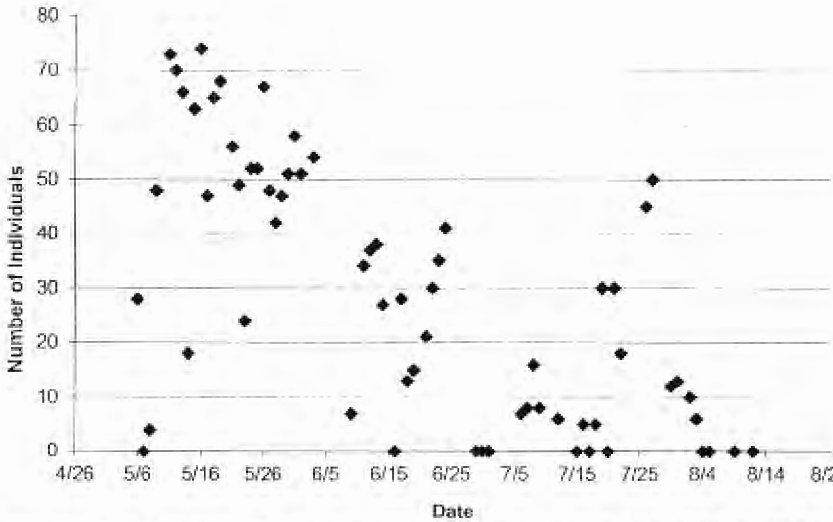


Figure 6. Number of California least terns counted at the ODSVRA night roost in 2015.

Importance of ODSVRA least tern breeding colony

The ODSVRA least tern breeding colony has benefited from the increased level of protection and management actions provided since 2002. The colony is important in meeting statewide recovery goals as loss of breeding habitat has resulted in a fragmented population distribution and a limited number of remaining breeding sites (USFWS 1985, 2006). On a regional level, there are very few active breeding sites along the central coast of California and none remain between ODSVRA and San Francisco Bay. Within San Luis Obispo and Santa Barbara counties, there are four least tern colony sites with annual or intermittent use, all sites have management providing protective measures and monitoring. ODSVRA is the only site in San Luis Obispo County. Rancho Guadalupe Dunes County Park (RGDCP), Vandenberg Air Force Base (VAFB), and Coal Oil Point Reserve (COPR) are in Santa Barbara County and approximately 7, 22, and 85 miles south of the ODSVRA colony, respectively. For this regional population, ODSVRA has become an important source of productivity. During the period 2004-15, ODSVRA produced a minimum of 558 juvenile terns while RGDCP, VAFB, and COPR combined produced an estimated 197 juveniles (Table 4, Table 5).

Table 4. California least tern reproductive success reported for current or recent breeding sites in San Luis Obispo and Santa Barbara counties from 2004-15.

Note that chicks are not banded at Rancho Guadalupe Dunes County Park (RGDCP), Vandenberg Air Force Base (VAFB), and Coal Oil Point Reserve (COPR). Sources: RGDCP (pers. comm. staff), VAFB (pers. comm. Dan Robinette for all years), and COPR (pers. comm. staff).

Year	Site	No. pairs (est. for ODSVRA)	No. nests	No. nests hatching	No. chicks	No. juveniles	No. juveniles per total no. nest	No. juveniles per pair (est. for ODSVRA)
2005	ODSVRA	47-53	59	39	66	20	0.34	0.38-0.43
	RGDCP	4	4	0	0	0	0.00	0.00
	VAFB	44	44	18	32	1	0.02	0.02
	COPR	0	0	0	0	0	0.00	0.00
2006	ODSVRA	31-35	38	28	45	36	0.95	1.04-1.16
	RGDCP	0	0	0	0	0	0.00	0.00
	VAFB[1]	2	2	0	0	0	0.00	0.00
	COPR	5	5	4	7	7	1.40	1.40
2007	ODSVRA	54-60	66	51	90	70	1.06	1.17-1.3
	RGDCP	1	1	1	1	1	1.00	1.00
	VAFB	18	18	13	20	16	0.89	0.89
	COPR	4	6	2	4	0	0.00	0.00
2008	ODSVRA	55-56	56	50	99	70	1.25	1.26-1.27
	RGDCP	0	0	0	0	0	0.00	0.00
	VAFB	18	18	17	32-33	19	1.06	1.06
	COPR	1	1	0	0	0	0.00	0.00
2009	ODSVRA	25-26	26	23	43	33	1.27	1.29-1.32
	RGDCP	2-3	3	2	3	3	1.00	1.00-1.50
	VAFB	30	31	28	56	37	1.19	1.23
	COPR	0	0	0	0	0	0.00	0.00
2010	ODSVRA	23	23	20	35	29	1.26	1.26
	RGDCP	1	1	1	2	2	2.00	2.00
	VAFB	33	34	29	57	29	0.85	0.88
	COPR	0	0	0	0	0	0.00	0.00
2011	ODSVRA	33-34	35	31	55	50	1.43	1.47-1.52
	RGDCP	0	0	0	0	0	0.00	0.00
	VAFB	32	32	19	36	4	0.13	0.13
	COPR	1	1	0	0	0	0.00	0.00
2012	ODSVRA	41-44	46	33	52	42	0.91	0.97-1.02
	RGDCP	0	0	0	0	0	0.00	0.00
	VAFB	18	18	12	21	10	0.56	0.56
	COPR	0	0	0	0	0	0.00	0.00
2013	ODSVRA	48-53	57	45	85	56	0.98	1.07-1.17
	RGDCP	0	0	0	0	0	0.00	0.00
	VAFB	15	15	15	25	19	1.27	1.27
	COPR	0	0	0	0	0	0.00	0.00
2014	ODSVRA	47-48	49	42	76	58	1.18	1.21-1.23
	RGDCP	0	0	0	0	0	0.00	0.00
	VAFB	17	21	15	30	20	0.95	1.18
	COPR	0	0	0	0	0	0.00	0.00
2015	ODSVRA	44-49	54	48	84	69	1.28	1.41-1.57
	RGDCP	0	0	0	0	0	0.00	0.00
	VAFB	22	22	22	45	29	1.32	1.32
	COPR	0	0	0	0	0	0.00	0.00

[1] Minimum counts of adult terns at the VAFB colony site were 60 and 40 in 2004 and 2006, respectively, but nesting was limited.

Table 5. Number of reported breeding least tern pairs and juveniles produced at ODSVRA and the combined sites of Rancho Guadalupe Dunes County Park (RGDCP), Vandenberg Air Force Base (VAFB), and Coal Oil Point Reserve (COPR) from 2004-15.
During this period, almost all tern chicks were banded at ODSVRA and observation of color-banded individuals was an important means to document juvenile production. Banding does not occur at the other sites and other methods are used to estimate number of juveniles produced.

	ODSVRA			RGDCP, VAFB, and COPR combined	
Year	Est. no. breeding pairs	No. juveniles		No. breeding pairs	No. juveniles
2004	47-55	25		15	0
2005	47-53	20		48	1
2006	31-35	36		7	7
2007	54-60	70		23	17
2008	55-56	70		19	19
2009	25-26	33		32-33	40
2010	23	29		34	31
2011	33-34	50		33	4
2012	41-44	42		18	10
2013	48-53	56		15	19
2014	47-48	58		17	20
2015	44-49	69		22	29
Total juveniles produced		558			197

WESTERN SNOWY PLOVER

Number of breeding adults

In the absence of a population of individually banded snowy plover adults, which provides the most accurate means to identify breeding population size, ODSVRA uses a method that includes examining the single day high count of concurrent nests (for females) and concurrent nests and broods (for males) (see Monitoring and Management Actions section for additional information on determining number of breeding adults). In 2015, there was a minimum of 205 breeding adults (92 females and 113 males). This is a decrease of 9.3% from the minimum estimated number of 226 breeding adults in 2014 and compares to a range of 95-190 adults for 2008-13. The average minimum number of breeding adults for the last five years (2011-15) is 189, increasing to 198 for the last three years (Table 6, Figure 7).

Beginning in 2005, the USFWS has coordinated a rangewide window survey count of the U.S. Pacific coast breeding population of the snowy plover between the last week of May and first week of June. In 2015, the survey at ODSVRA counted 180 adult plovers (82 males, 80 females, and 18 of unknown sex), 88% of the minimum number documented by known breeding activity. In ten of the 11 years from 2005-15, the window survey count at ODSVRA was lower than the minimum number of breeding birds (54-88% of minimum number). It was higher (107%) than the minimum number in 2008 (Table 7) (CDPR 2012).

Table 6. Number of snowy plover breeding adults, breeding males, fledglings, and chicks fledging per breeding male for the 14-year period 2002-15.

Year	Min. no. breeding adults	Min. no. breeding males	No. fledglings	No. fledglings per breeding male[1]
2002	32	18	35	1.94
2003	84	52	107	2.06
2004	121	67	66	0.99
2005	116	65	82	1.26
2006	107	58	17	0.29
2007	79	47	66	1.40
2008	95	54	72	1.33
2009	114	66	81	1.23
2010	137	78	107	1.37
2011	160	94	152	1.62
2012	190	105	96	0.91
2013	163	92	187	2.03
2014	226	120	196	1.63
2015	205	113	277	2.45
Average for 14-year period 2002-15	131	74	110	1.47
Average for 5-year period 2011-15	189	105	182	1.73
Average for 3-year period 2013-15	198	108	220	2.04

[1]Number of fledglings per breeding male will be overestimated if the number of breeding males is undercounted.

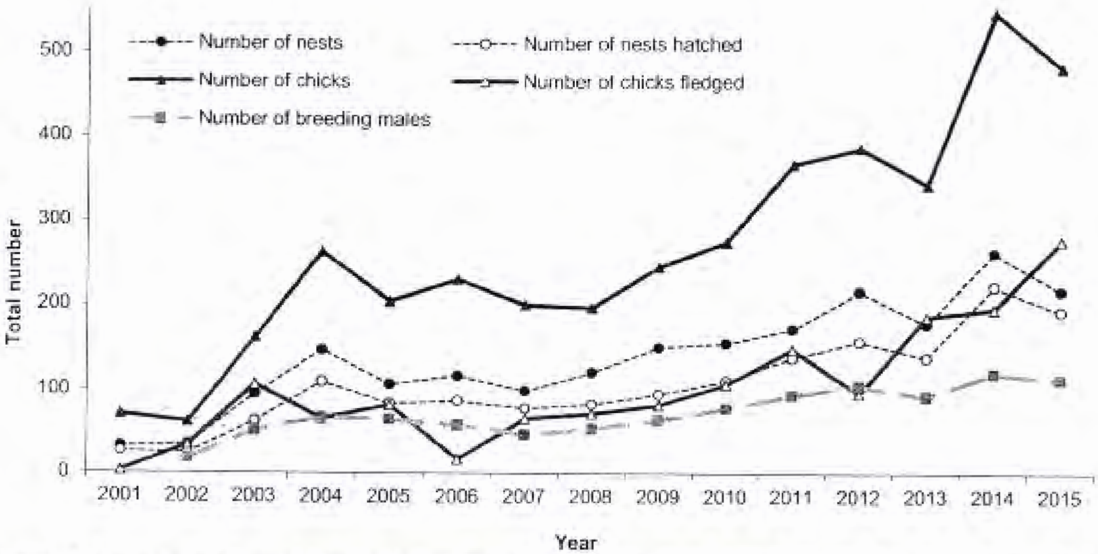


Figure 7. Number of snowy plover breeding males, nests, nests hatched, chicks, and chicks fledged at ODSVRA from 2001-15.

Prior to 2001, monitoring in Oso Flaco and Pismo Dunes Natural Preserve was intermittent and fledgling information was not obtained.

Table 7. Number of adult snowy plovers counted on USFWS breeding season window surveys versus calculated minimum number of breeding adults at ODSVRA from 2005-15.

Year	Calculated minimum number of breeding adults	Summer breeding window survey numbers	Breeding window numbers/ calculated minimum numbers
2005	116	92	79%
2006	107	87	81%
2007	79	60	76%
2008	95	102	107%
2009	114	98	86%
2010	137	74	54%
2011	160	112	70%
2012	190	145	76%
2013	163	94	58%
2014	226	180	80%
2015	205	180	88%

Number and distribution of nests

There were 217 known nesting attempts, including 15 identified only by detection of brood (unknown nest location), initiated between 17 March– 4 July. Of the 202 nests from known locations 182 (90.1%) were in the Southern Exclosure, 7 (3.5%) in North Oso Flaco, and 13 (6.4%) in South Oso Flaco. More specifically for the Southern Exclosure, there were 76 nests in 6 exclosure, 57 in 7 exclosure, 40 in 8 exclosure, and 9 in Boneyard exclosure (Appendix C). The maximum number of known location nests active at one time was 88 on 2 May, with the highest number in 6 exclosure (34 nests). (Table 8, Table 9, Table E.1 in Appendix E).

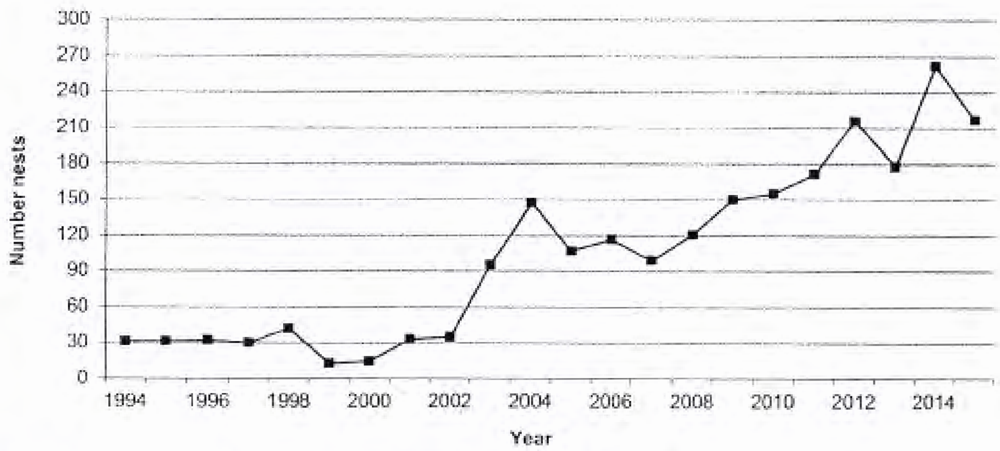


Figure 8. Number of snowy plover nests at ODSVRA from 1993-2015.

Table 8. Snowy plover nest distribution and success at ODSVRA in 2015.
Excludes 15 nests known only from detection of broods.

Location	No. nests (no. known location and fate)	No. eggs laid	No. nests hatching	Percent known location and fate nests hatching
6 exclosure	76 (74)	215	66	89.2
7 exclosure	57 (53)	159	48	90.6
8 exclosure	40 (39)	116	33	84.6
BY exclosure	9 (9)	27	6	66.7
TOTAL SOUTHERN EXCLOSURE	182 (175)	517	153	87.4
North Oso Flaco	7 (7)	20	5	71.4
South Oso Flaco	13 (13)	36	9	69.2
TOTAL OSO FLACO	20 (20)	56	14	70.0

Table 9. Nesting success of snowy plovers at ODSVRA from 2001-15.

Number of eggs from nests with unknown location is a minimum number derived from number of chicks seen. A more detailed table of nesting success for 2001-15 is included as Table E.1 in Appendix E. Percent hatching is calculated using known location hatched nests divided by total known location and fate nests. Number of fledglings per nest is number of known fate chicks fledged divided by total number of nests.

na=not available

Year	Total no. nests (no. known location and fate)	Min. no. eggs	Ave. clutch size (no. nests known location and complete clutch size)	No. nests hatching (no. known location)	Percent hatching	No. chicks (no. chicks with known fate)	No. known fate chicks fledged (percent fledged)	No. fledglings per nest
2001	33 (30)	na	na	26 (26)	86.7	71 (71)	3 (4.2)	0.09
2002	35 (35)	99	na	25 (25)	71.4	62 (62)	35 (56.5)	1.00
2003	95 (93)	254	na	63 (62)	67.7	162 (159)	108 (67.9)	1.14
2004	147 (140)	415	2.87 (141)	110 (105)	75.0	263 (263)	66 (25.1)	0.45
2005	107 (103)	290	2.86 (96)	84 (80)	77.7	204 (204)	82 (40.2)	0.77
2006	117 (114)	336	2.89 (115)	87 (87)	76.3	230 (230)	17 (7.4)	0.15
2007	99 (91)	290	2.93 (89)	78 (70)	76.9	200 (198)	66 (33.3)	0.67
2008	121 (119)	341	2.85 (116)	83 (81)	68.1	197 (197)	72 (36.5)	0.60
2009	150 (147)	418	2.85 (144)	95 (94)	63.9	245 (245)	81 (33.1)	0.54
2010	155 (150)	431	2.88 (146)	111 (109)	72.7	275 (275)	107 (38.9)	0.69
2011	172 (160)	487	2.88 (159)	138 (131)	81.9	365 (365)	152 (41.6)	0.88
2012	216 (203)	603	2.94 (200)	157 (152)	74.9	386 (386)	96 (24.9)	0.44
2013	178 (167)	502	2.93 (162)	138 (130)	77.8	343 (343)	200 (58.3)	1.12
2014	262 (239)	725	2.86 (243)	222 (206)	86.2	547 (547)	196 (35.8)	0.75
2015	217 (195)	612	2.92 (192)	182 (167)	85.6	494 (494)	277 (56.1)	1.28

Average clutch size, clutch loss and nest hatching rate

There were 217 identified nesting attempts, including 15 known only by brood, and of these 182 hatched (Table 9, Figure 8, Figure 9). For 192 nests with known complete clutch size (and excluding nesting attempts known only by brood) the average number of eggs was 2.92. This compares to an average of 2.89 eggs per clutch (range=2.85-2.94) for the 11-year period 2004-14. Excluding 22 nests (seven with unknown fate and 15 detected by brood only), the clutch hatching rate was 85.6% (167/195). This compares to an average of 74.7% (range=63.9-86.2 %) from 2002-14 (Table 9). The nest hatching rate in 2015 was higher in the Southern Exclosure (87.4%) than in Oso Flaco (70.0%), as has been the case in 12 of the previous 14 years. Twenty-eight nests were known to fail, with losses attributed to abandoned pre-term (12); abandoned unknown pre- or post-term (4); abandoned post-term (1); abandoned, suspected wind (1); cause unknown (3); raven (4); avian predator (2); and unidentified predator (1) (Table 10, Table 11, Table E.1 and Figure E.1 in Appendix E).

Table 10. Attributed causes of snowy plover nest loss at specific locations at ODSVRA in 2015.

Area	Abandoned pre-term	Abandoned post-term	Abandoned, suspected wind	Abandoned unknown pre- or post-term	Failed, cause unknown	Unidentified predator	Avian predator	Raven
Southern Exclosure								
6 exclosure	5	1	0	2	0	0	0	0
7 exclosure	3	0	1	1	0	0	0	0
8 exclosure	3	0	0	1	1	0	0	1
Boneyard exclosure	0	0	0	0	1	0	2	0
TOTAL SOUTHERN EXCLOSURE	11	1	1	4	2	0	2	1
Oso Flaco								
North Oso Flaco	0	0	0	0	0	1	0	1
South Oso Flaco	1	0	0	0	1	0	0	2
TOTAL OSO FLACO	1	0	0	0	1	1	0	3
ODSVRA TOTAL	12	1	1	4	3	1	2	4

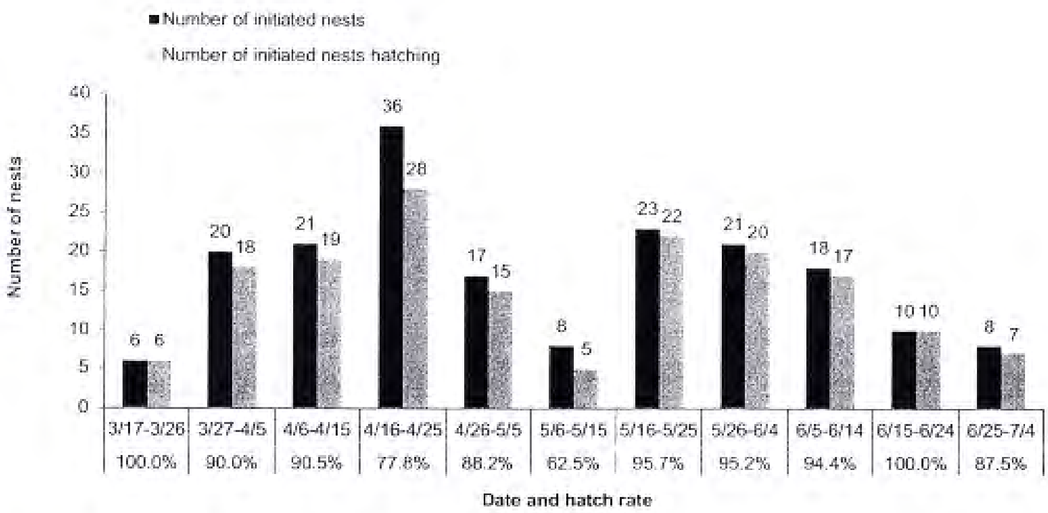


Figure 9. Number of known location and known fate snowy plover nests with known initiation date (n=188) initiated per 10-day period and number known to hatch at ODSVRA in 2015.

Table 11. Attributed causes of snowy plover nest loss in Southern Exclosure and Oso Flaco at ODSVRA from 2002-15. The percentage of total loss for each cause is shown for the 14-year period 2002-15. Prior to 2010, nest abandonment suspected due to wind was included with nests abandoned pre-term; these causes of nest loss are shown separately for 2010-15. So. Excl. = Southern Exclosure.

Year	Area	Abandoned pre-term	Abandoned post-term	Abandoned, suspected wind	Abandoned unknown pre- or post-term	Failed, eggs removed by staff	Failed, cause unknown	Unidentified predator	Avian predator	Gull	Corvid	Raven	Northern harrier	Coyote	Raccoon	Skunk	Flooded	Total
2002	So. Excl.				6		1							1				8
	Oso Flaco				2													2
2003	So. Excl.	17	2					3				1						23
	Oso Flaco	2					1	1				4						8
2004	So. Excl.	12					7	2				2		1				24
	Oso Flaco	4					2	3									1	10
2005	So. Excl.	9	3				7											19
	Oso Flaco	2	1					1										4
2006	So. Excl.	5	4				2	1		3				4				19
	Oso Flaco							1		3							2	7
2007	So. Excl.	4	1				9					1						15
	Oso Flaco	2					2					1		1				6
2008	So. Excl.	10			3		7	4		1			1				1	27
	Oso Flaco	3			1			5									2	11
2009	So. Excl.	9				3	1	8	13	2			1				1	38
	Oso Flaco	4					2	2	4							1	1	14
2010	So. Excl.	3	2	11				4	6								2	28
	Oso Flaco	1		2					2						1	2	1	9
2011	So. Excl.	6	3	1	1		2	1	5		3							22
	Oso Flaco							2			2				1	2		7
2012	So. Excl.	11	1	6	3		3	3	5		3		5	1	1		1	43
	Oso Flaco	3	1	1														5
2013	So. Excl.	5	5	15			3	1										29
	Oso Flaco	3	2	2						1								8
2014	So. Excl.	13	1		4	2	2										1	23
	Oso Flaco	6		1				1						1			1	10
2015	So. Excl.	11	1	1	4		2		2			1						22
	Oso Flaco	1					1	1				3						6
2002-15 Total failed nests	So. Excl.	115 33.8%	23 6.8%	34 10.0%	21 6.2%	5 1.5%	46 13.5%	27 7.9%	31 9.1%	6 1.8%	6 1.8%	5 1.5%	7 2.1%	7 2.1%	1 0.3%	0 0.0%	6 1.8%	340
	Oso Flaco	31 29.0%	4 3.7%	6 5.6%	4 3.7%	0 0.0%	8 7.5%	17 15.9%	6 5.6%	4 3.7%	2 1.9%	8 7.5%	0 0.0%	2 1.9%	2 1.9%	5 4.7%	8 7.5%	107
2002-15 Grand Total So. Excl. and Oso Flaco		146 32.7%	27 6.0%	40 8.9%	25 5.6%	5 1.1%	54 12.1%	44 9.8%	37 8.3%	10 2.2%	8 1.8%	13 2.9%	7 1.6%	9 2.0%	3 0.7%	5 1.1%	14 3.1%	447

Chick fledging rate

Of the 494 snowy plover chicks hatched, 331 were banded and the fate of 163 unbanded chicks is believed known (94 fledged) (Appendix B). The primary reason chicks remained unbanded was their close proximity to young plover or tern broods and the need to avoid undue disturbance. In addition, a number of very young unbanded chicks were lost prior to any banding opportunity. Unbanded chicks were tracked by a combination of the following: chicks with a banded adult, with banded sibling(s), and a concentrated monitoring effort to locate all broods and determine number and size of chicks. In the absence of a high percentage of chicks being banded at ODSVRA, it would not be possible to obtain accurate chick survival and fledging rates. Between 14 May and 15 August, ten unbanded broods (23 chicks) were observed on the shore and were from hatched nests whose chicks were not banded while at the nest. Two of the ten broods were subsequently banded. Although these broods could not be assigned to a specific nest and exclosure, all chicks were tracked and fledglings are included in totals. The fledging rate for banded chicks was 55.3% (183/331) and 57.7% (94/163) for unbanded chicks. The fledging rate for all chicks combined was 56.1% (277/494). This compares to 35.8% in 2014 and an average rate of 38.6% (range=7.4-67.9%) for the 12-year period 2002-13 (Table 9, Table E.1 in Appendix E) (CDPR 2007-13).

In 10 of 13 years during the period 2003-15, the fledging rate of chicks hatching in the early season (prior to 20 June) has been higher, by an average of 21 percentage points, than chicks hatching in the late season (20 June or later). (See 2012 report for how early versus late season was determined.) In 2015, the late season had a higher chick fledging rate (67%) compared to the early season (51%). Noticeable was the very poor survival of the initial 11.3% of the total number of chicks produced, with only 9 of 56 chicks (16.1%) fledging. This was in sharp contrast to subsequent chick survival, with 268 of 438 (61.2%) chicks fledging (Figure 10, Figure 11, Figure 12).

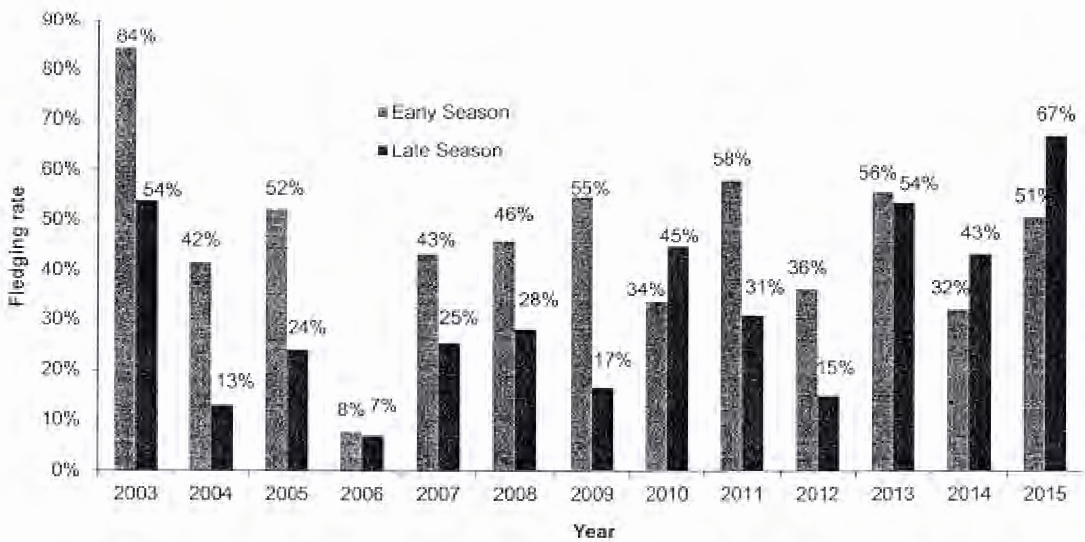


Figure 10. Fledging rate of chicks hatching in early season (prior to 20 June) and late season (20 June or later) at ODSVRA from 2003-15.

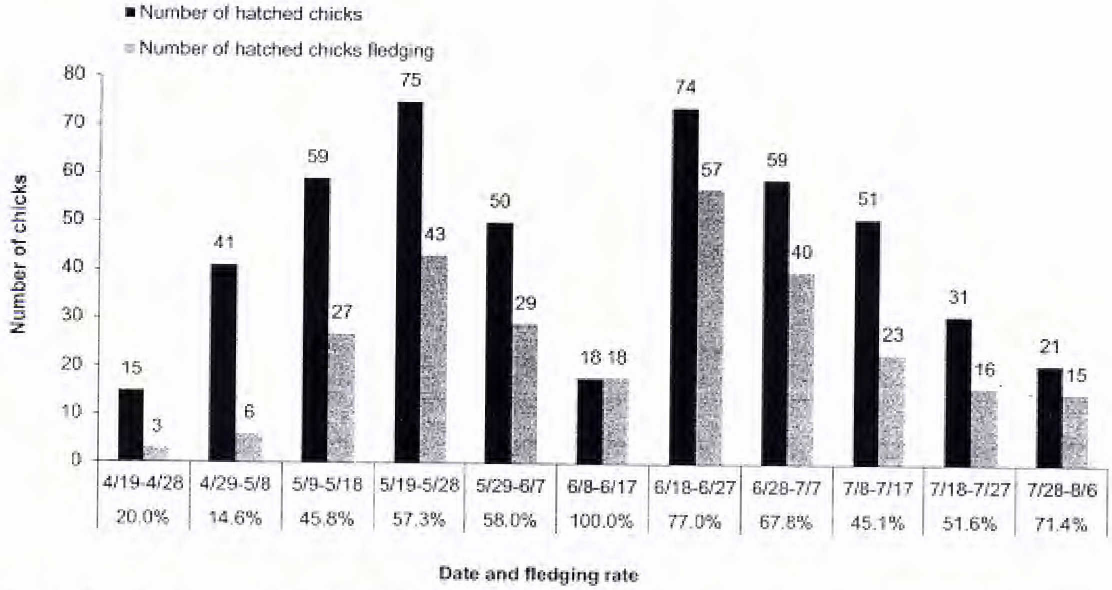


Figure 11. Number of snowy plover chicks hatching per 10-day period and number subsequently fledging at ODSVRA in 2015.

Includes all chicks with known fate (494). For broods that either originated from unknown location (39 chicks from 15 broods) or were not assigned to a specific nest (15 chicks from 7 broods) a hatch date was estimated based on chick size.

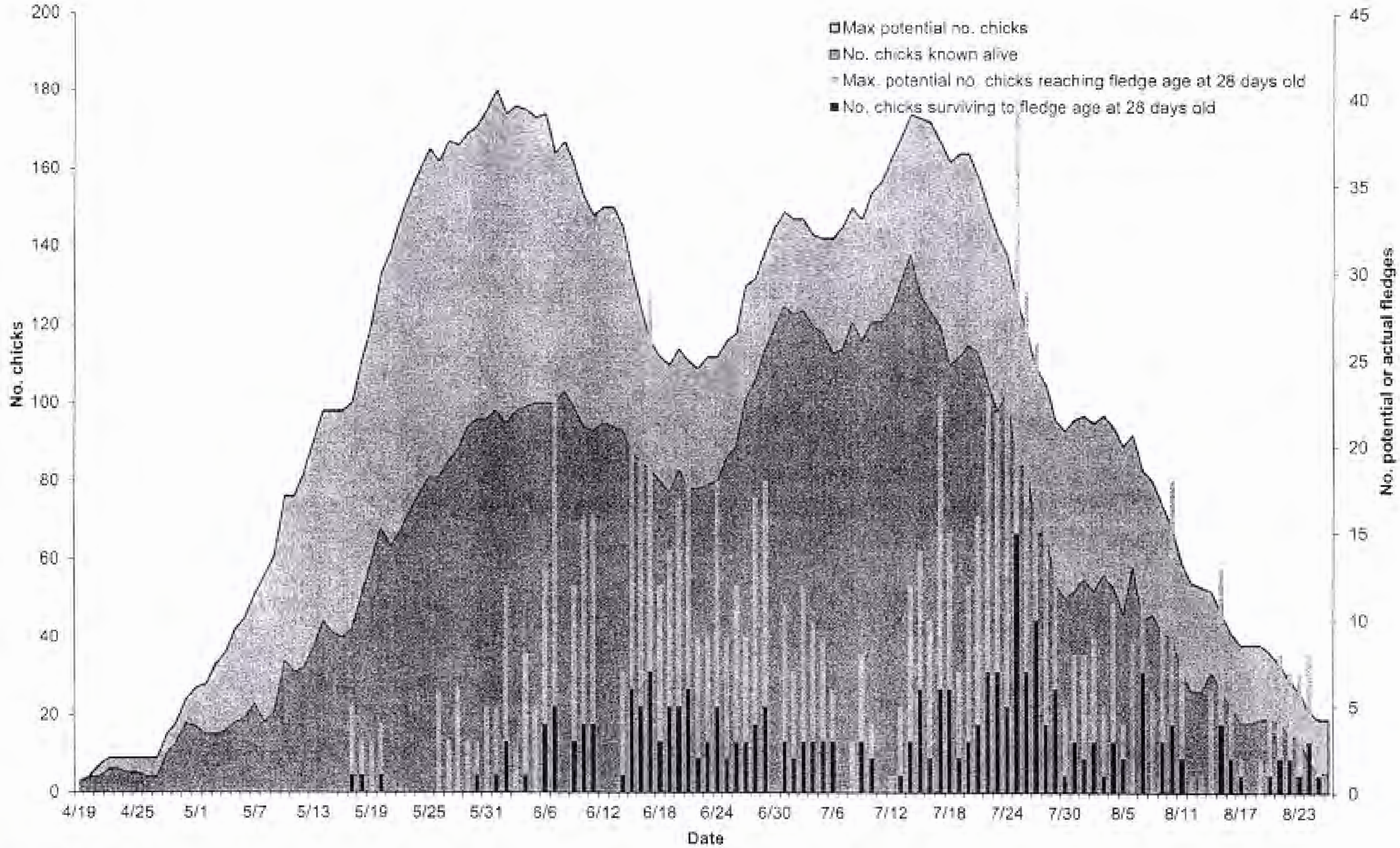


Figure 12. Chick survival and fledge rate from 19 April to 26 August at ODSVRA in 2015.

Of the total of 494 chicks hatching, 485 closely tracked chicks are represented in this figure. Number chicks known alive calculated using date of last sighting during regular surveys of all chicks. No.=number

Brood movement and age of chick loss

At ODSVRA most snowy plover broods are initially led from the nest by the parent(s) to the nearest shore to forage, and the close proximity of quality shoreline habitat for raising chicks can benefit productivity, as mortality rates are typically highest for very young chicks. In 2009-15, the majority (65-78%) of tracked broods were not known to move beyond the individual beach section (6, 7, and 8 exclosures, North Oso Flaco, and South Oso Flaco) nearest to where they hatched. (Note that the disproportionate loss of very young chicks increases the observed proportion of broods remaining in the area where hatched, as the entire brood may be lost before movement outside of that area occurs.) In 2015, 143 of 191 fledglings were from broods remaining in the same general shoreline area adjacent to where hatched (excluded are 86 fledglings from unbanded broods and broods not assigned to a specific nest that were greater than two days old when first seen and prior potential movement unknown).

Sites south of ODSVRA and within the contiguous dune complex also manage and monitor snowy plovers. In addition, park resource staff periodically monitored the adjoining Guadalupe-Nipomo Dunes NWR to search for ODSVRA broods. Only two banded broods from ODSVRA were seen being raised south of the park boundary, all on the adjoining Guadalupe-Nipomo Dunes NWR (two of four chicks fledged).

Of 344 carefully tracked chicks (327 banded and 17 unbanded chicks with banded siblings) from known location nests, 153 were believed lost. Chick loss in 2015 was highest for very young chicks (0-4 days of age), accounting for 64.7% of total loss (Figure 13). This is above the average of 47% loss (range=38%-54%) from 2009-14 (CDPR 2014). For 206 chicks reaching 16 days of age in 2015, the fledge rate was 93%. This is higher than the average of 77% for the previous six years (range=71-84%) and is equal to the results from a six-year (1977-82) study at Monterey Bay in Monterey County, California, that found at least 93% of the 124 chicks reaching 16 days of age fledged (Warriner et al. 1986).

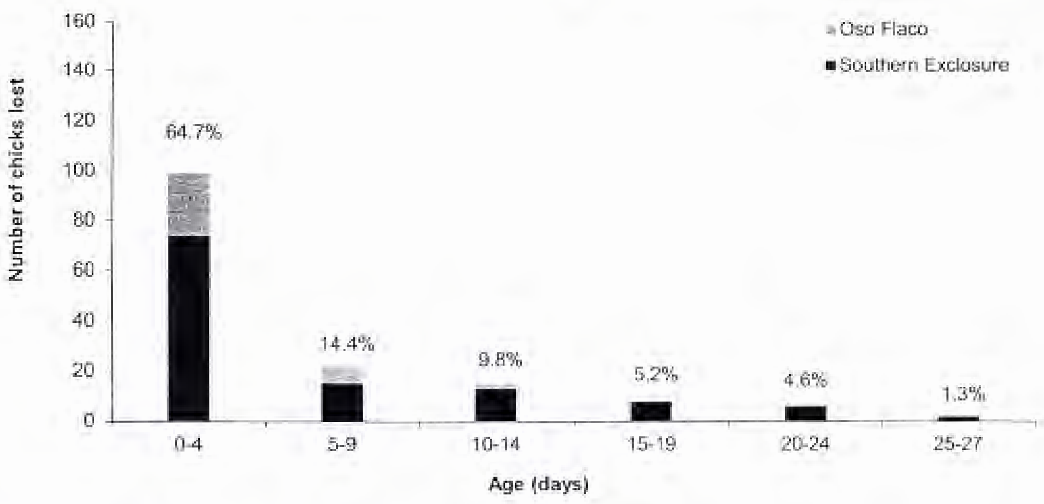


Figure 13. Loss of snowy plover chicks by age and location last seen in the Southern Exclosure and Oso Flaco at ODSVRA in 2015.

Number and percentage of total chicks lost shown for each age group. There were 344 chicks included in the analysis; 153 of these were lost. Data excludes broods that could not clearly be identified and tracked individually.

Productivity measured by number of fledglings produced per adult male

Based on a population viability analysis in the USFWS Pacific coast western snowy plover recovery plan, a rate of 1.0 fledglings produced per male is believed necessary to prevent population decline with 1.2 fledglings per male allowing for moderate population growth (assuming approximately 75% annual adult survival and 50% juvenile survival) (USFWS 2007). In 2015, the number of chicks fledging per male was 2.45, a high level of productivity which will promote population growth. During the 2002-15 period, average productivity was 1.47 fledglings per male and exceeded 1.2 fledglings per male in 11 of the 14 years (Table 6). (Note that if the number of breeding males is underestimated, the number of chicks fledged per male is an overestimate.)

Mortality (other than eggs)

There was a minimum of 18 documented snowy plover mortalities (other than eggs) at ODSVRA during the 2015 breeding season (1 March to 30 September). Five of these were the result of depredation of one chick and four adults. Predators involved were Western gull (*Larus occidentalis*) (one chick), merlin (*Falco columbarius*) (one adult), and peregrine falcon (*Falco peregrinus*) (three adults). Documented mortality other than predation included 10 chicks, two juveniles, and one adult. One of these chicks was killed by the aggressive behavior of an adult plover associated with a nearby shoreline nest. An additional four chicks from two broods were aggressively attacked by nearby adults and believed to not have survived the incident (for additional information see Predators and predator management section on page 41, Notes section, and the Mortality Table in Appendix G).

Protection of nests with exclosures and symbolic fencing

Of the 195 nests from known location and with known fate, 146 received some form of wire mesh fencing. Ninety-five percent (138/146) of these were within the large seasonal exclosure predator fencing installed at the beginning of the season in 6, 7, 8, and Boneyard exclosures and North Oso Flaco. These nests had an 88% hatch rate.

For the 6, 7, and 8 exclosures and North Oso Flaco, there were an additional 43 nests established on the shoreline outside of the seasonal fencing. This shoreline is closed to public use during the nesting season. Three nests (all in North Oso Flaco) were protected by individual circular exclosures and 100% hatched. Forty nests were protected only by a symbolic rope fencing with signs that provides no predator protection but is designed to prevent/reduce vehicle and pedestrian trespass. These nests did not receive individual wire fence protection due to a combination of the following factors: avoiding disturbance of nearby broods, nest abandonment concerns due to adult mortality, and a continuing high hatch rate without the use of wire fencing. Of these nests 83 % (33/40) hatched.

In South Oso Flaco there were 13 nests, all within seasonal symbolic rope fencing (visitor pedestrian use allowed outside of symbolic fencing). On two occasions a nest was found west of the symbolic fence and the fence was moved westward. One nest failed before a planned circular exclosure could be installed and seven nests did not receive any wire exclosure due to concerns of windblown sand potentially burying eggs and adult vulnerability to predators. Of these eight nests four hatched (50% hatch rate). Five nests received circular exclosures and 100% hatched (Table E.2 in Appendix E).

Banded snowy plovers breeding at ODSVRA in 2015

In California the closest site north of ODSVRA where banding occurs is Monterey Bay in Monterey County (most all chicks banded). To the south, banding has not occurred at the Guadalupe-Nipomo Dunes NWR for 13 years, but occurs annually at Vandenberg Air Force Base in Santa Barbara County (varying percentage of chicks banded), and at several sites in San Diego County. The great majority (87.6%, 92/105) of known origin banded birds breeding at ODSVRA in 2015 represent recruitment from chicks banded and fledged from ODSVRA. Ten breeding birds were banded as chicks from 2008 to 2014 at Vandenberg Air Force Base. Three were banded as chicks in Monterey County from 2013 and 2014 (one each from Salinas River State Beach, Marina State Beach, and Reservation Road). An additional seven breeding birds were missing one or more bands and were from unknown locations. (Table D.3 in Appendix D).

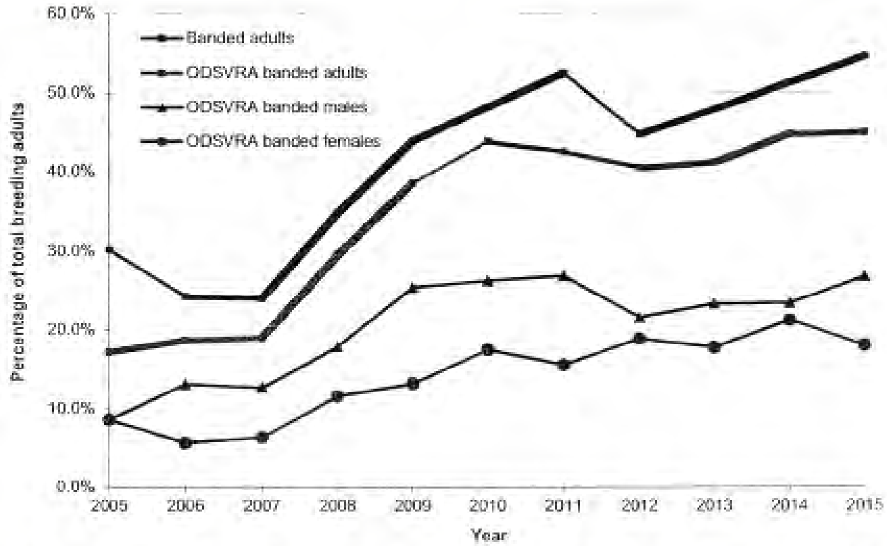


Figure 14. Percentages over the total calculated breeding population at ODSVRA of all verified banded adults and the sum of males and females originally banded at ODSVRA breeding from 2005-15.

All ODSVRA banded adults were banded on-site when chicks.

Snowy plover surveys at ODSVRA during the nonbreeding season

Surveys for wintering plovers (Pacific coast breeding birds joined by interior breeding birds) were conducted two to five times a month (see Monitoring and Management Actions for survey details). Between 1 October 2014 and 28 February 2015, single day wintering plover counts at ODSVRA ranged from 156 to 312 birds (single day high count on 8 December 2014). The shore was divided into five beach sections and the monthly average number of plovers (from two to five weekly surveys) was obtained for each section. Of the five sections, the beach north of Grand Avenue had no birds throughout the October to February period. Grand Avenue to marker post 2 had an average of 130 plovers (range of monthly averages=83-169) for the five-month period. The section from marker post 6 to the southern boundary of the open riding area, closed to public entry during the breeding season, had an initial high number of birds, averaging 144 in October and 101 in November. This declined to an average of 23 plovers (range=2-49) from December to February. In Oso Flaco the average monthly number of plovers ranged from 0-27 over the five-month period (Figure 15).

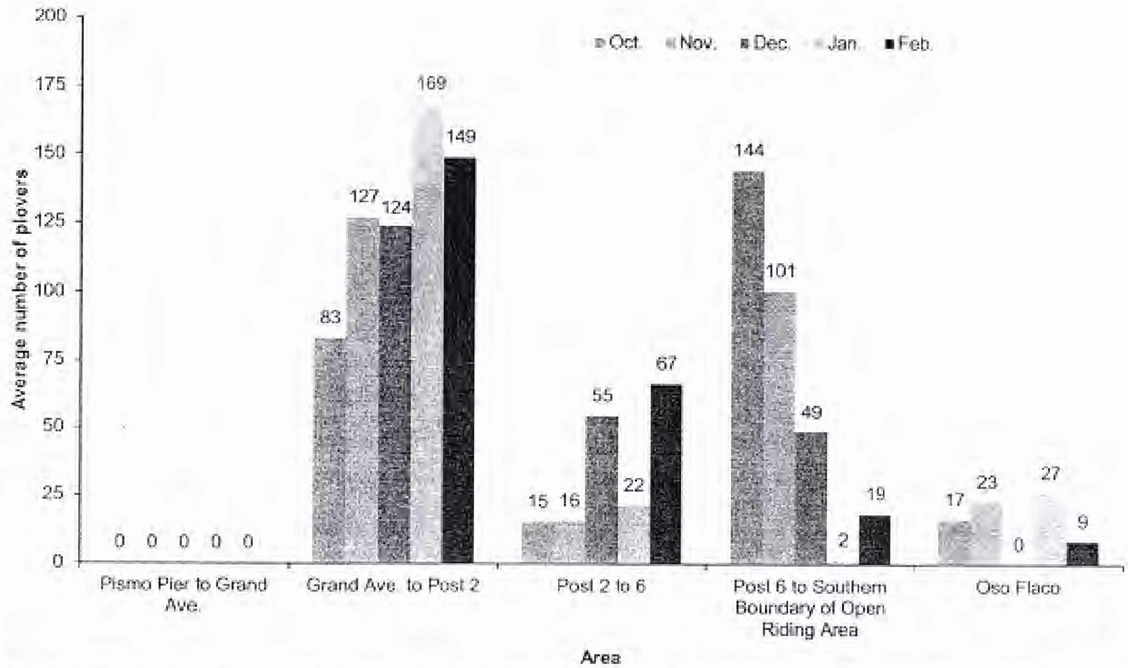


Figure 15. Monthly average number of snowy plovers observed during nonbreeding season surveys at ODSVRA from October 2014 to February 2015.
Surveys conducted two to five times a month.

Beginning in 2004, ODSVRA has participated in a snowy plover winter season window survey organized by USFWS and conducted in January throughout the U.S. Pacific coast. Plovers present during this time include birds from both the Pacific coast breeding population and interior breeding birds wintering on the coast. In 2015, the survey at ODSVRA counted 238 adult plovers. This compares to an average winter window count of 147 (range=62-261) during the 11-year period 2004-14 (Figure 16).

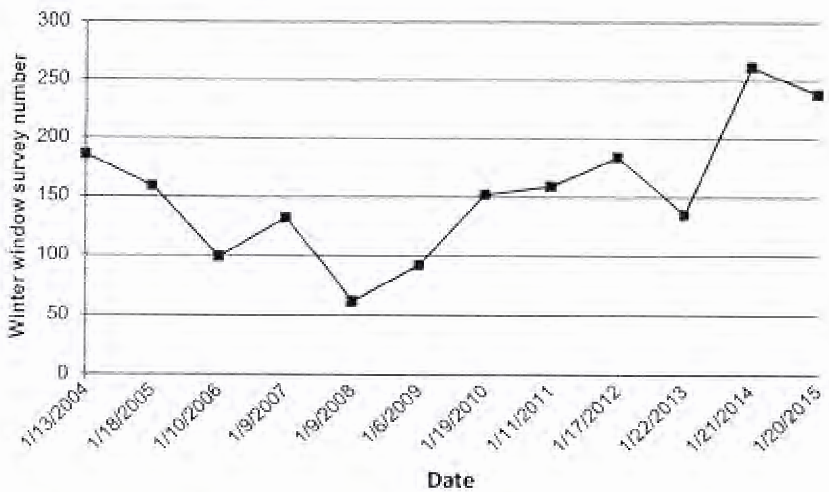


Figure 16. Number of snowy plovers counted on USFWS winter window surveys from 2004-15.

One hundred and thirty-seven banded snowy plovers were recorded during surveys from 1 October 2014 to 28 February 2015. These birds were banded at the following locations (all in California with one exception): 97 from ODSVRA; 25 from Vandenberg Air Force Base in Santa Barbara County; eight from the Monterey Bay area in Monterey County; one from Oregon; and six were missing one or more bands and were from unknown locations (Table D.2 in Appendix D).

Factors Influencing Least Tern and Snowy Plover Reproductive Success

The following is a discussion of some of the factors that influence reproductive success of terns and plovers at ODSVRA. The adequacy of any single factor alone is not sufficient to achieve and sustain recovery goals.

Size of protected habitat
Maintaining an adequate size of protected habitat at ODSVRA has been important in providing sufficient area for terns and plovers to roost, nest, and raise young. Protected breeding habitat of sufficient size allows nests and chicks to be dispersed which can reduce exposure and vulnerability to predators, as well as reduce adverse disturbance from human recreational activities. For plovers, it also improves opportunities for chicks to have access to adequate invertebrate food resources.

Quality of protected habitat
During the March through September least tern and snowy plover nesting season, habitat within the seasonal Southern Exclosure is protected and closed to public entry. Following the nesting season, and for the five-month period October through February, the area is open to public use, including camping, street-legal vehicles, and off-highway vehicles. This recreational use results in large areas of flattened terrain and barren sand with very limited scattered natural debris and vegetation. Snowy plovers often nest in areas of available limited patchy cover and to offer more areas of disruptive cover the park staff places material in the 6, 7, and 8 exclosures. Materials added include surf-cast kelp (wrack), branches, driftwood, and woodchips. See 2012 report for habitat enhancement analysis and results.

Predators and predator management
Predators and predation can be an important factor limiting least tern and snowy plover reproductive success (Page et al. 1995; Thompson et al. 1997). Predators may impact terns and plovers directly by depredating eggs, chicks, juveniles, or adults. Indirect predator impacts, such as disturbance, can increase time spent by adults in vigilance or avoidance behavior, and may limit incubating and brooding behavior. Presence of predators may result in a brood becoming scattered and the loss of any chick failing to reunite with the adult. Depredation of an adult tern or plover may result in egg abandonment or loss of dependent chicks.

Species known to be predators of terns and plovers were documented by both number of days detected, as well as number of occurrences (mammalian) and sightings (avian). Number of days detected describes the total number of days predator presence was documented in the nesting area (Southern Exclosure and Oso Flaco) during the nesting season. Additional information was collected in order to estimate the extent of predator activity, both temporally and spatially, in the protected area. Occurrences and sightings were used for mammalian and avian predators, respectively, to reflect the difference in manner of detection; almost all mammalian predators were detected by tracks whereas almost all avian predators were detected by direct observation (with the notable exception of nocturnal owls). Both occurrences and sightings are used to better describe the extent of predator activity on a single day by categorizing presence separately for the different areas of the Southern Exclosure (6, 7, 8, and Boneyard exclosures) and Oso Flaco (North and South). In addition, observations of an individual remaining in one area longer than one hour are counted as multiple sightings (one sighting per hour or portion thereof) in order to account for possible additional impacts. Information was more limited for mammalian predators and does not include details such as number of individuals, behavior, or duration of presence. The date range for all observations discussed is from 1 March to 10 September. (Note that the number of recorded occurrences or sightings for the first two weeks of March may be biased lower, with less time during this period spent on predator surveys and more time spent on habitat enhancement and fencing projects.)

Selective live-trapping and relocation of avian predators was conducted by Ventana Wildlife Society and lethal removal of both mammalian and avian predators was conducted by USDA Wildlife Services. Predator monitoring efforts by these contractors were conducted from February to September. Five coyotes and one common raven (*Corvus corax*) were removed lethally. One northern harrier (*Circus cyaneus*) and one peregrine falcon were live-trapped and relocated (Table F.2 in Appendix F).

Documented Predation

Predation can occur quickly, leaving little or no evidence, and it is likely that only a small percentage of events are documented during a season. There are many hours each day (including almost all night hours) when monitoring staff and/or predator management specialists are not present to observe predation. Even when monitors are present, there are limitations in the ability to detect predators, such as diurnal avian predators, that can travel quickly over large distances. Despite limited documentation of predation events and detection bias, predators of particular concern identified during the 2015 season included peregrine falcon, northern harrier, gull spp., raven, and coyote.

For least terns and snowy plovers known clutch loss to predation in 2015 included one tern nest to raccoon (*Procyon lotor*) and seven plover nests: four to common raven, two to unidentified avian predator, and one to unidentified predator. From 2002-15, 2.3% (15/651) of all tern nests with known fate were known to be lost to predators (nine mammalian, one avian, and five unidentified predator). During this same 14-year period, 6.9% (136/1957) of plover nests with known location and fate were documented lost to predation (17 mammalian, 75 avian, and 44 unidentified predator).

Five documented predation events, other than eggs, in 2015 included: four adult plovers (one by merlin and three by peregrine falcon); and one plover chick (Western gull) (Appendix G). This compares to ten documented losses in 2014: two juvenile or adult terns (peregrine falcon), six plover chicks [three by peregrine falcon and three by California gull (*Larus californicus*)], one adult plover (unidentified avian predator), and one plover of unknown age (California gull).

Mammalian Predators

Mammals removed under predator management actions were limited to five coyotes. All other mammalian predator species noted on-site were not known or suspected of having significant impacts on terns or plovers in 2015.

Opossum

Opossum (*Didelphis virginiana*) tracks were documented on four days in the Southern Exclosure and Oso Flaco in 2015 and averaged 11 days per season (range=3-25) from 2007-14 (Figure 17). From 2002-15, known nest loss to opossum was limited to two tern nests, occurring in 2010 and 2013.

Skunk

Skunk (*Mephitis mephitis*) tracks were documented on 17 days in the Southern Exclosure and Oso Flaco and averaged 25 days per season (range=2-57) from 2007-14 (Figure 17). From 2002-15, known nest loss to skunk was limited to five plover nests in Oso Flaco, occurring from 2009-11.

Raccoon

Raccoon tracks were documented on 56 days throughout the Southern Exclosure and Oso Flaco. Tracks and scat indicated that raccoons commonly traveled across the exclosure to forage in the intertidal zone on prey that included mole crabs (*Emerita analoga*). Documented raccoon activity averaged 109 days (range=45-145) for 2007-14 (Figure 17). From 2002-15, known nest loss to raccoons was limited to one tern nest in 6 exclosure in 2015 and two plover nests in Oso Flaco, occurring in 2010 and 2011.

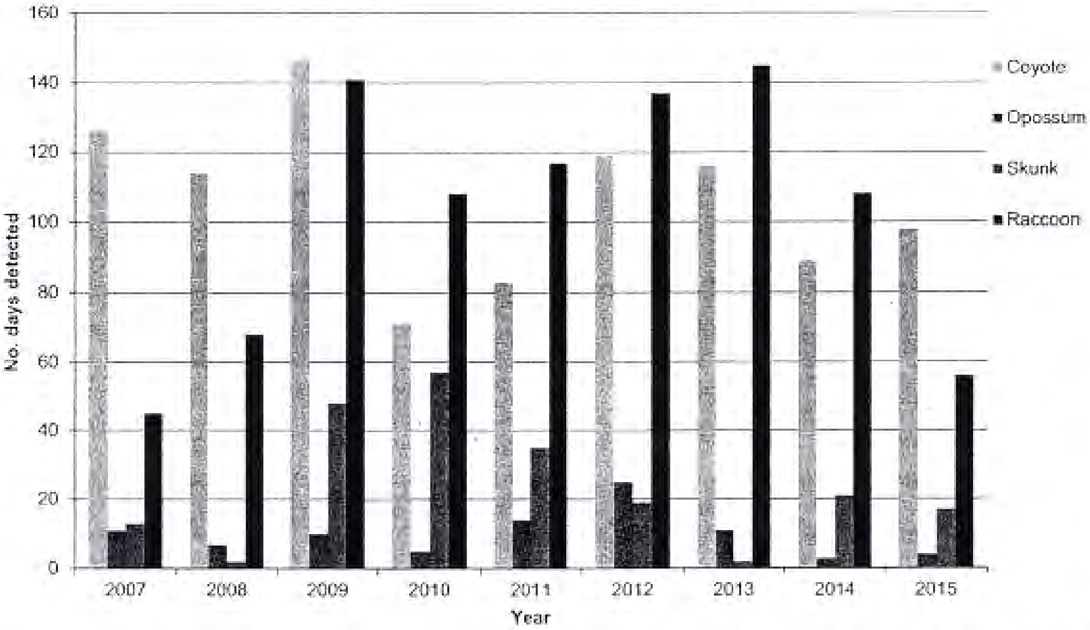


Figure 17. Number of days coyote, opossum, skunk, and raccoon were detected in the Southern Exclosure and Oso Flaco at ODSVRA from 2007-15.

Coyote

Live sightings of coyotes have rarely been documented inside the exclosure or along the shoreline during daytime hours. The lack of diurnal sightings, as well as timing of observed fresh tracks relative to windblown sand and tides, indicate that coyote activity is primarily nocturnal in these areas.

Five coyotes were removed in an effort to reduce the threat of predation and disturbance due to coyote presence documented within sensitive shoreline chick-rearing habitat. This compares to an average of seven removed per year from 2007-14 (range=4-11). As part of monitoring at ODSVRA, coyote scat encountered by monitoring staff and contractors was checked in the field for plastic or aluminum bands used for banding least terns and snowy plovers. No bands were found in coyote scat in 2013-15. Four coyote scats found in 2012 contained a total of 11 bands (representing a minimum of one plover chick, two unknown age plovers, and one unknown age tern) (CDPR 2012, 2013, 2014).

In the combined Southern Exclosure and Oso Flaco areas, coyote presence was recorded on 99 days (this includes 48 days inside the predator fenced portion of the Southern Exclosure and North Oso Flaco). For comparison, coyote presence was documented an average of 104 days (range=71-147) during the previous six-year period from 2009-14. There was a total of 213 recorded coyote occurrences in distinct areas in 2015. This compares to an average of 202 (range=99-307) for the previous six years. One hundred and thirty-six occurrences were recorded on the Southern Exclosure and North Oso Flaco shoreline this season, compared with an average of 112 (range =37-193) for the last six years (Table 12, Appendix F.1). It should be noted that predator tracks are documented opportunistically and counts represent a minimum level of activity. In addition, shoreline accessibility may vary between years making direct comparison difficult.

From 2002-15, documented coyote depredation of nests has been limited to nine plover nests and six tern nests, occurring in 2002 (1 plover, 2 tern), 2003 (1 tern), 2004 (1 plover, 2 tern), 2006 (4 plover), 2007 (1 plover), 2012 (1 plover), 2013 (1 tern), 2014 (1 plover).

Table 12. Coyote occurrence in the Southern Exclosure and Oso Flaco at ODSVRA from 2009-15. Date range is from 1 March to 10 September (a 194-day period).

Year	Inside Southern Exclosure and North Oso Flaco predator fencing	6, 7, 8 exclosure shoreline	North Oso Flaco shoreline	South Oso Flaco	Total no. occurrences (Total no. days detected)
2009	19	99	94	95	307 (147)
2010	5	24	23	47	99 (71)
2011	10	17	20	55	102 (83)
2012	92	100	47	35	274 (119)
2013	49	55	38	60	202 (116)
2014	28	115	38	42	223 (89)
2015	48	104	32	29	213 (99)

Avian Predators

One northern harrier and one peregrine falcon were live-trapped and relocated and one raven was lethally removed. The peregrine falcon was banded and confirmed returning within 98 days on 14 August after being relocated approximately 467 miles to the north on 8 May. The northern harrier was also banded and relocated approximately 295 miles to the north. One raven was lethally removed in response to documented ness loss and frequent sightings of ravens at our site and adjacent sites. Efforts were also made to trap a merlin and red-tailed hawk until concerns of threats diminished. Avian predators perched in sensitive areas within the Southern Exclosure and Oso Flaco were hazed when possible (see Management Actions section for more detail).

Merlin

From 12 March - 8 April, a minimum of two merlins were documented on 16 days (31 sightings) actively hunting shorebirds in the Southern Exclosure and Oso Flaco (Table 13). On several occasions, merlins hunting or perching in the nesting area were hazed by monitors and on 12 March an adult male merlin was observed eating an adult plover banded GG:WW on 7 exclosure shoreline. For five of the eight days from 12 March - 19 March a merlin was sighted flying over and hunting the shoreline of the 6, 7, and 8 exclosures. For four of these five days, an adult male merlin was confirmed. In response, efforts were made to attempt trapping problem merlins. Subsequently, merlin sightings declined in frequency and identifying an individual was difficult. For this reason, and the understanding that merlins began migrating out of the area, trapping attempts were discontinued and replaced with hazing techniques combined with extended monitor coverage on the shoreline. No merlins were seen after 8 April through the end of the season. For the eight-year period from 2007-14, recorded merlin activity averaged six days (range=0-11) with most activity occurring in March and April. During this period merlins were documented taking adult plovers once each year from 2004-06 at ODSVRA, and an adult female merlin was observed eating a small shorebird that may have been a plover in 2011. In 2014, their presence coincided with several plover nests being abandoned pre-term with adult mortality suspected as the cause.

American kestrel

There were 38 documented sightings of American kestrels (*Falco sparverius*) in the Southern Exclosure and Oso Flaco on 18 days. Kestrels were observed perch-hunting primarily in North and South Oso Flaco and perched on 6 and 7 exclosure fences on eight days. On these days kestrels were hazed out of sensitive areas. For the eight-year period from 2007-14, recorded kestrel activity averaged 14 days (range=6-28).

Owl

The majority of owl "sightings" are from detection of tracks with very few visual sightings. The level of owl activity, as evidenced by tracks, is difficult to estimate during daytime monitoring as there is limited entry into the nesting and chick-rearing areas to look for tracks. The tracks may extend only a short distance and can be quickly covered by windblown sand. In addition, accessibility to areas where tracks have often been noted previously (e.g., North Oso Flaco, 8 exclosure, 7.5 revegetation area) may vary between years making direct comparison difficult. Most owl tracks documented at ODSVRA are likely from great horned owls (*Bubo virginianus*) but may also be from barn owls (*Tyto alba*). Burrowing owls (*Athene cunicularia*) have also been seen at ODSVRA in previous years but would not be confused with other species and have typically migrated out of the area before the tern and plover breeding season.

Owl presence was detected on five days with five separate sightings this season occurring in Boneyard and 7 exclosures (Table 13, Figure 18). In the eight-year period from 2007-14, owl activity was documented on an average of 32 days (range=10-53).

Red-tailed hawk

Red-tailed hawks (*Buteo jamaicensis*) were primarily observed perching in the North and South Oso Flaco foredunes and in the 7.5 revegetation area. Red-tailed hawks have not been known to depredate plover or tern nests, chicks, or adults at ODSVRA but are a known predator from observations at other sites and their sustained presence represents a disturbance factor to broods and incubating adults nearby. On several occasions, red-tailed hawks perched in the nesting area were hazed by monitors. Red-tailed hawk presence was documented on 65 days (143 sightings) (Table 13, Figure 18). From 2007-14, activity was recorded on an average of 39 days (range=7-74). Based on concurrent sightings and age, there was a minimum of four individuals (two adults, one juvenile and one immature) observed in or adjacent to the nesting area. One adult identified by plumage characteristics, observed frequently perch hunting within the North and South Oso Flaco foredunes and 7.5 revegetation area, was hazed out of these sensitive areas from 12 April to 22 May. Due to the continued presence of this bird within sensitive areas, trapping efforts were attempted but ceased after sightings became less frequent and priorities switched to monitoring the increased raven activity around 22 May.

Northern harrier

Northern harriers have been documented as nest predators at ODSVRA in past years. In 2015, there were 39 sightings of northern harriers on 26 days. In the eight-year period from 2007-14, activity was recorded on an average of 43 days (range=25-60) (Figure 18, Table 13). Based on age and sex, there was a minimum of three individuals (one adult male, one sub-adult female and one juvenile female) observed during this season. From 14 April to 23 April a sub-adult female harrier was observed almost daily hunting for extended periods of time in 8 exclosure, North Oso Flaco and South Oso Flaco. The bird was also observed consuming a large avian prey item inside 8 exclosure on 22 April. On 23 April, one sub-adult female was trapped at the south end of North Oso Flaco and relocated approximately 295 miles away to Sutter Buttes near Yuba City, north of Sacramento.

Table 13. Sightings of merlin, American kestrel, large owl spp., red-tailed hawk, northern harrier, and peregrine falcon in specific areas of the Southern Exclosure and Oso Flaco at ODSVRA in 2015.

Date range is from 1 March to 10 September (194-day period).

Location	Merlin	American kestrel	Large owl spp.	Red-tailed hawk	Northern harrier	Peregrine falcon	Total
6 exclosure	13	8	0	9	4	41	75
7 exclosure	10	6	2	20	2	31	71
8 exclosure	4	7	0	23	7	28	69
Boneyard exclosure	3	4	3	15	0	15	40
North Oso Flaco	1	5	0	58	10	19	93
South Oso Flaco	0	9	0	18	16	29	72
TOTAL	31	39	5	143	39	163	420

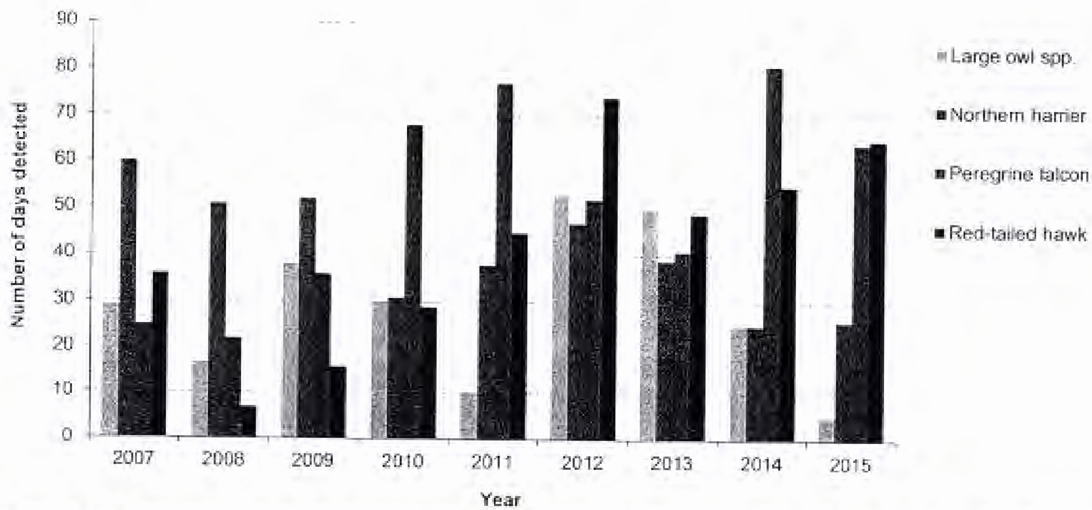


Figure 18. Number of days large owl spp., northern harrier, peregrine falcon and red-tailed hawk were detected in the Southern Exclosure and Oso Flaco at ODSVRA in 2007-15.

Date range is from 1 March to 10 September (194-day period).

Peregrine falcon

On 28 April, a sub-adult male peregrine falcon with plumage characteristics and head markings allowing it to be identified to individual was observed eating an adult plover in 8 exclosure. This peregrine was also observed frequently hunting and catching prey on the shoreline of 6 and 7 exclosures from 3 - 21 April. The falcon was determined to be enough of a threat to the breeding plovers and terns to trap and it was caught on 4 May. On 8 May, the peregrine was banded with a USGS metal band on the right leg and a black visual identification tag (VID) band (50AB) on the left leg before being relocated approximately 467 miles north to the Fort Jones area east of Mount Shasta. On 14 August, this individual was confirmed to have returned to Oceano Dunes SVRA. On 28 August, the "50AB" banded bird caught and ate a banded plover on the 6 exclosure shoreline. The bird was hazed out of the area after eating its prey. Attempts were not made to trap this bird again because the majority of plover and all tern broods had fledged (Appendix G).

Peregrines were commonly observed actively hunting, perching, and consuming prey in the Southern Exclosure and Oso Flaco. Peregrines hunting on the exclosure shoreline, even when not focused on plovers and terns, can cause disturbance that limits foraging time for plover chicks while increasing the risk of broods being separated or moved. Peregrines perched in the nesting area for an extended period of time were hazed by monitors on 24 days in 2015 (sometimes requiring repeated efforts before the bird left the nesting area). Hazing peregrines out of sensitive areas provided a temporary solution but did not appear to deter individual falcons from returning to ODSVRA. In addition to the two documented predation events by the 50AB sub-adult male, one juvenile male peregrine was observed catching and eating a small prey item on 8 exclosure shoreline on 18 August that was later identified as an adult plover based on feather remains collected at the prey site.

In 2015, there were 163 sightings of peregrine falcon on 64 days (Table 13). This represents a 55.0% decrease in sightings from the previous year (362 sightings on 81 days) and an increase of 5.8% above the average of 154 (range=38-362) sightings from 2008-14 (Table 14). The average number of days peregrines were recorded during the period 2008-14 was 54 (range=22-81). There was a minimum of six individual peregrine falcons identified at ODSVRA this season; one adult male, one unbanded adult female, one adult female (VID band "17D"), one sub-adult male (VID band "50AB"), one unbanded immature, and one juvenile. The adult female with VID band "17D" was banded as a nestling in 2013 in southern California and was seen at ODSVRA last year with sub-adult plumage.

Table 14. Sightings of peregrine falcon in specific areas of the Southern Exclosure and Oso Flaco at ODSVRA from 2008-15.

Date range is from 1 March to 10 September (a 194-day period).

Location	2008	2009	2010	2011	2012	2013	2014	2015
6 exclosure	11	13	37	39	41	28	75	41
7 exclosure	11	13	29	45	37	23	85	31
8 exclosure	5	13	25	40	31	19	67	28
Boneyard exclosure	6	6	11	32	9	2	11	15
North Oso Flaco	4	9	24	37	27	14	69	19
South Oso Flaco	1	20	18	12	11	14	55	29
Total no. sightings	38	74	144	205	156	100	362	163
No. days detected	22	36	68	77	52	41	81	64
No. peregrines trapped	0	1	3	0	1	0	1	1

Corvids (American crow and common raven)

American crows (*Corvus brachyrhynchos*) and common ravens are efficient predators at many tern and plover nesting sites and can have pronounced impacts over a short period of time. American crow sightings were limited to two sightings over two days. There were 23 sightings of common raven over six days and ravens were hazed from sensitive areas on two days. Raven sightings were typically of two birds flying together. During the eight-year period 2007-14, crows were seen annually on an average of six days (range=0-10) and ravens on six days (range=2-14) (Table F.1 in Appendix F). In 2015, four plover nests were documented lost to raven on 22 May. Sites within the Guadalupe-Nipomo Dunes complex to the south also experienced raven impacts. The Chevron (Guadalupe Restoration Project) site reported a minimum of eight plover nests documented lost to raven and the Rancho Guadalupe Dunes County Park documented ravens eating newly hatched plover chicks from 18 – 27 May. Ravens were considered to be a serious threat and one raven was lethally removed on 1 June from Rancho Guadalupe Dunes County Park by the ODSVRA USDA Wildlife Services contractor. Raven sightings decreased after this removal and no other losses to raven were identified at ODSVRA and the Chevron site. One raven continued to be seen at Rancho Guadalupe Dunes County Park after 1 June.

Gulls

On 5 June, a first winter western gull repeatedly picked up and dropped a small plover chick before flying with it to the waterline where it dipped the chick in the water. It is suspected that the chick was then eaten by the gull. An agitated adult plover was seen running around the gull and other adult plovers were observed alert and displaying in front of gulls foraging higher on the beach. This event represents a minimum number of one plover chick lost to gulls this season. Additionally, a sub-adult California gull was observed scavenging a likely dead plover chick with green bands near the waterline in the northern section of 6 exclosure shoreline (suspected SP88 chick, attacked by SP32 adult plover earlier this same day and assumed dead). There were no adult plovers observed reacting to this California gull (Notes section, Table G.3 in Appendix G).

Gulls can pose a significant threat to snowy plover breeding success at ODSVRA, especially individual gulls that key in on adults with broods. Such gulls can become "specialists" searching for and preying on chicks over a wide area. Depredation events can happen quickly and easily go undetected. In nine of the 12 years from 2004-15, gulls have been documented taking plover chicks. Between 2011-14 gulls took a minimum of 21 plover chicks, juveniles or adults. In 2011, three gulls took a minimum of six chicks, three juveniles, one juvenile or adult, and five plovers of unknown age over a four-day period from 28 July to 31 July. In 2012, a gull pellet found on 6 exclosure shoreline contained nine bands, representing a minimum of three unknown-age plovers taken by gulls; none of these predation events were observed. In 2013, no plovers were known depredated by gulls. In 2014, two gulls took a minimum of two plover chicks and one juvenile or adult.

Gulls are present year-round at ODSVRA with numbers fluctuating throughout the year. To document seasonal changes as well as long-term trends, daily surveys at specific locations and monthly surveys of the shoreline of the entire park are completed from March through September (see Monitoring and Management Actions section for more detail). In 2015, there was a maximum count of 3,225 on 2 July for the entire park. For the past seven years from 2009 to 2015, counts for the entire park have been much lower in the months from March to May, increasing in June, highest in July and August, and decreasing in six of seven years in September (Figure 19).

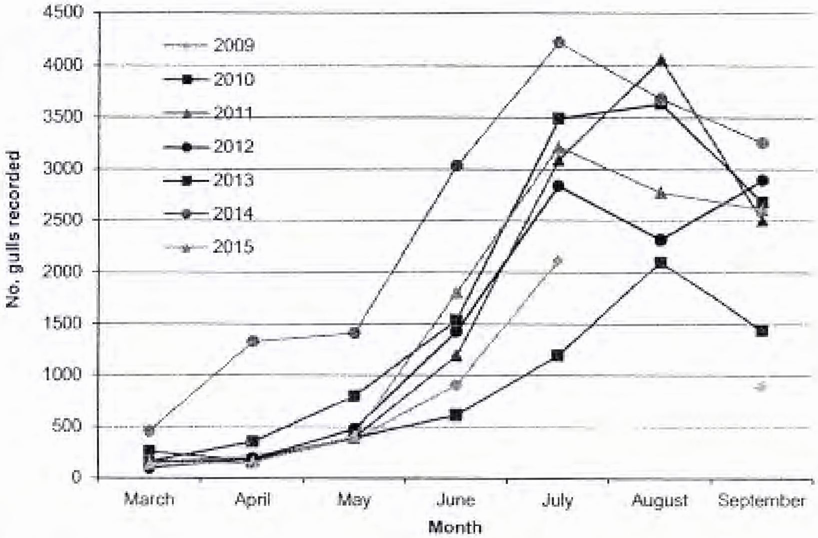


Figure 19. Monthly gull count along entire ODSVRA shoreline for March to September in 2009-15. Information not available for August 2009. Monthly surveys were conducted between 6 am and 1 pm. From 2009 to 2014, average monthly counts were calculated using weekly counts. Weekly survey data were only included if the entire park's shoreline was covered. In 2015, a single survey was conducted each month.

RECOMMENDATIONS

Continue monitoring

Monitoring is critical for effective protection of nesting terns and plovers. As problems and threats arise for adult birds, nests, and chicks, timely information from monitoring can help guide appropriate management actions and evaluate their effectiveness. Monitoring efforts at ODSVRA should have adequate funding, resources, and flexibility to address anticipated problems (e.g., nesting failure, causes of chick loss, predator pressure) as well as unanticipated problems. Specific recommendations for monitoring are the following:

Continue banding least tern and snowy plover chicks

Continue banding least tern and snowy plover chicks to better understand chick behavior and factors promoting or threatening survival of chicks (e.g., feeding rates for tern chicks, foraging activity and movements of plover chicks, age and location of disappearance of different cohorts of chicks). Banding also provides a means to document fledging success. Without this information, the seasonal productivity of terns and plovers at ODSVRA would be unknown and management effectiveness could not be assessed. Additionally, bands provide an opportunity to gain insight into predator impacts on chicks and fledglings. Over time, banding of tern and plover chicks will provide information on natal site fidelity of terns and plovers fledged at ODSVRA, as well as migration to other sites.

Continue banding least tern chicks to individual

Beginning in 2006, least tern chicks were banded to allow individual chicks to be identified. This was done, in part, by placing one or two different colors of tape on the federal band, creating a unique combination for each chick. Banding to individual provides the opportunity to gain additional information that otherwise may not be obtainable, including:

1) providing the most accurate means to count the number of juveniles produced;
2) identifying if different areas within the colony are having different fledging success during a season;
3) identifying if broods hatching more than one chick are fledging more than one chick;
4) tracking individual chick and juvenile movement within the ODSVRA colony;
5) providing information on the length of stay of individual juveniles at the colony site after fledging;
6) tracking recruitment of juveniles into ODSVRA's breeding population; and
7) tracking movement of individuals to other colonies in California.

Banding to individual provides valuable information to assist in developing and assessing site management actions directed toward the recovery of the least tern.

Continue option to band adult snowy plovers

The occurrence of abandoned plover nests can raise concern about possible mortality of adult plovers. If elevated adult mortality rates occur or are suspected, it could prove beneficial to band certain adults. This would allow monitors to verify if mortality was taking place and possibly identify the causes.

Continue to provide adequate-sized bumpouts and single nest exclosures to better protect least tern and snowy plover nests in or close to the open riding area

Least tern and snowy plover nests inside the Southern Exclosure and located close to the north or east fence receive temporary additional fencing to create a buffer from recreational activities in the open riding area. These bumpouts connect to the fence adjacent to the nests and extend into the open riding area. Prior to 2010, only nests found within 75 feet of the Southern Exclosure fence were given a bumpout. Beginning in 2010, nests found within 100 feet of the Southern Exclosure fence bordering the open riding area received bumpouts. Nests inside the exclosure and more than 100 feet from the fence may also receive a bumpout if repeated disturbance from the open riding area is observed. Prior to 2012, nests found in the open riding area initially received an 82-foot-radius circular single nest exclosure as per the previously existing protocol. It is our experience that these earlier identified minimums (75 feet and 82 feet) are not sufficient to adequately reduce disturbance from recreational activity and, in response to birds flushing from their nests, additional fence installation was often necessary to increase the size of the buffer.

In 2015, three least tern nest and six snowy plover nests were given bumpouts to increase the distance from the nest to the open riding area fence to a minimum of 100 feet. All three least tern nests (LT16, LT19, and LT20) hatched a total of four chicks and three chicks fledged. Five of the plover nests (SP8, SP24, SP49, SP75, and SP113) hatched a total of 12 chicks and six chicks fledged. One plover nest (SP59) was abandoned pre-term (see Appendix A and Appendix B).

For 2016, it is recommended to continue to install bumpouts for nests close to the Southern Exclosure fence to create a buffer of at least 100 feet between the nest and the open riding area. Nests in the open riding area should receive a single nest exclosure with a minimum radius of 100 feet. Nests will be monitored closely to assess the adequacy of protective fencing in reducing disturbance. If necessary, bumpouts or single nest exclosures may increase in size if disturbance to incubating birds is observed as a result of recreational activity. ODSVRA will continue to maintain a safe vehicle corridor adjacent to the north and east fence, any bumpouts, and single nest exclosures.

Continue to position a large section of the shoreline exclosure fence further east (inland) to provide a wider functional shoreline habitat

The shoreline west of the exclosure west fence is important snowy plover habitat for rearing chicks. Prior to 2011, the management practice has been to place the west fence as low as possible on the shoreline. This was to maximize the amount of nesting and potential brooding area inside the seasonal fence protected from coyotes. In 2011, two small experimental shoreline fence sections, located in 6 and 7 exclosures, were placed up to 100 feet further to the east and these areas appeared to have a broader and more functional shoreline when evaluated at the end of the season. In 2012-15, the shoreline fence was moved 100 feet east for the southern half of 6 exclosure and for the majority of 7 exclosure (except for the 7.5 revegetation area) (Appendix C). The Southern Exclosure is seasonally open to off-highway vehicles during five months of the year between October and February. As a result of recreational activity during this time, the shoreline of the 6, 7, and 8 exclosures has almost no cover or topographic relief at the beginning of the breeding season and park staff distributes wood and wrack to provide some cover above and below the drift line. The shoreline is further altered with the installation of the west fence as it results in substantial deposition of fine windblown sand on the leeward (east) side of the fence. A fence set low on the shore can result in a very narrow swath of shore with cover (west of the fence) bordered by limited cover over the majority of a strip of habitat (approximately 100 to 180 feet wide) immediately east of the fence, with deposited sand burying existing or introduced cover.

Moving the west fence 100 feet eastward improved shoreline habitat characteristics for chick-rearing by allowing for a wider area of shore with cover and wrack. There was more topography and cover created by increased debris, woodchips, and wrack as well as greater foraging opportunities with the increased area of habitat enhancement. There continued to be broad areas of mobile sand with little cover east of the west fence.

Adjusting the fence eastward allows for the following benefits to the overall management goals for snowy plover productivity:

1) allow access from the shoreline for monitoring staff to maintain a wider swath of shore with habitat enhancement materials (including wrack) throughout the breeding season;
2) reduced chance of high tides and surf washing up and removing a low-set fence and habitat enhancement material;

3) provide better conditions for pioneering plants to grow in a wider area between the high tide line and the west fence (windblown sand deposited leeward of the fence can adversely impact seedling survival);
4) may increase foraging opportunities for plovers;
5) may reduce vulnerability to predators by providing more space and cover for chicks; and
6) may reduce bouts of aggression between adults with broods by decreasing brood density and, therefore, may decrease the chance of chicks becoming separated from their brood or attacked by adults with other broods.

It is recommended for 2016 to repeat the shoreline configuration as was present in 2015, with a large portion of the 6 and 7 exclosure shoreline fence approximately 100 feet to the east of the typical shoreline fence location. The northern section of 6 exclosure would not be moved east to avoid potential impacts to nests on the shoreline from trespassers and to reduce the possibility of pushing nesting activity further to the east side and closer to the riding area in this narrow portion of north 6 exclosure. The shoreline fence should continue to be installed last (after all other fencing is installed) and as close to 1 March as possible to lessen the chance of storm-driven high surf damaging the fence.

Continue to enhance habitat in the Southern Exclosure by distributing natural materials, seed, and plants and increase efficiency with the help of maintenance staff and heavy equipment

Natural materials such as driftwood, woodchips, and wrack (surf-cast kelp) should be distributed in large amounts within the exclosures (including the shoreline) to enhance habitat features. Since 2002, wrack has been gathered by hand and placed in the exclosure. Approximately 180 cubic yards of wrack were distributed on the exclosure shoreline during the 2015 season as habitat enhancement. Greater efficiencies may be possible for this wrack distribution. Since 2008, OSDVRA monitoring staff has received assistance from available heavy equipment operators from park maintenance staff in loading woodchips to be distributed in the exclosure. A method using heavy equipment has not been found to collect and distribute large amounts of wrack from the open riding to the seasonal shoreline exclosure. Attempts in the past resulted in more sand than wrack being collected with the equipment compared to hand collection. In 2016, it is recommended that methods to better use heavy equipment for wrack collection should be further explored. The goal would be to have heavy equipment available throughout the season to assist in loading large piles of wrack collected from the open riding area, to then be placed in the seasonal exclosure to be distributed by permitted staff. This would increase staff efficiency and allow larger amounts of wrack to be dispersed on the shoreline, helping to maintain larger populations of invertebrate prey over a broader area for snowy plover chicks, fledglings, and adults. Broader distribution of wrack also provides shelter from wind and cover from predators. The use of heavy equipment needs to be balanced with other operational needs in the park.

Wrack and woodchip additions could also occur during the winter or prior to 1 March if materials and staff levels allow. Prior to the 2014 season during the winter months, a limited amount of wrack was placed in a few large piles as well as spread thinly in a few areas (600-1,000 square feet). These wrack areas persisted to the end of the season helping to create temporary hummocks within the exclosure and, in most cases, provided a favorable area for plants to grow. Wrack was not dispersed during the winter prior to 2015. As time permits, it is recommended to place large wrack piles in the winter or at the beginning of the season in the area where the seasonal exclosure will be located.

The addition of quick-growing annual dune vegetation should continue to be evaluated as a habitat enhancement option. Planting in early spring, with sufficient late rains, may allow enough time for plant growth to provide topographic features that could benefit plovers and terns. Seeding of areas in the Southern Exclosure with sea rocket, beach bur, and other on-site available seed is recommended as an option in 2016. Planting of sea rocket or other appropriate available container stock (grown on-site) in test plots with areas of added materials (e.g., woody debris, wrack) should also continue to be evaluated in

2016. The seeding and planting would occur as soon as possible after the fence is installed on 1 March. Seeding or planting may be attempted prior to the fence installation in order to take advantage of rain events and moist sand. The goal of this planting is to provide areas of scattered vegetation for cover and to encourage the development of small hummocks.

Continue to study the benefits of wrack addition to the Southern Exclosure shoreline and inoculation with wrack-associated invertebrates as a possible means to restore invertebrate species and biomass (these invertebrates are part of the prey base for snowy plover chicks, juveniles, and adults)

In 2007, a study was initiated by Drs. Jenifer Dugan and Mark Page, researchers from the Marine Science Institute at the University of California Santa Barbara (UCSB), examining the responses of invertebrate numbers and diversity in areas where wrack was added to the Southern Exclosure shoreline throughout the breeding season. Preliminary findings from the five-year study (2007-11) indicated that the seven-month seasonal closure (March-September) is not a sufficient period of time for invertebrates to effectively and naturally recover species diversity and abundance on the Southern Exclosure shoreline following five months of recreational use. In 2012, invertebrate sampling (by Dr. Dugan) was more limited, with one series of transects at the beginning of the season and repeated once at the end of the season. In 2013-15, park staff, following the same methodology, performed one series of invertebrate sampling at the end of the season and a beginning season sampling survey was done in 2015. The survey was comprised of 10 transects in the Southern Exclosure and three transects in North Oso Flaco (as a control). Samples were sent to Dr. Dugan at UCSB for analysis and findings added to the data set.

From 2012-15, park staff has inoculated wrack added to the shoreline with invertebrates following protocols developed by UCSB. If funding levels allow, experimental examination of wrack and invertebrate manipulation on the Southern Exclosure shore should continue in the 2016 season with the goal of identifying potential means to enhance the diversity and abundance of invertebrate species that are natural prey for plovers. Park staff should continue the end of season sampling, add a beginning of season sampling, and should continue to explore further ways to assess shoreline ecosystem health and responses to management actions.

Continue to look for an appropriate design to cover trash dumpsters

The predator management strategy at ODSVRA includes methods to discourage attracting predators to the site. The large trash dumpsters (22 feet long, 20 cubic yard capacity) located near marker post 2 attract a large number of gulls landing on and foraging in the dumpsters. Four to six dumpsters are present during the busy summer months. In 2012, an experimental cover was designed for one dumpster with fence material enclosed in an approximate 12-foot-high metal frame with heavy 7.5-inch-wide plastic strips hanging from the front of the frame. This design was intended to prohibit gulls from landing on the trash, allowed park visitors to easily discard their trash without lifting a lid, and allowed maintenance staff to lift the cover off and compact the trash with heavy equipment which is necessary before the dumpster can be pulled out and replaced each week. The cover was removed after periods of high winds quickly destroyed the plastic strips, making the cover ineffective. A dumpster cover design that could fit the needs of ODSVRA was not discovered and no covers were used in 2013-15. Daily surveys at the dumpster area resulted with the month of June having the highest daily average number of gulls (46) as well as the maximum number of gulls present at one time (392 on 26 June) (see section titled Predators and predator management on page 41 for more details). It is recommended for 2016 to cover the trash dumpsters in the marker post 2 area with lids designed to exclude gulls and meet the needs of the ODSVRA staff and visitors.

Continue to maintain option to salvage and rescue eggs, chicks, juveniles, and adults under very limited circumstances

In some circumstances the abandonment of least tern or snowy plover eggs and chicks can be directly attributed to human disturbance. The option to salvage such eggs and chicks to be raised in captivity by an approved facility and released in the wild is useful. Beginning in 2003, a limited number of abandoned but likely viable snowy plover eggs or chicks from ODSVRA were brought into captivity. Chicks were raised in a manner that they did not imprint on humans and were released into the wild when fledged. All fledglings were color-banded to individual to facilitate collecting information on movements, survival, and future reproductive success. Captive care should only be used selectively and not as a substitute for responding to the primary causes of elevated egg or chick abandonment rates. In 2015 there were no eggs or chicks brought into captive care from ODSVRA.

Ongoing management actions that will continue in 2016

The following are part of our ongoing management actions and monitoring procedures for which a specific recommendation is no longer necessary (see Monitoring and Management Actions section for more detail). Background information and justifications for these management actions have been discussed in detail in previous annual reports.

- Oso Flaco area protection will continue at the same monitoring and management level as set in 2005 (Site Description).
- The Arroyo Grande Creek protected area will be clearly delineated as a closed area around the Arroyo Grande Creek and lagoon by using posts and signs as practiced since 2006 (Site Description).
- Night vision equipment will continue to be used for monitoring the least tern night roost. The equipment has been used for monitoring since 2007.
- Continue monitoring least tern juveniles, night roost, and foraging activity at nearby freshwater lakes.
- Continue use of motion detector cameras for nest monitoring and train and permit additional monitoring staff as needed.
- Continue to use an anemometer with data logger from a wind tower to record daily wind speeds and direction.
- Continue option to use tern chick shelters.
- Continue option to use least tern chick fencing on the east side of the exclosure and a method to maintain the tern chick fencing will continue to be explored.
- Predator monitoring and management actions that have been in place since 2003 and 2004 will continue.
- Continue daily gull surveys as they were done in 2014 (gulls were counted at the trash dumpster area at marker post 2) and the full park monthly surveys will continue as they have been done since 2008.
- The Southern Exclosure protected area will include the use of increased fence height as practiced since 2006 and use of aprons as used since 2007 to improve the effectiveness of the perimeter fence in protecting the breeding terns and plovers.
- The Southern Exclosure and North Oso Flaco shoreline will continue to be protected, this includes maintaining the posts and rope at marker post 6 and Oso Flaco boardwalk intertidal zones to minimize trespass, which has been part of the management actions in these locations since 2008.
- Continue use of 10-foot by 10-foot single nest exclosures with net tops, circular exclosures with net tops, and mini-exclosures as needed to protect nests from avian predators. These small exclosures are not without risks to incubating adults and we will continue to closely monitor and evaluate their use.
- Surveys for plovers will continue during the nonbreeding season. These surveys have been conducted since the winter of 2009-10.
- Continue to document impacts and, when possible, reduce disturbance caused by low-flying aircraft over the Southern Exclosure and Oso Flaco.
- Continue to work to address water quality issues at Oso Flaco Lake.
- Efforts to retain skilled monitors will continue at ODSVRA.

NOTES

Least tern chick in open riding area

On 28 June, one 10-day-old chick of the two-chick LT42 brood moved 10 feet east of 7 exclosure and was picked up and placed back in the exclosure. A monitor was inside the exclosure for banding purposes prior to the chick being seen moving out of the exclosure. This banded chick (B/O:Y/G) was documented to fledge on 9 July.

Snowy plover chicks in open riding area

Nine snowy plover chicks from five different broods were observed in the open riding area. Four broods were observed immediately north of the 6 exclosure shoreline and in all cases but one, staff, contractors, and trespassers were not present in the exclosure prior to or during the time the chicks were in the open riding area and no disturbance factor was apparent. A disturbance caused by a person trespassing on the 6 exclosure shoreline did occur prior to one observation of one chick in the open riding area. The fifth brood observed in the open riding area was west of the Arroyo Grande Creek area. All broods that showed a tendency to move close to or north of marker post 6 were closely monitored for extended periods of time by staff or contractors.

Snowy plover brood near Arroyo Grande Creek

On 2 June, two approximately one-day-old unbanded chicks were found in the open riding area west of the Arroyo Grande Creek area (seasonally closed to public using symbolic fencing), approximately 2.6 miles north of the Southern Exclosure. They were attended by a male banded GG:VG and were likely from an unknown nest located in this area and assigned as SP134. From 2001-2014, there have been six snowy plover nests found near the Arroyo Grande Creek lagoon; three each found during the 2001 and 2010 seasons. During this same period, one plover nest was found in 2003 at Dunes Preserve.

The SP134 brood was continuously monitored on 2 June from 1:15 pm until nightfall and was observed being brooded by the male within the Arroyo Grande Creek closed area. The following morning, at 6:07 am, the SP134 adult and chicks were found in the open riding area west of the Arroyo Grande Creek closed area and the brood was moved south to the Southern Exclosure through a coordinated effort by park staff. Vehicle and pedestrian traffic was controlled from all directions by monitoring staff and park rangers to keep the area around the brood undisturbed. Additional monitors were positioned in vehicles at various distances from the brood to track their movement, and to monitor and flush gulls or other potential predators in the area. Two monitors were on foot northwest and northeast of the brood to slowly and carefully encourage movement of the brood south. The chicks were allowed time to be brooded by the adult and forage as needed and became more mobile as the weather warmed. Both chicks and adult crossed onto the 6 exclosure shoreline by 10:50 am.

The SP134 brood was monitored after entering the exclosure and the chicks were observed being attacked by adult plovers with two different broods located on the northern 6 exclosure shoreline (SP32 and SP86). The chicks were last observed at 11:00 am on 6 exclosure shoreline after being aggressively attacked by the SP86 adult; the chicks were observed to be pecked, picked up, and shaken repeatedly by the adult. The area was searched for an extended period, but the SP134 brood was not relocated on this date or on following days. An adult male banded GG:VG was found with three approximately one-day-old chicks from an unknown nest location (SP216) on 9 July and is possibly the same adult that was associated with the SP134 brood.

Snowy plover chicks moving north of 6 exclosure shoreline

On 29 May, one large banded chick was seen briefly by a monitor in the open riding area approximately 100 feet north of marker post 6. The chick appeared to be close to fledge age, but color band combination was not confirmed. Staff controlled traffic in a large area surrounding the location that the chick was last seen, and the area was carefully scanned using the vehicles as blinds. After no chicks (or adults) were seen in the open riding area for 30 minutes, monitors carefully walked the entire area while other monitors continued to watch from vehicles. No chicks were found in the open riding area after a thorough search. Just prior to the chick sighting in the open riding area, a person on foot was seen trespassing on the 6 exclosure shoreline approximately 1,500 feet south of marker post 6 and was contacted and escorted off the shoreline.

Between 4 to 27 June, banded chicks from SP88 nest were observed on the shoreline in the open riding area just north of 6 exclosure on 10 different days when three to 25 days old. On each occasion chicks involved were directed back into the exclosure and monitored closely. On 5 June, one chick was aggressively attacked by a nearby adult from SP32 brood. The chick was not moving after the attack and assumed dead. Two chicks reached 28 days of age but were obviously smaller in size and less developed than normal 28-day-old chicks/fledglings. The young birds continued to be closely monitored and were observed in the open riding area on four additional occasions from 30 June to 9 July. There were multiple sightings of a banded juvenile from SP88 in other areas of the park away from the 6 exclosure area from 20 July to 2 October. One juvenile was seen in Morro Bay, approximately 22 miles north of park, on 3 September.

On 23 June at 10:22 am, one chick from SP111 nest and two attending adults were observed 50 feet north of marker post 6 and were directed back into the exclosure and monitored for an extended period of time. One chick from this brood was last seen on this same day at 2:32 pm.

Two chicks from SP167 nest were observed in the open riding area on three occasions: 23 July, 3 August, and 7 August when the chicks were 10 to 25 days old. The two chicks were raised near the open riding area and reached 28 days of age on 10 August, but were obviously smaller in size and less developed than normal 28-day-old chicks/fledglings. The brood continued to be closely monitored and one of the young (31 days old but not flight-capable) was in the open riding area on 13 August. Two fledglings were last seen 16 August and one fledgling was last seen on the 6 exclosure shore near the open riding area on 27 August.

Injured least tern sighting

On 22 July, a live unbanded juvenile least tern was observed with a likely broken left wing (wing twisted and outer portion of wing pointed forward) and drooping right wing in 7 exclosure. The tern was monitored for an extended time and did not appear to be flight-capable. The tern was searched for on subsequent days but was not relocated. Although a carcass was not recovered it is assumed that this bird did not survive.

Injured snowy plover sightings

During the 2015 season, there were four adults, four to five juveniles, and three chicks observed with injuries. All but one were observed or found within the seasonal exclosure.

<u>Injured adult sightings</u>

Between 7 to 15 March, an unbanded female snowy plover was observed on three separate occasions limping with a right leg injury. The plover was seen in the open riding area between mid-ramps and marker post 2. The plover was not putting any weight on the leg and the right foot appeared to be swollen with a toe protruding at an odd angle.

On 16 May, the unbanded female snowy plover associated with the SP87 nest was observed within the seasonal exclosure with a right leg injury. It was viewed from a distance using a spotting scope and there appeared to be dried blood on the flank of the right side. The right leg was tucked up into the body feathers and the plover was hopping and standing on the left leg. The plover continued to be seen at the

SP87 nest and the leg condition improved over time. The three eggs were noted to be stained with what was likely dried blood on 25 May and the nest hatched three chicks on 31 May.

An unbanded male plover associated with the SP93 brood was observed south of marker post 6 with a left leg injury. The plover was seen limping on three days from 25 to 27 June. The leg had no visible swelling.

On 4 August, an injured unbanded adult female snowy plover being held by a park visitor was given to a resource staff member near marker post 3. The visitor reported that the bird was found on the shoreline in a roosting position and did not attempt to walk or fly when approached. There were no obvious exterior injuries. The plover was transported to Pacific Wildlife Care in Morro Bay on the same day and was examined by veterinarian Dr. Shannon M. Riggs. Dr. Riggs determined that the bird had sustained trauma to the right side of the head and the right eye. Further examination confirmed that vision to the right eye was significantly impaired to absent and vision was possibly limited in the left eye. The left wing had lost most of its flight feathers, yet appeared otherwise uninjured. The plover was cared for and medically treated at Pacific Wildlife Care for an extended period. Dr. Riggs determined that loss of vision would decrease the bird's ability to survive successfully in the wild and should not be released (medical record attached). The plover was transferred to Monterey Bay Aquarium on 30 September where they will attempt to use it to help foster plover chicks.

Injured juvenile sightings

Between 26 to 31 July, a 35- to 40-day-old unbanded snowy plover fledgling from SP144 nest was observed on 7 exclosure shoreline with an injury to the right leg. The leg hung loosely and was dragged on the sand. On 29 and 30 July, the fledgling was seen in the same shoreline location, hopping exclusively on its left leg, dragging the injured right leg on the ground, and appeared unable to fly. The injured plover was last seen on 31 July.

On 28 and 31 July, a 32- to 35-day-old fledgling snowy plover banded PG:WG from SP158 nest was observed in 8 exclosure with an injury to its right wing and likely not flight-capable. The juvenile was walking and foraging normally, but with its right wing tip drooping to the ground.

On 6 August, an unbanded juvenile snowy plover was observed limping and holding up its right leg on 6 and 7 exclosure shoreline. On 20 August, an unbanded juvenile snowy plover was observed with a moderate limp, possibly to the right leg, on the 8 exclosure shoreline. These two sightings may represent one or two different birds.

On 9 August, a juvenile snowy plover banded PV:YW from SP127 nest was observed foraging with a broken left wing on 8 exclosure shoreline.

Chick injury sightings

On 13 May, a five-day-old snowy plover chick, banded VV:GW from SP31 nest, was observed on 6 exclosure shoreline limping and putting very little weight on the right leg. There was no swelling or other evidence to suggest the bands were involved in the leg injury. The chick was last seen on 14 May with extremely limited mobility.

On 11 and 12 July, a 22- to 23-day old unbanded chick from SP156 brood was observed on 6 exclosure shoreline limping with a right leg injury. The leg hung loosely and the right foot appeared swollen. Subsequently, the chick was not seen with an injury and it fledged on 17 July.

On 22 July, one approximately two-day old chick from an unknown nest (assigned to SP217) had noticeable swelling on right side when observed closely as the brood was banded on the 8 exclosure shoreline. This chick was not banded and appeared and behaved normally when observed with binoculars and scope in field. The chick was last seen with the brood 12 August when approximately 23 days old.

Snowy plover chicks aggressively attacked by adult plovers

Aggression among adults with nests or broods was frequently noted. There were 98 observations of aggressive fighting recorded 1 May to 12 August in the following locations: 6 exclosure (60 observations), 7 exclosure (16 observations), 8 exclosure (14 observations), and North Oso Flaco exclosure (8 observations). The majority of aggression was observed on the shoreline, was usually brief, chicks were not observed to be harmed, and fighting was between the adults. Chicks were noted to be chased, attacked, or pecked at during 17 observations but were not known to be harmed. There were three additional fighting incidents on the 6 exclosure shoreline observed to have severe impacts on chicks, with more details below.

As noted previously, the SP134 two-chick brood that moved onto the exclosure shoreline from the Arroyo Grande Creek area on 3 June was aggressively attacked by adults on the 6 exclosure shoreline. The two chicks were not resighted after the attack or during subsequent monitoring.

On 5 June, one four-day-old GA:VY chick from the three-chick SP88 brood was attacked by nearby SP32 adult on the northern 6 exclosure shoreline. The GA:VY chick was not attended by an adult and the SP32 adult continued to attack the chick for several minutes. The chick was observed motionless and assumed dead after the attack as this brood was only seen with two chicks after the incident. Later in the day and in the same location, a sub-adult California gull was seen picking up and dropping a plover chick, unknown if dead or alive, before carrying it away. The chick was banded but combination not determined (a green band was noted). This may have been the GA:VY chick suspected killed earlier by an adult plover.

On 6 July, an adult male (unknown if banded or unbanded) was observed aggressively attacking two SP152 chicks banded PG:RB near their nest location in 6 exclosure. The chicks were banded at the SP152 nest location approximately three hours prior the observed attack. After attacking the two chicks, the aggressive male incubates the remaining egg at SP152. A female, banded NO:WY, also incubates the egg at SP152. Over the following 75 minutes, the male continued to alternate between the hatching egg at the nest and aggressively attacking the two banded chicks. The male was observed pecking, shaking, picking up and tossing the two chicks. The female was observed fighting with the male on one occasion. Neither of the adults brooded the two chicks during this time. The following morning on 7 July, three chicks (two banded and one unbanded) were near the SP152 nest with the NO:WY female, with one banded chick having limited mobility. This was the last observation of the banded chicks and no male was seen in the area interacting with the chicks or female. On 9 July, one unbanded chick was seen with the banded female on 7 exclosure shoreline. The NO:WY female continued to attend the unbanded chick until it fledged and they were last seen 23 August on 8 exclosure shoreline.

Least tern carcass found

On 21 July, a dead juvenile least tern, banded L:Y/G from LT9, was found in 7 exclosure approximately 50 feet east of the western fence. The carcass was located on a sandy surface among scattered sea rocket plants, positioned with ventral surface of body to the ground with the wings folded. The carcass was not fresh. The body cavity was open and maggots were present. Necropsy results indicated the cause of death was undetermined because the carcass was too decomposed; however, gunshot trauma and other trauma that would have resulted in bone fractures were ruled out as causes of death (see attached necropsy report).

Snowy plover carcasses collected or observed
A total of seven carcasses were collected; one adult, one juvenile, one large chick or young fledgling, and four chicks. Carcass remains were taken to the Santa Barbara Museum of Natural History. In addition, one chick carcass was observed but not recovered due to proximity of young plover broods.

Carcasses of one snowy plover juvenile and one large chick or young fledgling in the riding area
On 7 October at about 9:00 am, park maintenance staff found a dead snowy plover a few feet from the western 8 exclosure fence in the riding area. Maintenance staff were in the process of removing the fence and moved the plover to a location 11 feet west of the fence. The juvenile plover carcass, banded VG:PB from SP36 brood, did not appear to have been driven over, lacked eyes, and was full of maggots, but was otherwise intact. It fledged from ODSVRA on 9 June and was last alive seen on 8 exclosure shoreline 1 October.

On 7 October at 2:25 pm, a dead snowy plover was found by park maintenance staff about three feet west of the 6 exclosure fence line in the riding area. The unbanded large chick or young fledgling plover carcass was not in tire tracks, slightly buried, and very dry and desiccated. The last unbanded chick fledged on 30 August and on 10 September the area was thoroughly walked and the carcass was not found, which indicates it was likely buried and became unburied with recent winds.

Carcasses or remains of one adult and five chicks found within the Southern Exclosure
On 12 September, the intact desiccated carcass of an unbanded adult snowy plover was collected from 7 exclosure.

On 12 June, the carcass of an unbanded chick was observed on 6 exclosure shoreline near two unbanded SP107 chicks and the associated RR:- adult male but could not be recovered due to proximity of young plover broods.

Four additional desiccated carcasses of snowy plover chicks (two banded and two unbanded) were found on 8 and 10 September within the Southern Exclosure. Chick carcasses were collected from the 6 exclosure shoreline (2), 7 exclosure (1), and 8 exclosure shoreline (1). By location of carcasses, these chicks are different than the carcass noted on 12 June on the 6 exclosure shoreline but not collected. See Appendix G for additional details regarding the chick carcasses.

Least tern band found on ground near the nesting exclosure
On 7 July, a single metal band covered in orange tape was found on the sand surface in southwestern Pipeline revegetation area adjacent to 8 exclosure. The aluminum band had been subjected to enough pressure to result in a deformation of the band at the seam (pushed inward). This USGS 1A band numbered 1841-98476 was used at ODSVRA in 2009 on 10 July to band a one-day-old California least tern chick from LT2 nest (located within the predator fencing of 8 exclosure) with the color combination of O:W/B. Both banded chicks hatching from this nest were last seen on 11 July when two days old.

LITERATURE CITED

CDPR. 2014. Nesting of the California least tern and western snowy plover at the Oceano Dunes State Vehicular Recreation Area, San Luis Obispo County, California 2014 Season. Unpublished Report, CDPR, Off-Highway Motor Vehicular Recreation Division.

CDPR. 2013. Nesting of the California least tern and western snowy plover at the Oceano Dunes State Vehicular Recreation Area, San Luis Obispo County, California 2013 Season. Unpublished Report, CDPR, Off-Highway Motor Vehicular Recreation Division.

CDPR. 2012. Nesting of the California least tern and western snowy plover at the Oceano Dunes State Vehicular Recreation Area, San Luis Obispo County, California 2012 Season. Unpublished Report, CDPR, Off-Highway Motor Vehicular Recreation Division.

CDPR. 2011. Nesting of the California least tern and western snowy plover at the Oceano Dunes State Vehicular Recreation Area, San Luis Obispo County, California 2011 Season. Unpublished Report, CDPR, Off-Highway Motor Vehicular Recreation Division.

CDPR. 2010. Nesting of the California least tern and western snowy plover at the Oceano Dunes State Vehicular Recreation Area, San Luis Obispo County, California 2010 Season. Unpublished Report, CDPR, Off-Highway Motor Vehicular Recreation Division.

CDPR. 2009. Nesting of the California least tern and western snowy plover at the Oceano Dunes State Vehicular Recreation Area, San Luis Obispo County, California 2009 Season. Unpublished Report, CDPR, Off-Highway Motor Vehicular Recreation Division.

CDPR. 2008. Nesting of the California least tern and western snowy plover at the Oceano Dunes State Vehicular Recreation Area, San Luis Obispo County, California 2008 Season. Unpublished Report, CDPR, Off-Highway Motor Vehicular Recreation Division.

CDPR. 2007. Nesting of the California least tern and western snowy plover at the Oceano Dunes State Vehicular Recreation Area, San Luis Obispo County, California 2007 Season. Unpublished Report, CDPR, Off-Highway Motor Vehicular Recreation Division.

Frost, N. 2015. California least tern breeding survey, 2014 season. California Department of Fish and Wildlife, Wildlife Branch, Nongame Wildlife Program Report, 2015-01. Sacramento, CA.

Frost, N. 2014. California least tern breeding survey, 2013 season. California Department of Fish and Wildlife, Wildlife Branch, Nongame Wildlife Program Report, 2014-01. Sacramento, CA.

Frost, N. 2013. California least tern breeding survey, 2012 season. California Department of Fish and Wildlife, Wildlife Branch, Nongame Wildlife Program Report, 2013-01. Sacramento, CA.

Marschalek, D.A. 2012. California least tern breeding survey, 2011 season. California Department of Fish and Game. Sacramento, CA.

Marschalek, D.A. 2011. California least tern breeding survey, 2010 season. California Department of Fish and Game. Sacramento, CA.

Marschalek, D.A. 2010. California least tern breeding survey, 2009 season. California Department of Fish and Game. Sacramento, CA.

Marschalek, D.A. 2009. California least tern breeding survey, 2008 season. California Department of Fish and Game. Sacramento, CA.

Marschalek, D.A. 2008. California least tern breeding survey, 2007 season. California Department of Fish and Game. Sacramento, CA.

Marschalek, D.A. 2007. California least tern breeding survey, 2006 season. California Department of Fish and Game. Sacramento, CA.

Massey, B.W. and J.L. Atwood. 1981. Second-wave nesting of the California least tern: age composition and reproductive success. Auk 98:595-605.

Page, G.A., J.S. and J.C. Warriner, and P.W.C. Paton. 1995. Snowy Plover (*Charadrius alexandrinus*). In The Birds of North America, No. 154, (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, PA, and The American Ornithologists' Union, Washington DC.

Thompson, B.C., J.A. Jackson, J. Burger, L.A. Hill, E.M. Kiroch, and J.L. Atwood. 1997. Least Tern (*Sterna antillarum*). In The Birds of North America, No. 290, (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, PA, and The American Ornithologists' Union, Washington, D.C.

USFWS. 2007. Recovery Plan for the Pacific Coast Population of the western Snowy Plover (*Charadrius alexandrinus nivosus*). In two volumes. Sacramento, CA. xiv+751pp.

USFWS. 2006. Five-Year Review Summary and Evaluation for the California Least Tern (*Sterna antillarum browni*). USFWS, Carlsbad, CA. September 2006.

USFWS. 1985. Recovery Plan for the California Least Tern (*Sterna antillarum browni*). USFWS, Portland, OR. 112 pp.

Warriner, J.S., J.C. Warriner, G.W. Page and L.E. Stenzel. 1986. Mating system and reproductive success of a small population of polygamous snowy plovers. Wilson Bulletin 98(1):15-37.

APPENDICES

Appendix A. California least tern nests at ODSVRA in 2015.

Least tern chicks were banded with yellow over green vinyl tape on a size 1A blank aluminum band on the right leg and a size 1A numbered aluminum federal band on the left. Color tape was placed on the federal band to create combinations unique to individual. (For a description of color band letter codes see Appendix B.) Chicks were weighed immediately prior to banding, typically at one to three days old. Fifteen chicks from ten hatching nests were not banded. A total of 12 unbanded fledglings were seen concurrently in 6 and 7 exclosures on 15 July. Information on adult pair is provided where known. Sex of adults is typically not known. Contents of several non-hatching eggs were examined post-season at the Santa Barbara Museum of Natural History.

Location: 6 = 6 exclosure, 7 = 7 exclosure, 8 = 8 exclosure

U = unbanded

unk = unknown

Nest	Location	Adult pair	Estimated initiation date	Nest fate	Estimated fate date	No. eggs	No. chicks (No. fledge)	Chick band combination (chick weight in grams)	Confirmed fledged	Notes
1	6	-:W/A W/B:(?)	19 May	Hatch	12 Jun	2	2 (2)	Y/W:Y/G (6.7) W/G:Y/G (6.5)	Y/W:Y/G W/G:Y/G	
2	6		19 May	Hatch	10 Jun	3	3 (3)	W:Y/G (5.4) K:Y/G (5.3) A/W:Y/G (5.5)	W:Y/G K:Y/G A/W:Y/G	
3	6		18 May	Hatch	10 Jun	2	2 (2)	A:Y/G (6.1) O:Y/G (6.6)	A:Y/G O:Y/G	
4	6	W:- female U male	20 May	Hatch	12 Jun	2	2 (1)	B/W:Y/G (7.0) R/W:Y/G (6.5)	B/W:Y/G	
5	6	U Banded	23 May	Hatch	13 Jun	2	1 (1)	W/A:Y/G (7.6)	W/A:Y/G	Unknown fate for second egg.
6	6	-:G/O S:-	21 May	Hatch	11 Jun	2	2 (2)	G/W:Y/G (7.8) O/W:Y/G (6.9)	G/W:Y/G O/W:Y/G	
7	6	-:G/B	19 May	Hatch	9 Jun	2	2 (0)	Y:Y/G (7.1) G:Y/G (7.2)		Both chicks last seen at one day old on 10 June.
8	6		20 May	Hatch	10 Jun	2	2 (2)	N:Y/G (5.8) R:Y/G (5.7)	N:Y/G R:Y/G	
9	6		20 May	Hatch	10 Jun	2	2 (2)	L:Y/G (6.9) B:Y/G (6.3)	L:Y/G B:Y/G	On 21 July, the carcass of the fledgling-size L:Y/G tern was recovered in 7 exclosure. This bird was last seen when banded on 10 June at nest. (see Necropsy report)
10	6	U	21 May	Hatch	11 Jun	2	2 (2)	P:Y/G (6.9) V:Y/G (5.9)	P:Y/G V:Y/G	

Nest	Location	Adult pair	Estimated initiation date	Nest fate	Estimated fate date	No. eggs	No. chicks (No. fledge)	Chick band combination (chick weight in grams)	Confirmed fledged	Notes
11	7		23 May	Failed, unknown cause	1 Jun	2	0			Nest found at two eggs on 24 May and seen incubating from 24 May through 31 May. Nest not incubated after 31 May and no eggs were found post-season. Nest was in a location where it would not have been incubated without detection for a long enough period to suspect hatch.
12	6		20 May	Failed, unknown cause	24 May	1	0			Nest incubated on 20 May and 23 May. Unable to confirm incubation 24 May through 27 May and no eggs were found at nest on 27 May. Nest was in a location where it would not have been incubated without detection for a long enough period to suspect hatch.
13	6	W/(B?):W/A	20 May	Hatch	13 Jun	1	1 (unk)	U		One unbanded chick last seen on 16 June at three days old.
14	6		20 May	Hatch	13 Jun	2	2 (unk)	U U		Two unbanded chicks suspected to be this brood were last seen on 24 June at 11 days old.
15	6		19 May	Hatch	13 Jun	2	2 (unk)	U U		Two unbanded chicks last seen on 15 June at two days old.
16	6	U Banded	24 May	Hatch	15 Jun	2	1 (unk)	U		On 25 May, nest found at two eggs located 90 feet west of east fence and received a bumpout on 26 May to increase distance of nest from open riding area to over 100 feet. One chick and one egg last seen at nest site on 15 June at hatch. On 16 June raccoon tracks at nest site and nest bowl empty.
17	7	B:W/B -:S	24 May	Hatch	17 Jun	2	2 (2)	Y/G:Y/G (5.1) A/O:Y/G (5.9)	Y/G:Y/G A/O:Y/G	
18	6		28 May	Hatch	22 Jun	1	1 (1)	A/R:Y/G (5.9)	A/R:Y/G	
19	6	U	25 May	Hatch	16 Jun	2	2 (2)	G/Y:Y/G (6.8) R/Y:Y/G (6.0)	G/Y:Y/G R/Y:Y/G	On 26 May, nest found at two eggs located 68 feet west of east fence and received a bumpout on 27 May to increase distance of nest from open riding area to over 100 feet.

Appendix A. California least tern nests at ODSVRA in 2015 (continued).

Nest	Location	Adult pair	Estimated initiation date	Nest fate	Estimated fate date	No. eggs	No. chicks (No. fledge)	Chick band combination (chick weight in grams)	Confirmed fledged	Notes
20	6	U Y/O:W/B	25 May	Hatch	15 Jun	2	1 (1)	W/B:Y/G (7.3)	W/B:Y/G	On 26 May, nest found at two eggs located 35 feet west of east fence and received a bumpout on 27 May to increase distance of nest from open riding area to over 100 feet. On 2 September, one cracked egg was collected at nest site. Egg contents revealed no sign of fertilization.
21	6	V:B/W U	24 May	Hatch	14 Jun	2	2 (2)	W/O:Y/G (9.1) B/Y:Y/G (6.7)	W/O:Y/G B/Y:Y/G	
22	7	U	27 May	Hatch	17 Jun	2	2 (1)	Y/B:Y/G (5.7) Y/R:Y/G (6.5)	Y/R:Y/G	Y/B:Y/G chick last seen on 26 June at 9 days old.
23	7		27 May	Hatch	17 Jun	2	2 (2)	Y/A:Y/G (6.1) Y/O:Y/G (6.3)	Y/A:Y/G Y/O:Y/G	
24	7		28 May	Hatch	18 Jun	1	1 (1)	O/G:Y/G (7.5)	O/G:Y/G	
25	7	B/W:(A/G)?	29 May	Abandoned post-term	26 Jul	1	0			Nest observed incubated for 58 days from 29 May to 25 July. On 1 August, one egg in shallow nest bowl and faint tracks. Egg collected 2 September. Contents examined and a dead, desiccated embryo found inside.
26	7		25 May	Hatch	15 Jun	2	2 (2)	W/R:Y/G (6.5) W/Y:Y/G (7.1)	W/R:Y/G W/Y:Y/G	
27	6	O:B/W	21 May	Hatch	17 Jun	2	2 (2)	A/Y:Y/G (5.0) O/Y:Y/G (5.3)	A/Y:Y/G O/Y:Y/G	
28	6		29 May	Hatch	20 Jun	2	2 (2)	B/A:Y/G (7.5) R/A:Y/G (8.4)	B/A:Y/G R/A:Y/G	
29	6		29 May	Hatch	19 Jun	2	2 (2)	B/R:Y/G (5.7) R/B:Y/G (7.1)	B/R:Y/G R/B:Y/G	
30	6	B/W:G/W	25 May	Hatch	18 Jun	2	2 (unk)	U U		Two unbanded chicks last seen near nest on 21 June at two to three days old.

Appendix A. California least tern nests at ODSVRA in 2015 (continued).

Nest	Location	Adult pair	Estimated initiation date	Nest fate	Estimated fate date	No. eggs	No. chicks (No. fledge)	Chick band combination (chick weight in grams)	Confirmed fledged	Notes
31	7	U	20 May	Hatch	13 Jun	1	1 (unk)	U		One unbanded chick last seen at nest on 14 June at one day old.
32	6		25 May	Hatch	15 Jun	2	2 (unk)	U U		Two unbanded chicks last seen on 18 June at three days old.
33	6		29 May	Hatch	20 Jun	2	2 (2)	R/G:Y/G (5.9) G/B:Y/G (5.6)	R/G:Y/G G/B:Y/G	
34	6	W/B:Y/R U	30 May	Hatch	20 Jun	2	2 (2)	B/G:Y/G (6.5) G/R:Y/G (5.9)	B/G:Y/G G/R:Y/G	
35	6		27 May	Hatch	18 Jun	2	2 (2)	G/O:Y/G (6.0) O/A:Y/G (5.3)	G/O:Y/G O/A:Y/G	
36	7		29 May	Hatch	19 Jun	2	2 (2)	O/B:Y/G (5.7) O/R:Y/G (7.1)	O/B:Y/G O/R:Y/G	On 20 June, O/R:Y/G chick was found outside nest bowl lying on back and only making small uncoordinated movements. This chick was banded, warmed in hand, replaced in nest bowl, and did fledge.
37	6	B/W:B/Y	31 May	Hatch	21 Jun	2	2 (2)	G/A:Y/G (5.7) A/B:Y/G (6.3)	G/A:Y/G A/B:Y/G	
38	6		26 May	Hatch	16 Jun	1	1 (unk)	U		One unbanded chick last seen on 16 June at hatch.
39	6	U	31 May	Hatch	21 Jun	2	2 (1)	A/G:Y/G (6.1) W/R/W:Y/G (4.8)	W/R/W:Y/G	A/G:Y/G chick last seen on 23 June at two days old.
40	6	U	4 Jun	Hatch	30 Jun	2	1 (1)	W/B/W:Y/G (7.8)	W/B/W:Y/G	On 2 July, one LT40 chick and two LT41 chicks brooded by adult at LT41 nest, located 31 feet away from LT40 nest. Unknown fate for second egg.
41	6		4 Jun	Hatch	1 Jul	2	2 (1)	Y/B/Y:Y/G (4.9) Y/R/Y:Y/G (5.0)	Y/B/Y:Y/G	On 2 July, adult broods two LT41 chicks and one LT40 chick. Y/R/Y:Y/G chick was last seen when banded on 2 July at one day old.
42	7	U	28 May	Hatch	18 Jun	2	2 (1)	B/O:Y/G (6.3) R/O:Y/G (5.4)	B/O:Y/G	On 28 June, B/O:Y/G chick (10 days old) crossed east fence and crouched ten feet east of east fence in the open riding area and was placed back into the exclosure. This chick fledged on 9 July. R/O:Y/G chick was last seen when banded at hatch on 18 June.

Appendix A. California least tern nests at ODSVRA in 2015 (continued).

Nest	Location	Adult pair	Estimated initiation date	Nest fate	Estimated fate date	No. eggs	No. chicks (No. fledge)	Chick band combination (chick weight in grams)	Confirmed fledged	Notes
43	6	Banded	7 Jun	Depredated, raccoon	12 Jun	2	0			Nest depredated by raccoon.
44	7	U female Y/W:B/W male	7 Jun	Hatch	29 Jun	2	2 (2)	B/W/B:Y/G (5.2) R/W/R:Y/G (5.2)	B/W/B:Y/G R/W/R:Y/G	
45	6		28 May	Hatch	18 Jun	2	2 (unk)	U U		Two unbanded chicks last seen on 18 June at hatch.
46	6		25 May	Hatch	15 Jun	1	1 (unk)	U		One unbanded chick last seen on 16 June at one day old.
47	6	U (-:A/B)?	20 Jun	Hatch	11 Jul	2	1 (1)	O/B/O:Y/G (7.9)	O/B/O:Y/G	Unknown fate for second egg.
48	8		21 Jun	Hatch	12 Jul	2	2 (0)	A/B/A:Y/G (5.8) A/R/A:Y/G (5.3)		Both chicks last seen when banded on 13 July at one day old.
49	7	U	29 Jun	Hatch	20 Jul	2	2 (1)	R/Y/R:Y/G (10+) B/O/B:Y/G (9.1)	R/Y/R:Y/G	B/O/B:Y/G chick last seen when banded on 26 July at five days old.
50	7	U G/Y:B/W	29 Jun	Hatch	20 Jul	2	2 (1)	A/W/A:Y/G (5.3) B/R/B:Y/G (5.1)	A/W/A:Y/G	B/R/B:Y/G chick last seen when banded at hatch on 20 July.
51	6	Banded U	4 Jul	Hatch	25 Jul	1	1 (1)	L:Y/G (5.0)	L:Y/G	This chick was banded L:Y/G after the carcass of a fledgling from LT9, also banded L:Y/G, was found on 21 July.
52	7	B:-	12 Jul	Abandoned pre-term	31 Jul	1	0			Nest was observed incubating for 19 days from 12 July to 30 July. One egg was collected 4 August and an approximately 2.5-week-old dead embryo was found inside.
53	7		30 Jun	Hatch	21 Jul	1	1 (0)	O/Y/O:Y/G (5.4)		O/Y/O:Y/G chick last seen on 4 August at 14 days old.
54	6		Unknown	Abandoned, unknown if pre- or post-term	Unknown	2	0			Two eggs found post-season on 10 September. Egg contents revealed no sign of fertilization.

Appendix B. Snowy plover nests at ODSVRA in 2015.

Plover chicks were banded to brood. Split hatch noted for nests with eggs known to hatch on more than one day. Contents of several non-hatching eggs were examined for fertilization post-season at the Santa Barbara Museum of Natural History.

In reading the codes of color-banded birds the left leg is shown first and separated by a colon from the right leg. If two bands are on a single leg the upper band is shown first. A single band with two colors (bicolor band) has colors separated by a diagonal slash. Colors for letter codes: A = aqua (light blue), B = dark blue, G = dark green, L = lime (light green), K = black, N = brown, O = orange, P = pink, R = red, S = silver (bare metal federal band), V = violet, W= white, Y = yellow.

Location: 6 = 6 exclosure, 7 = 7 exclosure, 8 = 8 exclosure, BY = Boneyard exclosure, NOF = North Oso Flaco, SOF = South Oso Flaco

Adult pair: M = male, F = female, U = unbanded

Nest protection type: see Management Actions for description of seasonal exclosure, symbolic fence, bumpout; 10'x10', circular, and mini-exclosures.

na = estimated date not available due to insufficient information

* Nests marked with an asterisk have more detailed information included in the report Notes section.

Nest	Location	Adult Pair	Est. Initiation Date	Nest Fate	Fate date (est.)	No. known eggs	No. chicks (No. fledged)	No. chicks banded and combination	Nest Protection Type	Notes
1	7	F=U M=R-:W/B/W	20-Mar	Hatch	28-Apr	3	3 (0)	3 PG:BG	Seasonal exclosure	
2	6	F=U M=BB:YY	18-Mar	Hatch	20-Apr	3	1 (1)	1 PG:RW	Seasonal exclosure	Two eggs (without cracks) abandoned post-term.
3	7	F=NB:OW M=U	21-Mar	Hatch	22-Apr	3	2 (1)	2 VV:OY	Seasonal exclosure	One egg (without cracks) abandoned post-term.
4	SOF	F=RR:OY M=U	17-Mar	Hatch	19-Apr	3	3 (1)	3 PV:OW	Symbolic fence	
5	7	F=U M=	27-Mar	Hatch	1-May	3	3 (0)	3 unbanded	Seasonal exclosure	Split hatch. On 1 and 2 May, female inconsistently incubating and brooding at nest. Chicks not seen after hatch.
6	8	F=VV:VW M=GG:YG	27-Mar	Hatch	5-May	3	3 (1)	3 BB:BG	Seasonal exclosure	
7	7	F=U M=	29-Mar	Abandoned pre-term	25-Apr	3	0 (0)		Symbolic fence	
8	6	F=VV:VG M=PV:BR	31-Mar	Hatch	7-May	3	3 (0)	3 VO:BB	Bumpout Seasonal exclosure	
9	6	F=U M=U	31-Mar	Hatch	5-May	3	3 (2)	3 VG:VB	Seasonal exclosure	Split hatch.
10	6	F=U M=banded	19-Mar	Hatch	21-Apr	3	3 (0)	3 PG:WR	Seasonal exclosure	
11	8	F=GA:BW M=VG:WB	30-Mar	Hatch	2-May	3	1 (1)	1 PG:GW	Seasonal exclosure	Two eggs (without cracks) abandoned post-term. No sign of fertilization when egg contents examined.
12	7	F=U M=U?	31-Mar	Hatch	3-May	3	3 (0)	3 BB:AB	Seasonal exclosure	
13	8	F= M=GA:YW	27-Mar	Hatch	29-Apr	3	3 (0)	3 PV:GB	Seasonal exclosure	
14	8	F=U M=U	1-Apr	Hatch	4-May	3	2 (1)	2 BB:YR	Seasonal exclosure	One egg (without cracks) abandoned post-term. No sign of fertilization when egg contents examined.

Appendix B. Snowy plover nests at ODSVRA in 2015 (continued).

Nest	Location	Adult Pair	Est. Initiation Date	Nest Fate	Fate date (est.)	No. known eggs	No. chicks (No. fledged)	No. chicks banded and combination	Nest Protection Type	Notes
15	7	F=banded M=banded	na	Abandoned, unknown if pre- or post-term	7-Apr	3	0 (0)		Symbolic fence	
16	6	F=U M=GA:GY	7-Apr	Hatch	9-May	3	3 (3)	3 BB:OW	Seasonal exclosure	
17	6	F= M=VV:VB	5-Apr	Hatch	12-May	2	1 (1)	1 BB:OG	Seasonal exclosure	One egg (without cracks) abandoned post-term. No sign of fertilization when egg contents examined.
18	8	F=U M=GG:RW?	5-Apr	Hatch	8-May	3	2 (0)	1 VG:OW 1 unbanded	Seasonal exclosure	Split hatch. One egg (without cracks) abandoned post-term. Approximately one-week-old dead embryo in egg when contents examined.
19	8	F= M=U	28-Mar	Abandoned pre-term	26-Apr	3	0 (0)		Seasonal exclosure	
20	6	F=VG:OG M=	8-Apr	Hatch	14-May	3	3 (3)	3 GG:AB	Seasonal exclosure	
21	6	F=U M=U	4-Apr	Hatch	7-May	3	3 (1)	3 VV:BR	Seasonal exclosure	
22	6	F=V-:VW M=V-:AY	28-Mar	Hatch	30-Apr	3	3 (0)	3 BB:GB	Seasonal exclosure	
23	7	F=U? M=BB:YW	31-Mar	Hatch	3-May	3	2 (0)	2 PV:OG	Seasonal exclosure	One egg abandoned post-term.
24	6	F=VV:AA M=U	5-Apr	Hatch	10-May	3	2 (1)	2 PG:OG	Bumpout Seasonal exclosure	One egg (without cracks) abandoned post-term.
25	7	F= M=	na	Abandoned pre-term	na	2	0 (0)		Seasonal exclosure	
26	8	F=U? M=GG:PB	26-Mar	Hatch	28-Apr	3	3 (0)	3 BB:PY	Seasonal exclosure	
27	7	F=BG:GW M=U	28-Mar	Hatch	30-Apr	3	3 (0)	3 BB:AW	Seasonal exclosure	
28	7	F=BB:RW? M=U	7-Apr	Hatch	10-May	3	3 (0)	3 VV:OW	Seasonal exclosure	Split hatch.
29	8	F=U M=U	1-Apr	Hatch	4-May	3	1 (0)	1 PG:WB	Seasonal exclosure	Two eggs (without cracks) abandoned post-term.
30	7	F=GA:YG M=U	10-Apr	Hatch	13-May	3	3 (3)	3 VV:BW	Seasonal exclosure	
31*	6	F=U M=U	5-Apr	Hatch	8-May	3	3 (0)	3 VV:GW	Seasonal exclosure	Split hatch. On 13 May, one chick with severe limp and on 14 May, chick with limited mobility and was not seen subsequently.
32	6	F=RR:PB M=BB:BY	6-Apr	Hatch	9-May	2	2 (1)	2 PV:RY	Seasonal exclosure	
33	6	F=GG:BY M=VG:OB	7-Apr	Hatch	10-May	3	3 (3)	3 PV:PB	Seasonal exclosure	

Appendix B. Snowy plover nests at ODSVRA in 2015 (continued).

Nest	Location	Adult Pair	Est. Initiation Date	Nest Fate	Fate date (est.)	No. known eggs	No. chicks (No. fledged)	No. chicks banded and combination	Nest Protection Type	Notes
34	BY	F=NB:PG M=RR:OR	na	Depredated avian	9-May	3	0 (0)		Seasonal exclosure	All three eggs depredated by unidentified avian predator.
35	6	F=PV:WB M=GG:PW	12-Apr	Hatch	17-May	3	3 (0)	3 GG:PG	Seasonal exclosure	
36*	6	F=VV:BG M=U	7-Apr	Hatch	10-May	3	3 (1)	3 VG:PB	Seasonal exclosure	On 7 October, the intact carcass of a VG:PB fledgling was collected from 8 exclosure shoreline. Fledgling last seen alive on 1 October.
37	7	F=banded M=(GA:?V)?	7-Apr	Hatch	10-May	3	3 (0)	3 PV:AW	Symbolic fence	
38	8	F=VV:WY M=U	15-Apr	Hatch	18-May	3	3 (1)	3 GA:GW	Seasonal exclosure	
39	7	F=PV:VY M=GG:AY	15-Apr	Hatch	20-May	3	3 (1)	3 PG:WW	Symbolic fence	
40	7	F=PV:VG M=U	15-Apr	Hatch	18-May	3	3 (1)	3 BB:YG	Symbolic fence	
41	6	F=U M=	11-Apr	Hatch	14-May	3	3 (1)	3 PV:OB	Seasonal exclosure	On 10 September, the intact desiccated carcass of a small PV:OB chick was collected from 6 exclosure shoreline. The three chicks from this brood were last seen alive together on 15 May when one day old.
42	8	F=U M=U	3-Apr	Hatch	6-May	3	3 (0)	3 GA:BR	Seasonal exclosure	
43	NOF	F= M=BB:PB	10-Apr	Hatch	13-May	3	3 (0)	2 GA:YY 1 unbanded	Symbolic fence	One of the three chicks not banded and last seen with brood 17 May at four days old.
44	6	F= M=U	13-Apr	Hatch	17-May	3	2 (1)	2 GG:VG	Seasonal exclosure	One egg (without cracks) abandoned post-term. No sign of fertilization when egg contents examined.
45	6	F=BB:YW M=GG:RW	17-Apr	Hatch	22-May	3	3 (2)	3 PV:GG	Seasonal exclosure	
46	7	F=GG:YG M=U	9-Apr	Hatch	12-May	3	3 (2)	3 GA:AB	Seasonal exclosure	
47	7	F=U M=U	10-Apr	Hatch	13-May	3	2 (1)	2 GG:GY	Seasonal exclosure	One egg (without cracks) abandoned post-term.
48	SOF	F=U M=U	11-Apr	Hatch	14-May	3	2 (0)	2 GA:WG	Symbolic fence	One egg unknown fate.
49	7	F=U M=U	18-Apr	Hatch	19-May	3	3 (2)	3 VW:BB	Bumpout Seasonal exclosure	
50	NOF	F=U M=GG:AG	17-Apr	Depredated	20-May	3	0 (0)		Symbolic fence	All three eggs depredated by unknown species.

Appendix B. Snowy plover nests at ODSVRA in 2015 (continued).

Nest	Location	Adult Pair	Est. Initiation Date	Nest Fate	Fate date (est.)	No. known eggs	No. chicks (No. fledged)	No. chicks banded and combination	Nest Protection Type	Notes
51	6	F= M=banded	17-Apr	Abandoned pre-term	7-May	3	0 (0)		Seasonal exclosure	On 28 and 29 April, nest inconsistently incubated. On 30 April, camera installed. Camera confirmed female not incubating nest after 30 April. Adult female mortality suspected.
52	7	F=NO:AG M=U	19-Apr	Hatch	24-May	3	3 (3)	3 unbanded	Symbolic fence	Chicks not banded to avoid disturbing nearby young snowy plover broods.
53	7	F=U M=U	18-Apr	Hatch	19-May	3	3 (2)	3 GA:VW	Seasonal exclosure	
54	SOF	F=GA:YR M=BB:GR	18-Apr	Hatch	20-May	3	3 (1)	3 VV:OG	Symbolic fence	On 22 April, symbolic fence moved west to decrease possible pedestrian disturbance.
55	7	F=U M=U	16-Apr	Hatch	19-May	3	3 (1)	3 BB:YB	Seasonal exclosure	
56	7	F= M=	20-Apr	Abandoned, suspected wind	27-Apr	3	0 (0)		Seasonal exclosure	Three eggs buried during period of high winds. No sign of fertilization when egg contents examined.
57	8	F= M=GA:OW	22-Apr	Failed, unknown cause	9-May	3	0 (0)		Symbolic fence	
58	BY	F= M=	22-Apr	Depredated avian	12-May	3	0 (0)		Seasonal exclosure	Three eggs depredated by unknown avian predator.
59	8	F=U M=U	15-Apr	Abandoned pre-term	15-May	3	0 (0)		Bumpout Seasonal exclosure	On 13 May, one egg incubated in nest bowl and two eggs well buried four feet west of nest. Of the two buried eggs, one broke open while digging and was removed and one with existing small (3 cm) hole placed in nest bowl. On 15 May, one egg missing pre-term. Approximately one-week-old dead embryo in remaining egg found when contents examined.
60	6	F=U M=BB:WB	20-Apr	Hatch	23-May	3	2 (1)	2 GG:OW	Seasonal exclosure	One egg (without cracks) abandoned post-term.
61	6	F=U M=RR:OG	20-Apr	Hatch	23-May	3	2 (2)	2 BB:RB	Seasonal exclosure	One egg (without cracks) abandoned post-term.
62	6	F=U M=U	18-Apr	Hatch	21-May	3	3 (3)	2 GA:OG 1 unbanded	Seasonal exclosure	Split hatch.
63	6	F= M=	21-Apr	Abandoned pre-term	17-May	3	0 (0)		Seasonal exclosure	
64	6	F=U M=U	17-Apr	Hatch	20-May	3	3 (2)	3 GG:WG	Seasonal exclosure	
65	8	F= M=PV:YB	18-Apr	Hatch	21-May	3	3 (0)	3 PV:WG	Seasonal exclosure	

Appendix B. Snowy plover nests at ODSVRA in 2015 (continued).

Nest	Location	Adult Pair	Est. Initiation Date	Nest Fate	Fate date (est.)	No. known eggs	No. chicks (No. fledged)	No. chicks banded and combination	Nest Protection Type	Notes
66	6	F=PV:GG M=U	21-Apr	Hatch	27-May	3	2 (2)	2 GG:GW	Seasonal exclosure	On 22 May, one egg missing pre-term.
67	8	F= M=U	15-Apr	Hatch	18-May	3	3 (2)	3 PV:PG	Seasonal exclosure	
68	SOF	F=PG:AG M=U	21-Apr	Hatch	22-May	3	1 (0)	1 GG:WR	Symbolic fence	One egg abandoned post-term and one egg unknown fate. Chick last seen on 26 May, moving south toward Guadalupe-Nipomo Dunes NWR.
69	6	F=U M=	24-Apr	Abandoned pre-term	22-May	3	0 (0)		Seasonal exclosure	On 22 May, one egg missing pre-term.
70	6	F=NO:GB M=GG:BR	17-Apr	Hatch	20-May	3	3 (3)	3 VV:OB	Seasonal exclosure	
71	6	F=U M=U	19-Apr	Hatch	22-May	3	3 (2)	3 PV:BB	Seasonal exclosure	
72	7	F=U M=VO:BW	22-Apr	Hatch	25-May	3	3 (1)	2 PG:VB 1 unbanded	Seasonal exclosure	Unbanded chick last seen with brood 27 May when two days old.
73	8	F= M=	26-Apr	Abandoned pre-term	2-May	3	0 (0)		Seasonal exclosure	
74	7	F=NY:RB M=NO:GB	21-Apr	Hatch	24-May	3	3 (3)	3 GA:AR	Seasonal exclosure	
75	6	F=PG:GG M=RR:YY	23-Apr	Hatch	25-May	3	2 (1)	2 VG:OB	Bumpout Seasonal exclosure	Split hatch. One egg (with cracks) abandoned post-term.
76	BY	F=U M=	17-Apr	Hatch	20-May	3	3 (0)	3 BB:AY	Seasonal exclosure	
77	6	F=OY:RB M=U	22-Apr	Hatch	28-May	3	2 (0)	2 unbanded	Seasonal exclosure	One egg unknown fate. Chicks not banded to avoid disturbing nearby young snowy plover broods.
78	7	F=U M=U	24-Apr	Hatch	26-May	3	3 (3)	3 unbanded	Symbolic fence	Chicks not banded to avoid disturbing nearby young snowy plover broods.
79	8	F= M=PG:AR	24-Apr	Unknown	24-May	2	0 (0)		Symbolic fence	
80	7	F=PG:YG M=	25-Apr	Hatch	31-May	3	3 (0)	3 GG:RB	Seasonal exclosure	
81	BY	F=RR:OY? M=V-:BR	29-Apr	Hatch	30-May	3	3 (3)	3 VV:YG	Seasonal exclosure	
82	BY	F= M=	15-Apr	Failed, unknown cause	10-May	3	0 (0)		Seasonal exclosure	
83	SOF	F= M=VG:YB	26-Apr	Abandoned pre-term	7-May	2	0 (0)		Symbolic fence	
84	8	F=GA:VR M=BB:GB	23-Apr	Hatch	27-May	3	3 (3)	3 BB:GR	Seasonal exclosure	
85	6	F=U M=GA:WB	22-Apr	Hatch	27-May	3	3 (0)	3 PG:GB	Seasonal exclosure	

Nest	Location	Adult Pair	Est. Initiation Date	Nest Fate	Fate date (est.)	No. known eggs	No. chicks (No. fledged)	No. chicks banded and combination	Nest Protection Type	Notes
86	6	F=U M=GG:WB	24-Apr	Hatch	28-May	3	3 (2)	3 VO:BW	Seasonal exclosure	
87*	6	F=U M=BB:AG	25-Apr	Hatch	31-May	3	3 (2)	3 GG:YW	Seasonal exclosure	On 16 May, unbanded female associated with nest observed with dried blood on right side and favoring right leg. On 25 May, three eggs with dried blood stains, likely transferred from injury of female. Female continued to incubate and condition improved.
88*	6	F=U M=U	29-Apr	Hatch	1-Jun	3	3 (2)	3 GA:VY	Seasonal exclosure	Split hatch. Between 4 to 27 June, chicks observed in open riding area and directed back onto exclosure shore at marker post 6 on 10 different days. On 5 June, one chick attacked by nearby SP32 adult and assumed dead. Two chicks fledging from shore near open riding area were obviously smaller in size and less developed than normal 28-day-old chicks.
89	7	F= M=U	29-Apr	Hatch	1-Jun	3	3 (3)	3 unbanded	Symbolic fence	Chicks not banded to avoid disturbing nearby young snowy plover broods.
90	8	F=U M=GA:VY	26-Apr	Hatch	29-May	3	3 (2)	3 GG:RW	Seasonal exclosure	Split hatch. On 8 September, the intact desiccated carcass of one small GG:RW chick found on 8 exclosure shoreline. Chick last seen alive on 1 June when 2-3 days old.
91	8	F=U M=GA:BG	26-Apr	Hatch	29-May	3	3 (1)	3 PG:YB	Seasonal exclosure	Split hatch.
92	7	F= M=U	4-May	Hatch	7-Jun	2	2 (0)	2 unbanded	Seasonal exclosure	Chicks not banded to avoid disturbing nearby young snowy plover broods.
93*	6	F=PV:PW M=U	1-May	Hatch	3-Jun	3	3 (1)	3 PG:VG	Seasonal exclosure	From 25 to 27 June, an unbanded male associated with brood was observed limping with a left leg injury.
94	7	F=U M=GG:AY	22-Apr	Hatch	19-May	3	3 (0)	3 VG:BW	Seasonal exclosure	Split hatch.
95	8	F= M=RR:WB	19-Apr	Hatch	22-May	3	1 (1)	1 VV:RG	Seasonal exclosure	Two eggs unknown fate.
96	SOF	F=U M=U	6-May	Depredated raven	22-May	2	0 (0)		Symbolic fence	Both eggs depredated by common raven.
97	6	F=U M=GG:OW	2-May	Hatch	4-Jun	3	3 (0)	3 unbanded	Symbolic fence	Split hatch. Chicks not banded to avoid disturbing nearby young snowy plover broods.
98	7	F=BB:PW M=BB:PG	4-May	Hatch	6-Jun	3	3 (2)	3 VV:WR	Seasonal exclosure	Split hatch.

Nest	Location	Adult Pair	Est. Initiation Date	Nest Fate	Fate date (est.)	No. known eggs	No. chicks (No. fledged)	No. chicks banded and combination	Nest Protection Type	Notes
99	6	F=PG:BW M=GG:PW	1-May	Hatch	3-Jun	3	2 (2)	2 BB:OY	Seasonal exclosure	One egg (without cracks) abandoned post-term. No sign of fertilization when egg contents examined.
100	6	F=U M=U	10-May	Hatch	12-Jun	3	2 (2)	2 unbanded	Symbolic fence	One egg unknown fate. Chicks not banded to avoid disturbing nearby young snowy plover broods.
101	8	F=banded M=	22-Apr	Depredated raven	22-May	3	0 (0)		Seasonal exclosure	All three eggs depredated by common raven.
102	Unknown	F=U M=U	7-Apr	Hatch	(10-May)	1	1 (0)	1 unbanded		
103	7	F=U M=GA:Y-	28-Apr	Hatch	31-May	3	3 (2)	2 VG:YB 1 unbanded	Seasonal exclosure	Split hatch. One VG:YB chick and one unbanded chick fledged.
104	NOF	F=PG:VG M=U	13-May	Depredated raven	22-May	2	0 (0)		Symbolic fence	Both eggs depredated by common raven.
105	7	F=U M=U	1-May	Hatch	4-Jun	3	2 (2)	2 unbanded	Symbolic fence	Chicks not banded to avoid disturbing nearby young snowy plover broods.
106	7	F=U M=VV:VR	30-Apr	Hatch	7-Jun	3	3 (3)	3 unbanded	Symbolic fence	Chicks not banded to avoid disturbing nearby young snowy plover broods.
107*	6	F=banded M=RR:-	4-May	Hatch	6-Jun	3	3 (1)	3 unbanded	Seasonal exclosure	Chicks not banded to avoid disturbing nearby young snowy plover broods. On 12 June, one unbanded dead chick observed on shoreline near brood (and possibly associated with brood).
108	8	F= M=VV:WB	3-May	Hatch	5-Jun	3	3 (3)	3 VV:AR	Seasonal exclosure	
109	BY	F=U M=U	18-May	Hatch	21-Jun	3	3 (0)	3 unbanded	Seasonal exclosure	Not within maintained predator fencing.
110	SOF	F=U M=U	14-May	Depredated raven	22-May	3	0 (0)		Symbolic fence	All three eggs depredated by common raven.
111*	6	F=U M=U	18-May	Hatch	20-Jun	3	2 (0)	2 VG:RW	Seasonal exclosure	One egg (without cracks) abandoned post-term. No sign of fertilization when egg contents examined. On 23 June, one chick observed in the open riding area and directed back onto exclosure shore at marker post 6.
112	6	F= M=V-:AY	13-May	Hatch	15-Jun	2	1 (1)	1 PV:PW	Seasonal exclosure	One egg (with large pip hole and dead chick inside) abandoned post-term.
113	6	F=GG:GR M=PG:PW	23-May	Hatch	24-Jun	3	2 (2)	2 PV:GW	Bumpout Seasonal exclosure	One egg (without cracks) abandoned post-term.
114	7	F=U M=U	16-May	Hatch	18-Jun	2	2 (2)	2 PV:VR	Seasonal exclosure	
115	6	F= M=U	15-May	Hatch	17-Jun	3	3 (3)	2 GA:PG 1 unbanded	Seasonal exclosure	

Appendix B. Snowy plover nests at ODSVRA in 2015 (continued).

Nest	Location	Adult Pair	Est. Initiation Date	Nest Fate	Fate date (est.)	No. known eggs	No. chicks (No. fledged)	No. chicks banded and combination	Nest Protection Type	Notes
116	6	F= M=BB:PR	14-May	Hatch	16-Jun	3	3 (3)	3 unbanded	Symbolic fence	Chicks not banded to avoid disturbing nearby young snowy plover broods.
117	NOF	F=U M=U	24-May	Hatch	24-Jun	3	3 (3)	3 PV:VW	Circular excl. with top Symbolic fence	
118	8	F=U M=U	18-May	Hatch	20-Jun	3	3 (3)	3 PG:PG	Seasonal exclosure	
119	SOF	F=U M=U	21-May	Hatch	24-Jun	3	3 (2)	2 VV:RW 1 unbanded	Circular excl. with top Symbolic fence	Unbanded chick last seen with brood 24 June, on day of hatch.
120	8	F=GA:RB M=U	28-May	Hatch	29-Jun	3	3 (3)	2 VG:WR 1 unbanded	Seasonal exclosure	
121	BY	F=NB:PG M=RR:OR	18-May	Hatch	20-Jun	3	3 (3)	3 GA:OY	Seasonal exclosure	
122	BY	F=U M=VG:YB	28-May	Hatch	29-Jun	3	3 (1)	3 PV:YG	Seasonal exclosure	
123	7	F=U? M=U	25-May	Hatch	26-Jun	2	1 (1)	1 PG:BY	Seasonal exclosure	One egg (without cracks) abandoned post-term.
124	8	F=NS:WW M=GA:OW	29-May	Hatch	28-Jun	2	2 (1)	2 PV:RW	Symbolic fence	
125	6	F=VV:BG M=V-:BR	17-May	Hatch	19-Jun	3	3 (3)	3 unbanded	Seasonal exclosure	Chicks not banded to avoid disturbing nearby young snowy plover broods.
126	SOF	F=VG:AW M=U	30-May	Hatch	1-Jul	3	3 (2)	3 VG:YR	Circular excl. with top Symbolic fence	
127*	6	F=VV:VG M=U	28-May	Hatch	27-Jun	3	3 (3)	3 PV:YW	Seasonal exclosure	On 9 August, one live juvenile observed on 8 exclosure shore with broken left wing.
128	6	F=GG:VY M=U	18-May	Abandoned pre-term	16-Jun	3	0 (0)		Seasonal exclosure	From 9 to 15 June, inconsistent incubation of nest. One egg with no sign of fertilization and two eggs with approximately two-week-old dead embryos when egg contents examined.
129	6	F=U M=GG:RW	21-May	Hatch	23-Jun	3	3 (2)	3 VG:VY	Seasonal exclosure	
130	6	F=BB:WG M=GA:OG	30-May	Hatch	29-Jun	3	3 (2)	3 VG:OY	Seasonal exclosure	
131	7	F=U M=GG:AG	25-May	Hatch	27-Jun	3	3 (3)	3 PV:BY	Seasonal exclosure	
132	8	F=VV:VW M=unb	28-May	Hatch	30-Jun	3	3 (2)	3 unbanded	Seasonal exclosure	Chicks not banded to avoid disturbing nearby young snowy plover broods.
133	6	F=U M=NO:PB	21-May	Hatch	23-Jun	3	1 (0)	1 VV:GY	Seasonal exclosure	Two eggs (one without cracks and one with dried embryo inside) abandoned post-term.

Appendix B. Snowy plover nests at ODSVRA in 2015 (continued).

Nest	Location	Adult Pair	Est. Initiation Date	Nest Fate	Fate date (est.)	No. known eggs	No. chicks (No. fledged)	No. chicks banded and combination	Nest Protection Type	Notes
134*	Arroyo Grande Creek area	F= M=GG:VG	29-May	Hatch	(1-Jun)	2	2 (0)	2 unbanded		On 2 June, two approximately one-day-old chicks with GG:VG male first seen at the Arroyo Grande Creek Area (likely from an unknown nest located in this area). Brood approximately 2.6 miles north of marker post 6. On 3 June, the chicks and adult were moved south to the Southern Exclosure. Chicks were last observed aggressively attacked by another brooding adult very soon after entering exclosure shore.
135	NOF	F=U M=BB:VR	27-May	Hatch	28-Jun	3	3 (2)	3 unbanded	Circular excl. with top Symbolic fence	Split hatch. Chicks not banded to avoid disturbing nearby young snowy plover broods.
136	SOF	F=GA:YR M=U	29-May	Hatch	1-Jul	3	3 (2)	3 PV:WR	Circular excl. with top Symbolic fence	
137	6	F=GG:WY M=GG:AY	21-May	Hatch	23-Jun	2	2 (2)	2 VV:YR	Seasonal exclosure	
138	SOF	F=U M=U	27-May	Hatch	29-Jun	3	3 (3)	3 GA:GR	Circular excl. with top Symbolic fence	On 5 June, symbolic fence moved west to decrease possible pedestrian disturbance.
139	6	F=U M=RO:OY	27-May	Hatch	29-Jun	3	3 (1)	3 PV:WY	Seasonal exclosure	
140	6	F= M=	26-May	Abandoned pre-term	20-Jun	3	0 (0)		Seasonal exclosure	Three eggs abandoned pre-term, all with one-week-old dead embryo development when egg contents examined.
141	6	F=U M=VG:GY	30-May	Hatch	2-Jul	3	3 (1)	2 PV:RB 1 unbanded	Seasonal exclosure	Split hatch. Unbanded chick fledged.
142	6	F=PV:VY M=U	1-Jun	Hatch	4-Jul	2	2 (2)	2 unbanded	Seasonal exclosure	Chicks not banded to avoid disturbing nearby young snowy plover broods.
143	SOF	F= M=U	2-Jun	Hatch	5-Jul	3	3 (2)	2 GA:RG 1 unbanded	Circular excl. with top Symbolic fence	One GA:RG chick and one unbanded chick fledged.
144*	7	F= M=BB:YW	19-May	Hatch	21-Jun	3	3 (2)	3 unbanded	Symbolic fence	Chicks not banded to avoid disturbing nearby young snowy plover broods. From 26 to 31 July one fledgling favoring right leg, leg hangs loosely and drags on sand. Injured unbanded fledgling last seen on 31 July.
145	7	F=PV:VG M=U	24-May	Hatch	26-Jun	3	3 (2)	3 GA:PW	Symbolic fence	

Appendix B. Snowy plover nests at ODSVRA in 2015 (continued).

Nest	Location	Adult Pair	Est. Initiation Date	Nest Fate	Fate date (est.)	No. known eggs	No. chicks (No. fledged)	No. chicks banded and combination	Nest Protection Type	Notes
146	6	F= M=	na	Unknown	23-Jun	≥1	0 (0)		Symbolic fence	Nest location known by multiple observations of incubating adult between 4 and 22 June. To avoid disturbing young snowy plover broods, nest not walked to and complete clutch size unknown.
147	6	F=GG:VR M=GG:B(?)	26-May	Hatch	28-Jun	3	2 (0)	2 unbanded	Seasonal exclosure	One egg abandoned post-term.
148	6	F=U M=U	9-May	Hatch	11-Jun	3	3 (3)	3 unbanded	Seasonal exclosure	Chicks not banded to avoid disturbing nearby young snowy plover broods.
149	8	F=U M=banded	29-May	Hatch	1-Jul	3	3 (2)	3 VV:OR	Seasonal exclosure	
150	7	F= M=	28-May	Unknown	30-Jun	3	0 (0)		Seasonal exclosure	
151	7	F= M=	8-Jun	Abandoned pre-term	26-Jun	2	0 (0)		Seasonal exclosure	
152*	6	F=NO:WY M=	3-Jun	Hatch	6-Jul	3	3 (1)	2 PG:RB 1 unbanded	Seasonal exclosure	Split hatch. On 6 July, the two banded chicks were attacked aggressively by an adult male plover and were suspected not to survive the incident. Unbanded chick fledged.
153	BY	F=banded M=U	25-May	Hatch	27-Jun	3	3 (3)	2 PV:AG 1 unbanded	Seasonal exclosure	Split hatch.
154	Unknown	F=U M=VV:GB	6-May	Hatch	(8-Jun)	3	3 (3)	3 PV:AB		
155	7	F=U M=	9-Jun	Hatch	15-Jul	3	2 (0)	1 PG:YG 1 unbanded	Seasonal exclosure	Split hatch. One egg unknown fate. Unbanded chick last seen with brood 16 July, on day of hatch.
156*	6	F=U M=GG:PW	17-May	Hatch	19-Jun	3	3 (3)	3 unbanded	Symbolic fence	Chicks not banded to avoid disturbing nearby young snowy plover broods. On 11 and 12 July, one chick favoring right leg. Leg hangs and foot appears swollen. Chick subsequently observed moving normally.
157	6	F=PV:GG M=GG:PW	9-Jun	Hatch	10-Jul	3	3 (3)	3 unbanded	Symbolic fence	Chicks not banded to avoid disturbing nearby young snowy plover broods.
158*	8	F=U M=GG:PB	24-May	Hatch	26-Jun	3	2 (1)	2 PG:WG	Seasonal exclosure	One egg (without cracks) abandoned post-term. On 28 and 31 July, fledgling observed with right wing drooping to the ground.
159	6	F=U M=U	7-Jun	Hatch	10-Jul	3	3 (2)	3 unbanded	Symbolic fence	Chicks not banded to avoid disturbing nearby young snowy plover broods.

Appendix B. Snowy plover nests at ODSVRA in 2015 (continued).

Nest	Location	Adult Pair	Est. Initiation Date	Nest Fate	Fate date (est.)	No. known eggs	No. chicks (No. fledged)	No. chicks banded and combination	Nest Protection Type	Notes
160	6	F=U M=GA:GY	7-Jun	Hatch	10-Jul	3	3 (2)	3 unbanded	Symbolic fence	Chicks not banded to avoid disturbing nearby young snowy plover broods.
161	6	F=U M=GA:WB	9-Jun	Hatch	12-Jul	3	3 (1)	3 unbanded	Seasonal exclosure	Chicks not banded to avoid disturbing nearby young snowy plover broods.
162	8	F=U M=U	8-Jun	Hatch	11-Jul	3	3 (0)	3 unbanded	Symbolic fence	Chicks not banded to avoid disturbing nearby young snowy plover broods.
163	Unknown	F=U M=Y-:GO	15-Apr	Hatch	(18-May)	3	3 (2)	3 unbanded		Chicks not banded to avoid disturbing nearby young snowy plover broods.
164	8	F=VV:GW? M=PG:VW	25-May	Hatch	27-Jun	3	3 (3)	3 PV:WW	Seasonal exclosure	
165	8	F=U M=U	11-Jun	Hatch	14-Jul	3	3 (0)	3 unbanded	Symbolic fence	Chicks not banded to avoid disturbing nearby young snowy plover broods.
166	8	F=U M=U	26-May	Hatch	28-Jun	3	3 (3)	3 PV:AR	Seasonal exclosure	Split hatch.
167*	6	F=U M=BB:BY	9-Jun	Hatch	12-Jul	3	3 (2)	2 PG:VY 1 unbanded	Seasonal exclosure	Split hatch. Unbanded chick last seen with brood 22 July, when 10 days old. Between 23 July and 7 August, chicks observed in open riding area and directed back into exclosure on three different days. Two chicks fledging from shore near open riding area and were obviously smaller in size and less developed than normal 28-day-old chicks.
168	7	F=RR:(O?)Y M=U	12-Jun	Hatch	15-Jul	3	3 (0)	3 unbanded	Symbolic fence	Chicks not banded to avoid disturbing nearby young snowy plover broods.
169	6	F=VG:OG M=U	11-Jun	Hatch	14-Jul	3	2 (1)	2 unbanded	Symbolic fence	One egg abandoned post-term. Chicks not banded to avoid disturbing nearby young snowy plover broods.
170	6	F=BB:YW M=	na	Abandoned post-term	31-Jul	≥1	0 (0)		Symbolic fence	Nest location known by multiple observations of incubating adult during a 43-day period 18 June to 30 July. To avoid disturbing young snowy plover and least tern broods, nest not walked to and complete clutch size unknown. No evidence of hatch observed.
171	7	F=U M=banded	28-May	Unknown	30-Jun	3	0 (0)		Seasonal exclosure	

Nest	Location	Adult Pair	Est. Initiation Date	Nest Fate	Fate date (est.)	No. known eggs	No. chicks (No. fledged)	No. chicks banded and combination	Nest Protection Type	Notes
172	7	F= M=GA:GB	23-May	Hatch	25-Jun	≥2	2 (1)	2 unbanded	Symbolic fence	Nest location known by multiple observations of incubating adult. Minimum of two eggs based on number of observed chicks. To avoid disturbing young snowy plover broods, nest not walked to and chicks not banded.
173	7	F=PG:GG M=VO:BW	11-Jun	Hatch	14-Jul	3	3 (0)	3 unbanded	Symbolic fence	Chicks not banded to avoid disturbing nearby young snowy plover broods.
174	6	F=U M=BB:WB	17-Jun	Hatch	13-Jul	3	3 (2)	3 VG:PY	Seasonal exclosure	
175	6	F=U? M=	na	Abandoned, unknown if pre- or post-term	6-Jul	3	0 (0)		Seasonal exclosure	Nest observed active during a 15-day period 21 June to 5 July. On 19 September, three eggs collected from nest location.
176	7	F=RR:PW M=U	15-Jun	Hatch	18-Jul	3	3 (1)	3 unbanded	Symbolic fence	Chicks not banded to avoid disturbing nearby young snowy plover broods.
177	8	F=U M=VG:WB	12-Jun	Hatch	14-Jul	3	3 (0)	3 unbanded	Symbolic fence	Chicks not banded to avoid disturbing nearby young snowy plover broods.
178	7	F=(BG)?:OW M=U	16-Jun	Hatch	19-Jul	3	2 (1)	2 PV:OR	Seasonal exclosure	One egg (without cracks) abandoned post-term.
179	7	F=GG:YG M=U	4-Jun	Hatch	7-Jul	3	3 (3)	3 unbanded	Seasonal exclosure	Chicks not banded to avoid disturbing nearby young snowy plover and least tern broods.
180	8	F= M=	na	Abandoned, unknown if pre- or post-term	1-Jul	1	0 (0)		Seasonal exclosure	
181	7	F=U M=U	na	Unknown	28-Jun	≥1	0 (0)		Seasonal exclosure	Nest location known by multiple observations of incubating adult. To avoid disturbing young snowy plover and least tern broods, nest not walked to and complete clutch size unknown.
182	8	F= M=U	25-May	Hatch	27-Jun	3	3 (3)	2 PG:PB 1 unbanded	Seasonal exclosure	Split hatch.
183	6	F=PV:PW M=U	18-Jun	Hatch	19-Jul	3	3 (1)	3 VV:RY	Seasonal exclosure	
184	SOF	F= M=	27-Jun	Failed, unknown cause	7-Jul	2	0 (0)		Symbolic fence	
185	6	F= M=U	na	Abandoned, unknown if pre- or post-term	11-Jul	2	0 (0)		Symbolic fence	Nest observed active during a 12-day period 29 June to 12 July. On 7 September, 2-3 partial eggs found at nest site.

Appendix B. Snowy plover nests at ODSVRA in 2015 (continued).

Nest	Location	Adult Pair	Est. Initiation Date	Nest Fate	Fate date (est.)	No. known eggs	No. chicks (No. fledged)	No. chicks banded and combination	Nest Protection Type	Notes
186	7	F=U M=Y-:GO	11-Jun	Hatch	14-Jul	3	1 (1)	1 -:AY	Seasonal exclosure	One egg (without cracks) abandoned post-term. One egg (with cracks) unknown fate. Chick originally banded PV:AY and lost bands from left leg.
187	7	F=VV:AA M=U	23-Jun	Hatch	26-Jul	3	3 (1)	3 BB:AB	Seasonal exclosure	Split hatch.
188	8	F=OY:RB M=PV:YB	15-Jun	Hatch	18-Jul	3	3 (3)	2 PG:OW 1 unbanded	Seasonal exclosure	
189	6	F= M=U	13-Jun	Hatch	16-Jul	3	1 (0)	1 PG:WY	Seasonal exclosure	Two eggs (without cracks) abandoned post-term.
190	8	F= M=	5-Jun	Hatch	8-Jul	3	3 (0)	3 unbanded	Seasonal exclosure	
191	6	F=NO:GB M=U	10-Jun	Hatch	13-Jul	3	3 (2)	3 PV:YY	Seasonal exclosure	
192	7	F=U M=VV:YW	2-Jun	Hatch	5-Jul	3	1 (1)	1 unbanded	Symbolic fence	Two eggs unknown fate. Chick not banded to avoid disturbing nearby young snowy plover broods.
193	7	F=GA:GG M=U	14-Jun	Hatch	17-Jul	2	1 (0)	1 unbanded	Symbolic fence	Nest location known by multiple observations of incubating adult. On 17 July a minimum of two eggs observed through scope. To avoid disturbing young snowy plover broods, nest not walked to and chick not banded.
194	7	F=banded M=BB:GR	24-Jun	Hatch	27-Jul	3	3 (2)	3 BB:AW	Seasonal exclosure	
195	8	F=VV:VW M=GA:BG	22-Jun	Hatch	25-Jul	3	3 (2)	3 PG:BG	Seasonal exclosure	
196	8	F= M=GA:VY	25-Jun	Hatch	28-Jul	3	2 (1)	1 GA:WR 1 unbanded	Seasonal exclosure	Split hatch. One egg (with large opening and chick inside stuck to dried membrane) abandoned post-term. Unbanded chick last seen with brood 23 August, when 25 days old.
197	7	F= M=	22-Jun	Hatch	25-Jul	3	1 (0)	1 unbanded	Symbolic fence	Two eggs abandoned post-term. One of these eggs with fully developed dead embryo when egg contents examined.
198	7	F=U M=U	1-Jul	Hatch	3-Aug	2	2 (2)	2 PV:GB	Seasonal exclosure	
199	6	F=U M=RR:YY	28-Jun	Hatch	31-Jul	3	3 (2)	3 GG:VG	Symbolic fence	
200	7	F= M=	na	Unknown	21-Jul	≥1	0 (0)		Symbolic fence	Nest location known by multiple observations of incubating adult. To avoid disturbing young snowy plover and least tern broods nest not walked to and complete clutch size unknown.

Appendix B. Snowy plover nests at ODSVRA in 2015 (continued).

Nest	Location	Adult Pair	Est. Initiation Date	Nest Fate	Fate date (est.)	No. known eggs	No. chicks (No. fledged)	No. chicks banded and combination	Nest Protection Type	Notes
201	7	F= M=U	21-Jun	Hatch	24-Jul	3	3 (2)	3 BB:GB	Symbolic fence	
202	6	F=VV:BG M=U	29-Jun	Hatch	1-Aug	3	3 (0)	3 unbanded	Seasonal exclosure	Chicks not banded to avoid disturbing nearby young snowy plover broods.
203	NOF	F=GG:WY M=U	1-Jul	Hatch	3-Aug	3	3 (3)	3 VV:GW	Symbolic fence	
204	NOF	F=PV:WB M=	4-Jul	Hatch	6-Aug	3	3 (3)	3 GA:RW	Circular excl. with top Symbolic fence	
205	6	F= M=	na	Unknown	25-Jul	≥1	0 (0)		Seasonal exclosure	To avoid disturbing young least tern broods nest not walked to when active. Minimum one egg. One egg (without cracks) abandoned, unknown pre- or post-term.
206	6	F=PV:B(G)? M=U	30-Jun	Hatch	2-Aug	2	2 (2)	2 unbanded	Seasonal exclosure	Chicks not banded to avoid disturbing nearby young snowy plover broods.
207	Unknown	F= M=RR:WB	20-Jun	Hatch	(23-Jul)	1	1 (1)	1 unbanded		Chick not banded to avoid disturbing nearby young snowy plover broods.
208	Unknown	F= M=GG:BR	28-Jun	Hatch	(31-Jul)	3	3 (2)	3 unbanded		Chicks of unknown brood found on 6 exclosure shoreline at approximately nine days old and unable to band.
209	Unknown	F=GG:AY M=U	15-May	Hatch	(17-Jun)	3	3 (3)	3 unbanded		Chicks not banded to avoid disturbing nearby young snowy plover broods.
210	Unknown	F=U M=PG:AG	20-May	Hatch	(22-Jun)	3	3 (3)	3 unbanded		Chicks not banded to avoid disturbing nearby young snowy plover broods.
211	Unknown	F=U M=U	18-May	Hatch	(20-Jun)	3	3 (0)	3 unbanded		Chicks not banded to avoid disturbing nearby young snowy plover broods.
212	Unknown	F=U M=GG:AY	23-May	Hatch	(25-Jun)	3	3 (3)	3 unbanded		Chicks not banded to avoid disturbing nearby young snowy plover broods.
213	Unknown	F=U M=GA:YW	24-May	Hatch	(26-Jun)	3	3 (2)	3 BB:RW		
214	Unknown	F=VV:WY M=U	31-May	Hatch	(3-Jul)	3	3 (3)	3 unbanded		Chicks not banded to avoid disturbing nearby young snowy plover broods.
215	Unknown	F=U M=banded	5-Jun	Hatch	(8-Jul)	2	2 (0)	2 unbanded		Chicks not banded to avoid disturbing nearby young snowy plover broods.
216	Unknown	F=U M=GG:VG	5-Jun	Hatch	(8-Jul)	3	3 (2)	3 unbanded		Chicks not banded to avoid disturbing nearby young snowy plover broods.

Appendix B. Snowy plover nests at ODSVRA in 2015 (continued).

Nest	Location	Adult Pair	Est. Initiation Date	Nest Fate	Fate date (est.)	No. known eggs	No. chicks (No. fledged)	No. chicks banded and combination	Nest Protection Type	Notes
217*	Unknown	F=U M=U	17-Jun	Hatch	(20-Jul)	3	3 (1)	2 GG:OR 1 unbanded		When brood banded on 22 July, one chick observed with noticeable swelling on right side. This chick was not banded and last seen with brood 12 August when approximately 23 days old. Chick appeared and behaved normally when observed with binoculars and scope in field.
Insufficient information available to assign the following broods to a specific nest. Most to all of these broods were likely from nests with an assigned number, known to hatch and with chicks not banded at nest. The majority of chicks could not be banded to avoid disturbing nearby young snowy plover broods.										
UNK1	Unknown	F= M=GA:PY	na	Hatch	(12-May)	2	2 (0)	2 GA:AW		
UNK2	Unknown	F= M=U	na	Hatch	(23-May)	3	3 (2)	3 unbanded		
UNK3	Unknown	F=U M=U	na	Hatch	(25-Jun)	3	3 (3)	3 unbanded		
UNK4	Unknown	F= M=GG:OR	na	Hatch	(25-Jun)	1	1 (0)	1 unbanded		
UNK5	Unknown	F=U M=U	na	Hatch	(25-Jun)	3	3 (0)	3 unbanded		
UNK6	Unknown	F=GG:VY M=BB:YY	na	Hatch	(30-Jun)	3	3 (2)	3 unbanded		
UNK7	Unknown	F= M=U	na	Hatch	(8-Jul)	2	2 (2)	2 unbanded		
UNK8	Unknown	F= M=U	na	Hatch	(15-Jul)	3	3 (3)	3 PG:YY		
UNK9	Unknown	F= M=U	na	Hatch	(23-Jul)	1	1 (0)	1 unbanded		
UNK10	Unknown	F= M=U	na	Hatch	(27-Jul)	2	2 (1)	2 unbanded		

Appendix C. Maps of all California least tern and snowy plover nest locations at ODSVRA in 2015.

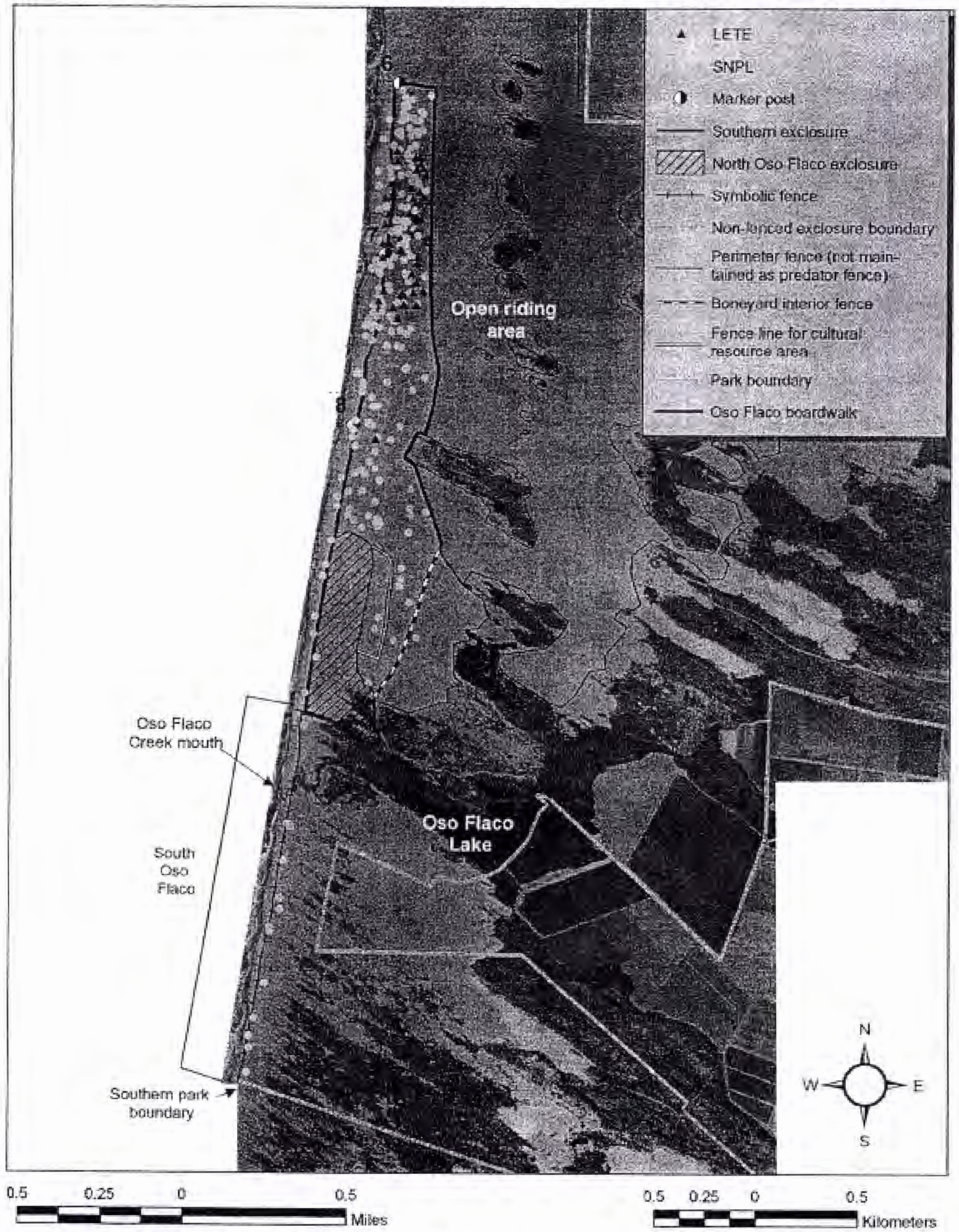


Figure C.1. All California least tern and snowy plover nest locations at ODSVRA in 2015.

Appendix C. Maps of all California least tern and snowy plover nest locations at ODSVRA in 2015 (continued).

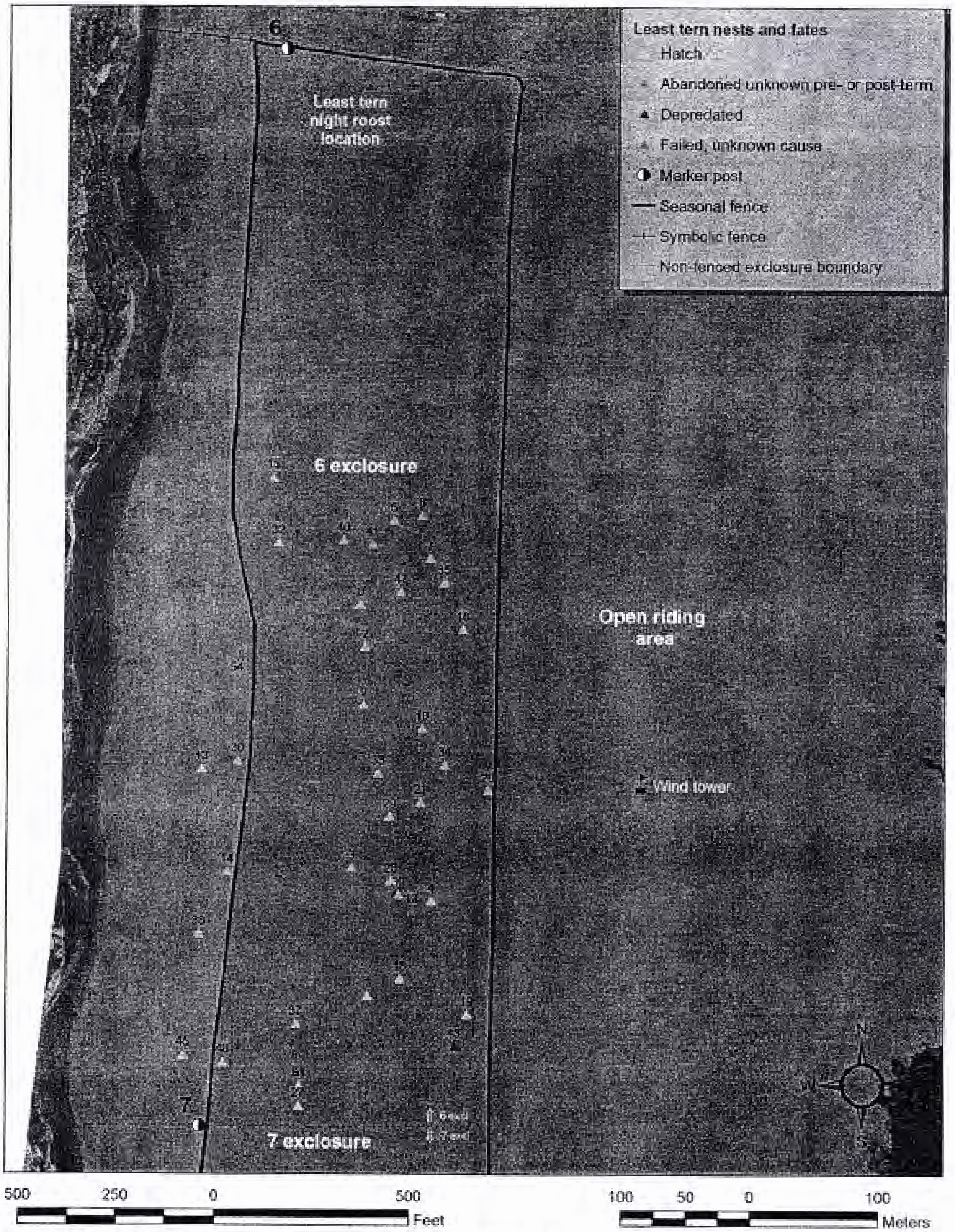


Figure C.2. California least tern nest locations at ODSVRA in 2015 (6 exclosure).

Appendix C. Maps of all California least tern and snowy plover nest locations at ODSVRA in 2015 (continued).

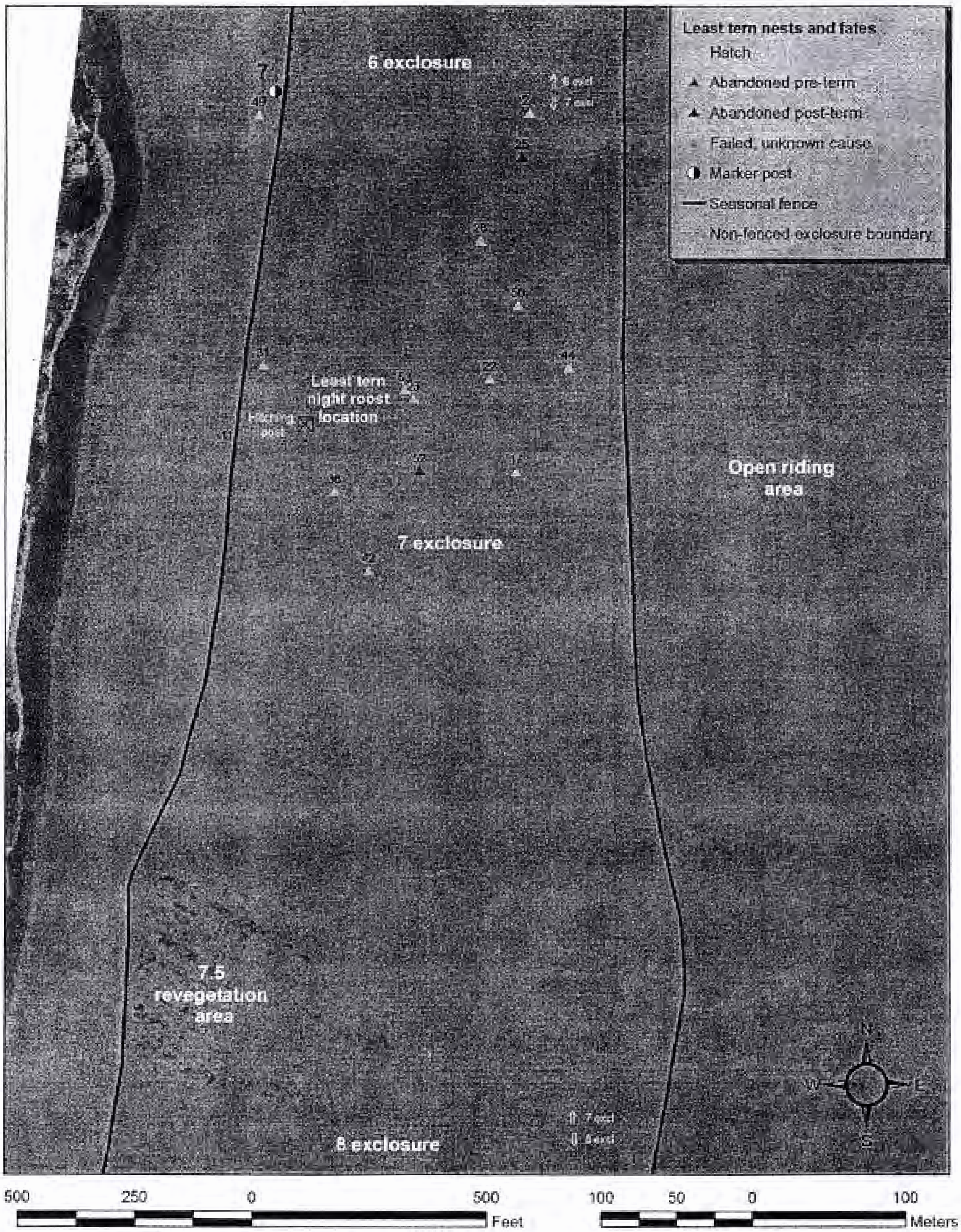


Figure C.3. California least tern nest locations at ODSVRA in 2015 (7 exclosure).

Appendix C. Maps of all California least tern and snowy plover nest locations at ODSVRA in 2015 (continued).

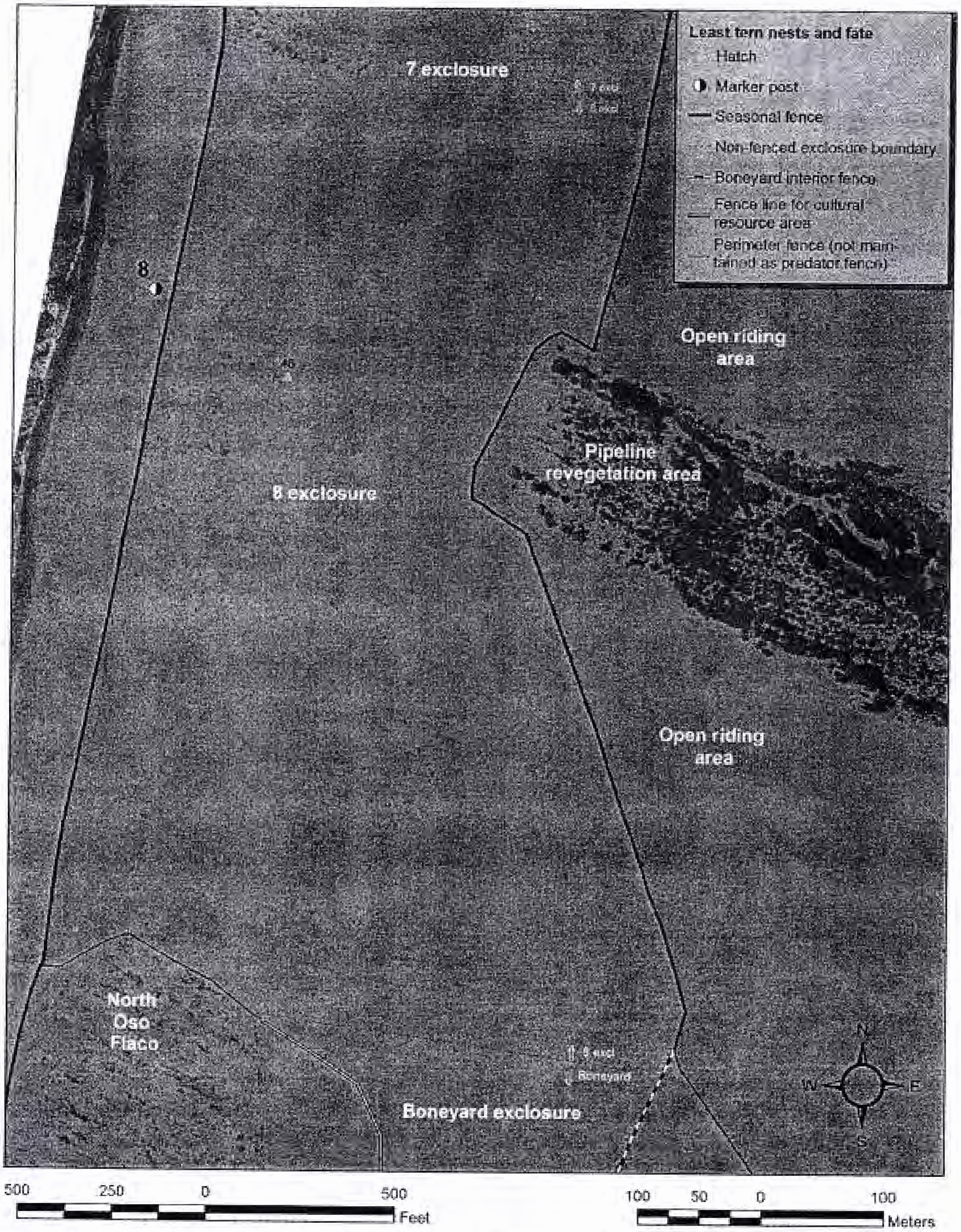


Figure C.4. California least tern nest locations at ODSVRA in 2015 (8 exclosure).

Appendix C. Maps of all California least tern and snowy plover nest locations at ODSVRA in 2015 (continued).

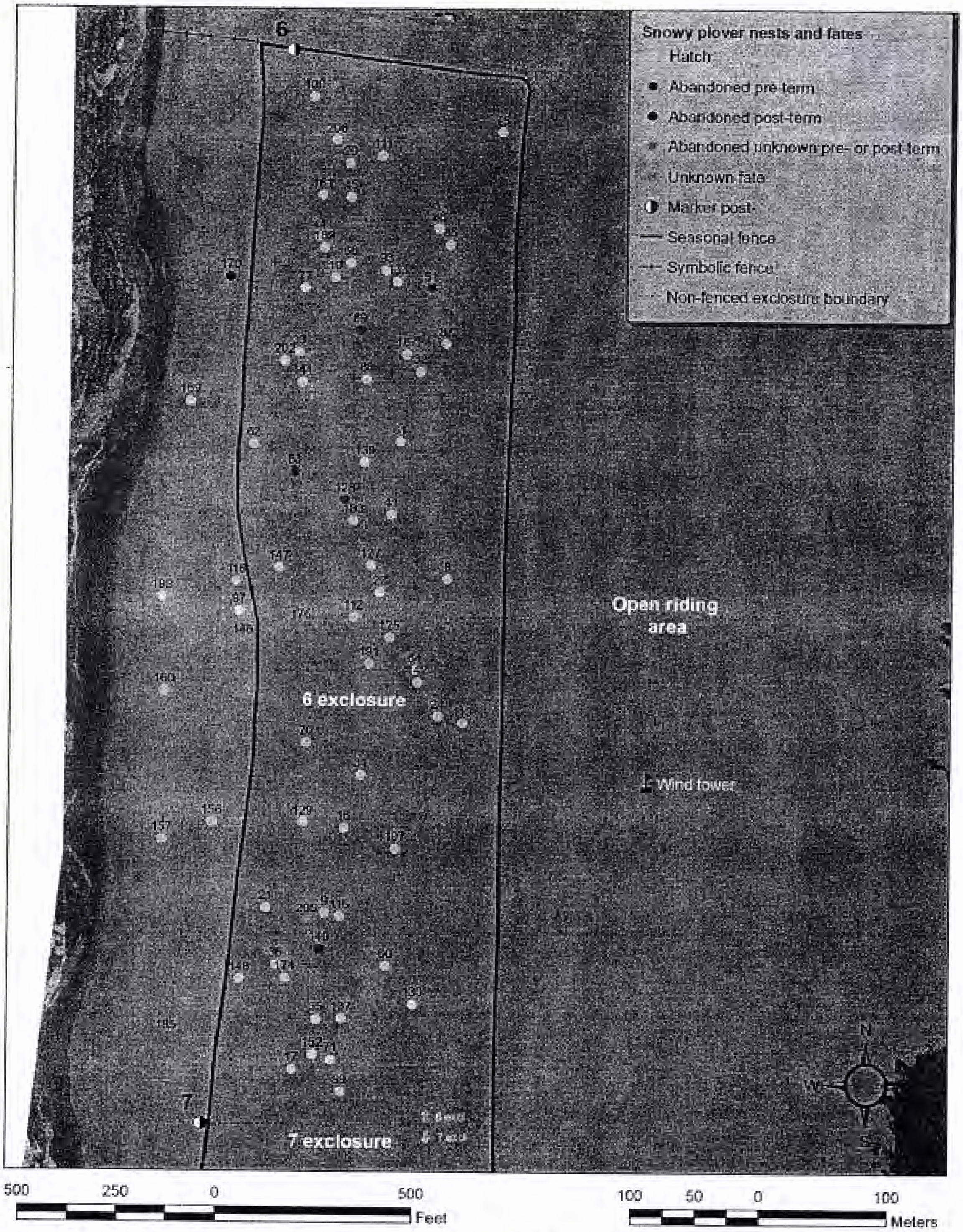


Figure C.5. Snowy plover nest locations at ODSVRA in 2015 (6 exclosure).

Appendix C. Maps of all California least tern and snowy plover nest locations at ODSVRA in 2015 (continued).

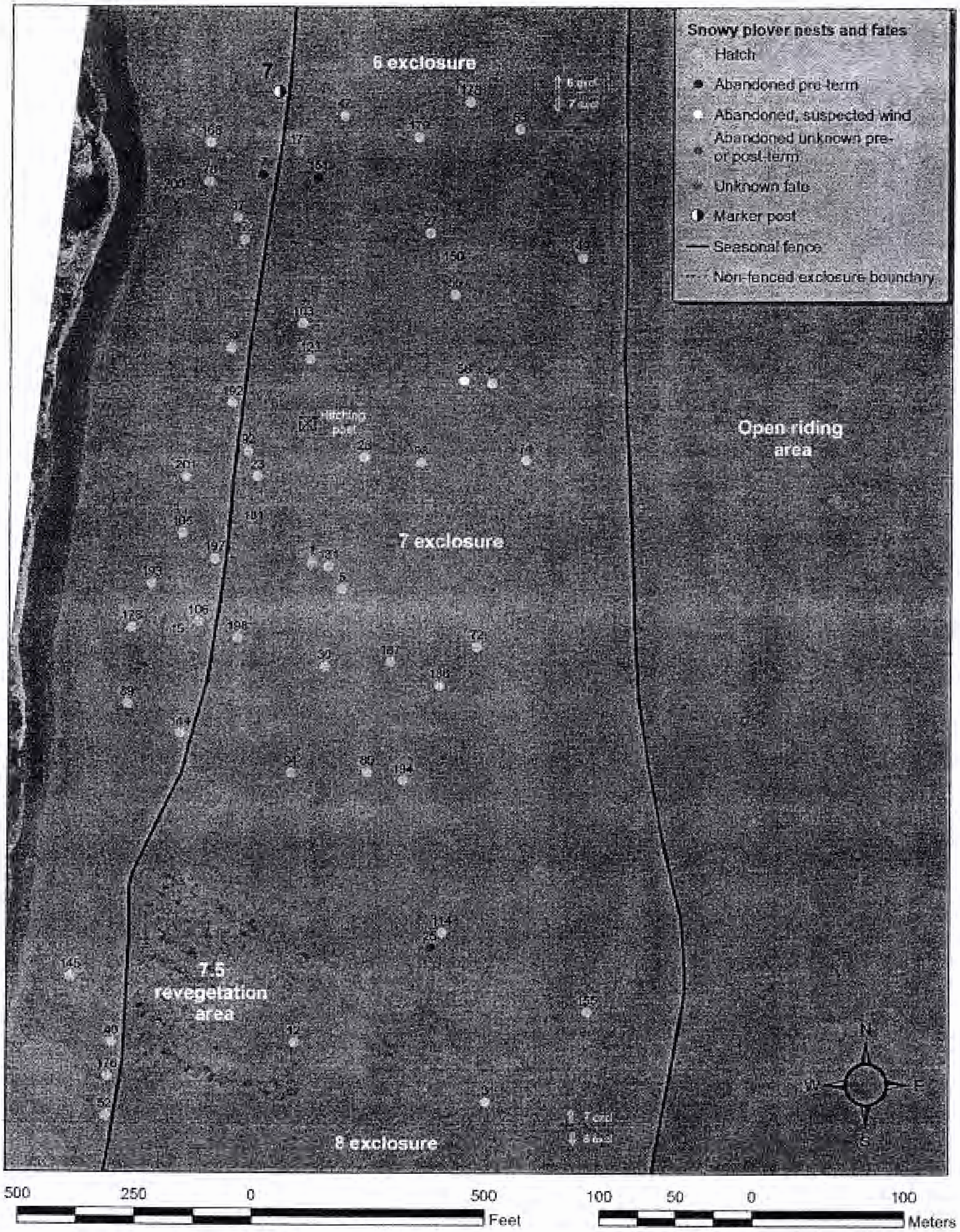


Figure C.6. Snowy plover nest locations at ODSVRA in 2015 (7 exclosure).

Appendix C. Maps of all California least tern and snowy plover nest locations at ODSVRA in 2015 (continued).

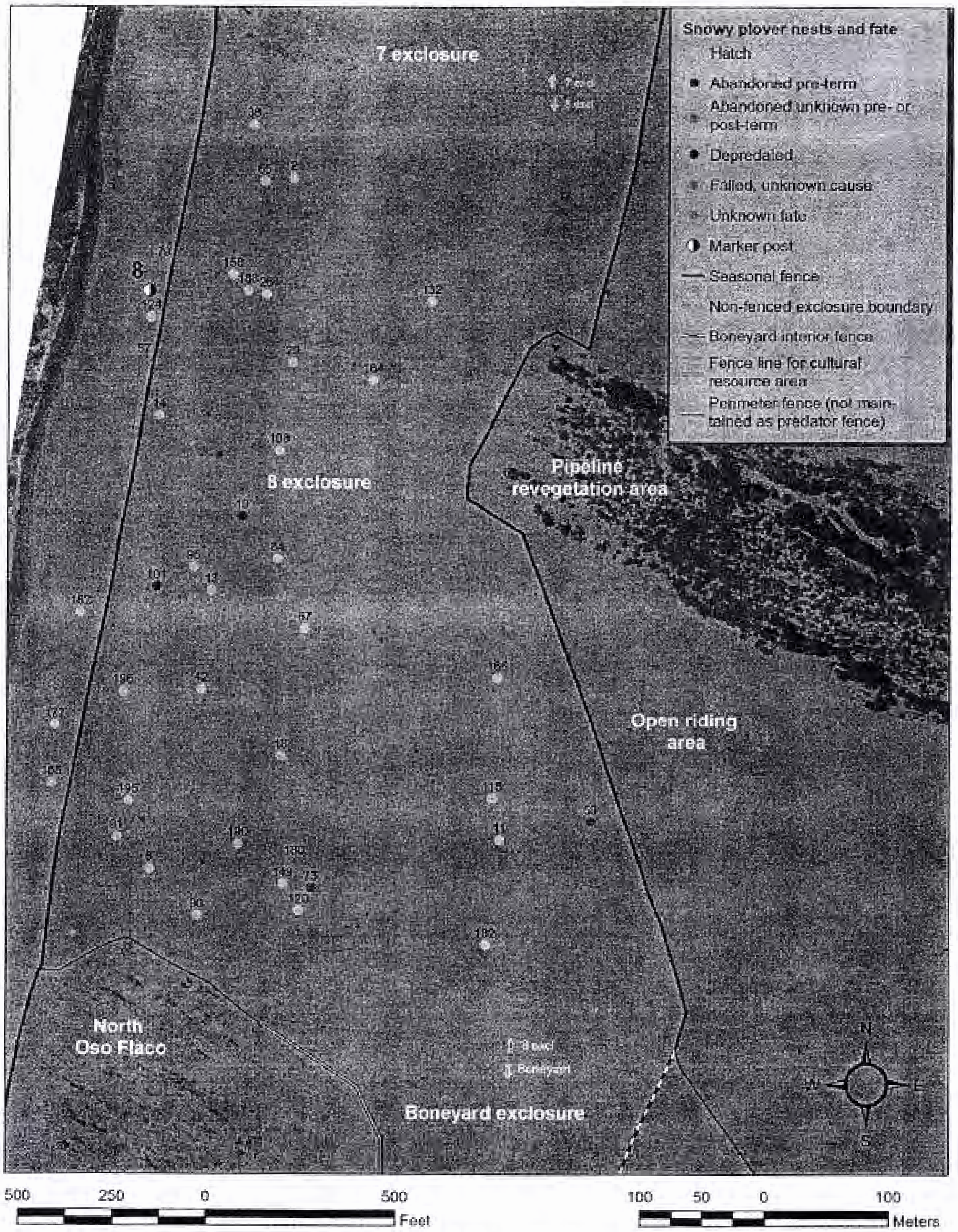


Figure C.7. Snowy plover nest locations at ODSVRA in 2015 (8 exclosure).

Appendix C. Maps of all California least tern and snowy plover nest locations at ODSVRA in 2015 (continued).

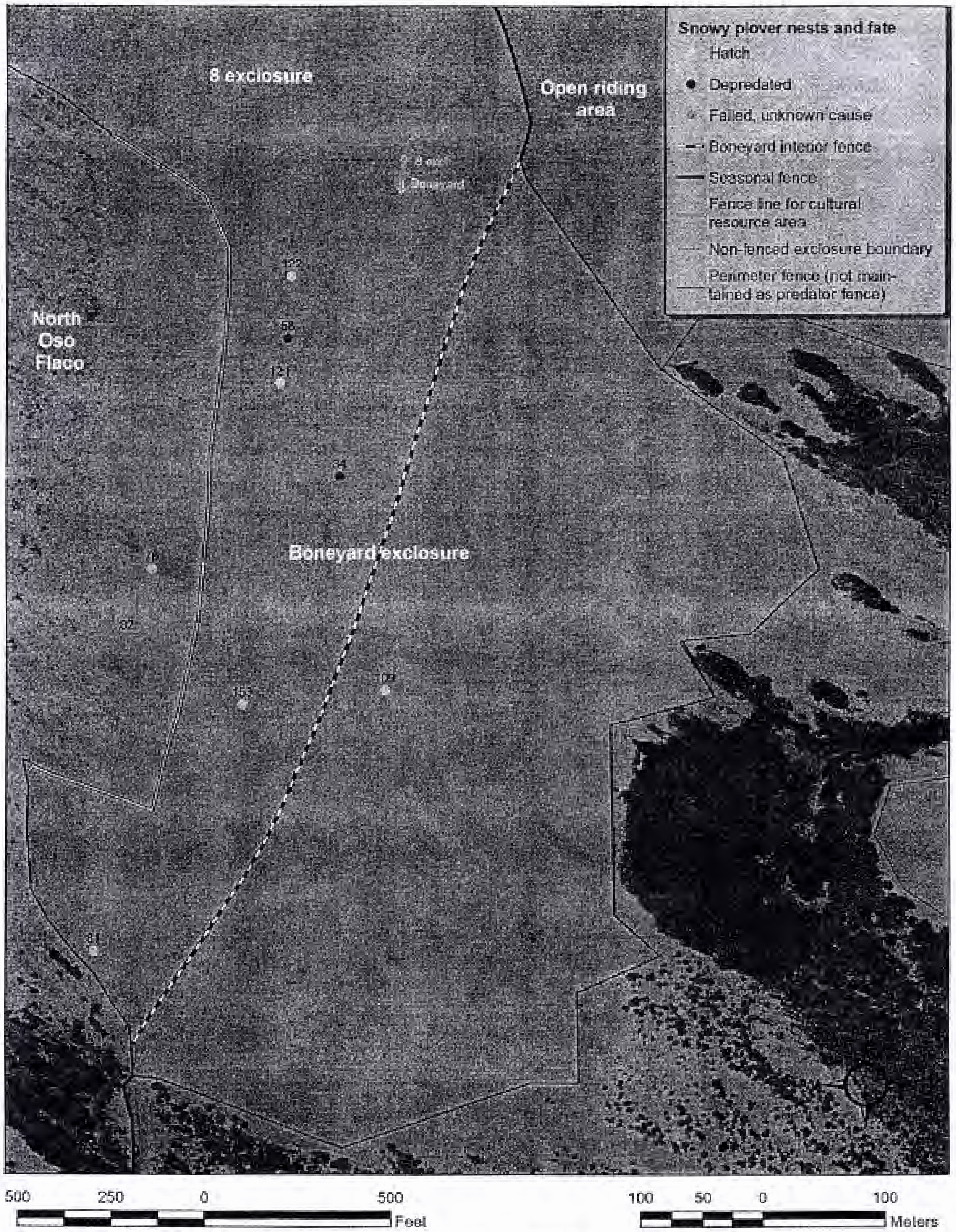


Figure C.8. Snowy plover nest locations at ODSVRA in 2015 (Boneyard exclosure).

Appendix C. Maps of all California least tern and snowy plover nest locations at ODSVRA in 2015 (continued).

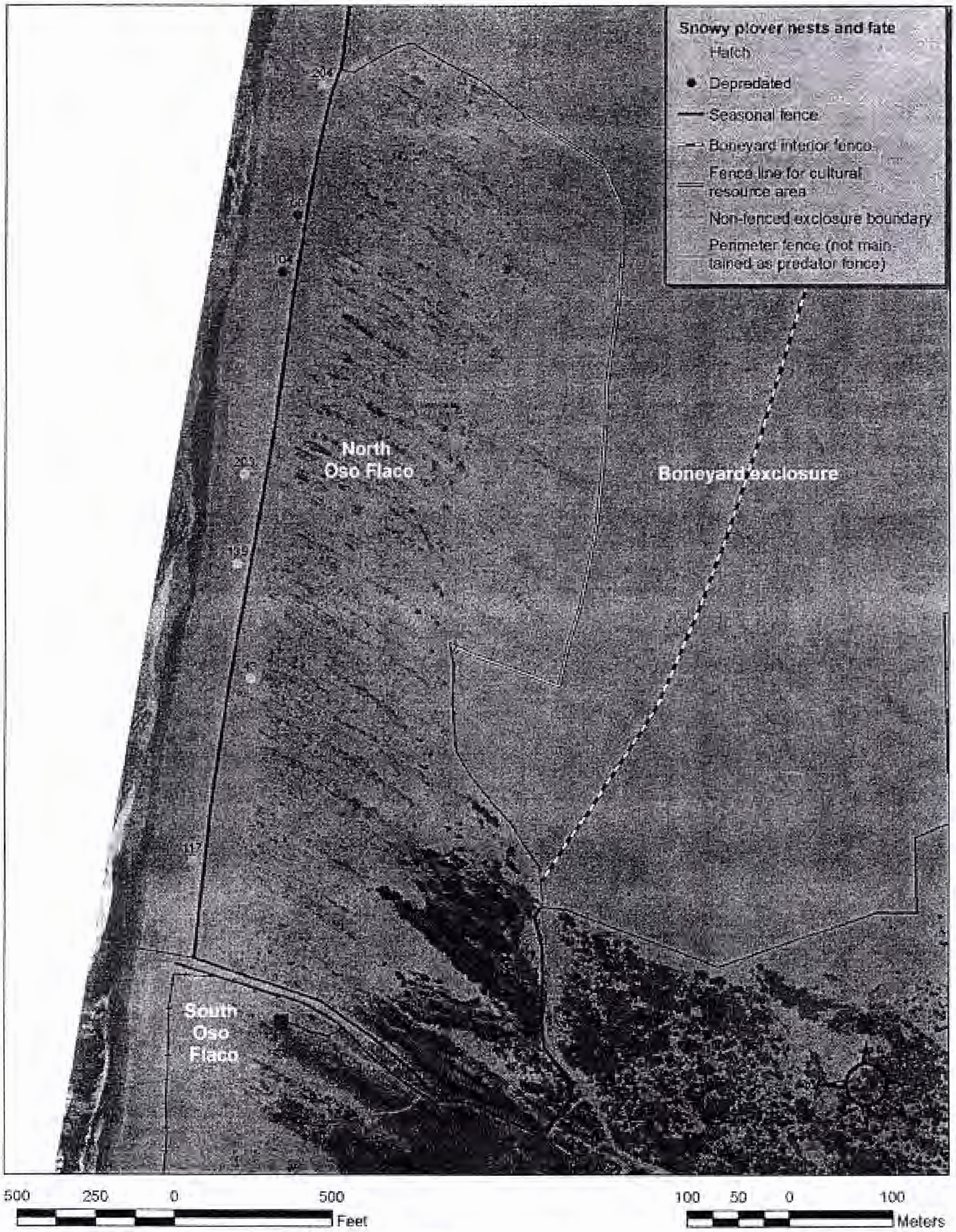


Figure C.9. Snowy plover nest locations at ODSVRA in 2015 (North Oso Flaco).

Appendix C. Maps of all California least tern and snowy plover nest locations at ODSVRA in 2015 (continued).

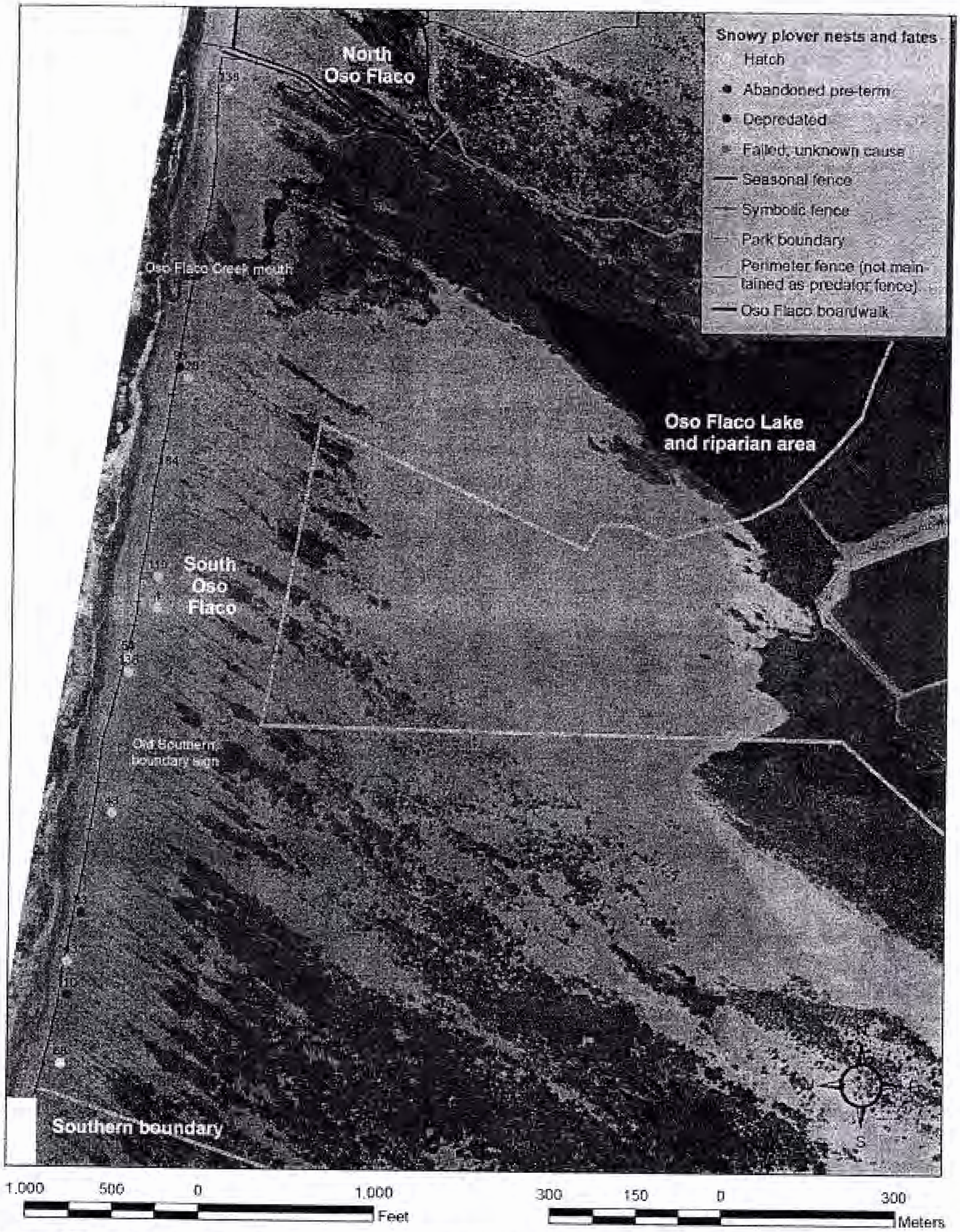


Figure C.10. Snowy plover nest locations at ODSVRA in 2015 (South Oso Flaco).

Appendix D. Banded least terns and snowy plovers.

Table D.1. Banded least terns recorded at ODSVRA in 2015.

Juveniles fledged from ODSVRA in 2015 are not included. All birds from ODSVRA were banded as chicks. Additional color-banded birds were recorded but combinations not confirmed. A number of birds had a band on only one leg. These birds may have been banded on only one leg or have lost a band. All possible band combinations of birds known fledging from ODSVRA are listed for incomplete band combinations or for band combinations that were used multiple years. Sex is included if copulation was observed and bands could be determined at that time. (For a description of color band letter codes see Appendix B.)

Band	Dates Seen	Origin and Year Banded	Notes
-:A/B	5/8	ODSVRA 2006, 2008, 2010, or 2011	Y/G:A/B in 2006, G/Y:A/B in 2008, W/B:A/B in 2010, B/W:A/B in 2011.
-:G/O	5/8, 6/11	ODSVRA 2008 or 2011	G/Y:G/O in 2008, B/W:G/O in 2011. **LT6 breeding adult.**
-:G/B	6/9	ODSVRA 2008 or 2011	G/Y:G/B in 2008, B/W:G/B in 2011. **LT7 breeding adult.**
-:S	6/17, 7/18, 7/23, 7/26, 8/4	unknown	Multiple sites may band with only the federal band. Also may be any ODSVRA fledgling from 2004 when all banded G/Y:S or any ODSVRA fledgling that lost the left band and tape on a metal band. **LT17 breeding adult.**
-:W/A	6/10, 7/18, 8/13	ODSVRA 2006, 2008, 2010, or 2011	Y/G:W/A in 2006, G/Y:W/A in 2008, W/B:W/A in 2010, B/W:W/A in 2011. **LT1 breeding adult.**
-:Y/O	7/26	ODSVRA 2006, 2008, or 2011	Y/G:Y/O in 2006, G/Y:Y/O in 2008, B/W:Y/O in 2011.
B:-	7/28	ODSVRA 2007, 2009, or 2013	B:G/Y in 2007, B:W/B in 2009 and 2013.
B/W:(A/G)?	7/7	ODSVRA 2011	**LT25 breeding adult.**
B/W:B/O	7/18	ODSVRA 2011	
B/W:B/Y	7/1, 7/8, 7/21	ODSVRA 2011	**LT37 breeding adult.**
B/W:G/W	7/18	ODSVRA 2011	**LT30 breeding adult.**
B/W:O/W	6/16	ODSVRA 2011	
B/W:O/Y	5/20, 7/28	ODSVRA 2011	
B/W:P	7/18	ODSVRA 2011	
B:W/B	5/25, 6/17, 7/18, 7/26	ODSVRA 2009 or 2013	**LT17 breeding adult.**
G/Y:B/W	7/7, 7/26, 8/4, 8/11, 8/12	ODSVRA 2008 or 2012	**LT50 breeding adult.**
G/Y:-	5/20, 5/10	ODSVRA 2004, 2008, or 2013	Male. May be any ODSVRA fledgling from 2004 when all banded G/Y:S, from 2008 when all were banded G/Y on left leg, or G/Y:W/B from 2013.
K:W/B	7/14	ODSVRA 2013	
O/A:W/B	7/18, 7/26	ODSVRA 2009 or 2013	
O/Y:B/W	5/19, 7/26	ODSVRA 2012	Male.
O:B/W	7/8, 7/23	ODSVRA 2012	**LT27 breeding adult.**
R/W:W/B	6/9, 7/18	ODSVRA 2013	
S:-	5/8, 6/11, 6/30, 7/18	unknown	Multiple sites may band with only the federal band. May also be any ODSVRA fledgling that lost the right band and tape on a metal band. **LT6 breeding adult.**
V:B/W	6/15, 6/16, 7/18, 7/20	ODSVRA 2012	**LT21 breeding adult.**
W/B:G/Y	5/17	ODSVRA 2007	
W/B:R/Y	6/15	ODSVRA 2010	

Table D.1. Banded least terns recorded at ODSVRA in 2015 (continued).

Band	Dates Seen	Origin and Year Banded	Notes
W/B:W	7/18	ODSVRA 2010	
W/B:W/Y	7/18, 7/26, 7/28	ODSVRA 2010	
W/B:Y/R	6/24	ODSVRA 2010	
W/R/W:W/B	6/21	ODSVRA 2013	
W/R:B/W	6/21, 7/4	ODSVRA 2012	
W/R:W/B	7/18, 7/26	ODSVRA 2013	
W:-	5/20, 7/20	ODSVRA 2007, 2009, 2012	W:G/Y in 2007, W:W/B in 2009 and 2014, or W:B/W in 2012. **LT4 breeding female.**
Y/G:B/W	8/3	ODSVRA 2006 or 2012	
Y/G:W/B	7/18	ODSVRA 2006 or 2013	
Y/O:W/B	6/16, 7/18	ODSVRA 2009	**LT20 breeding adult.**
Y/W:B/W	6/10	ODSVRA 2012	**LT44 possible breeding adult.**
Y/W/Y:-	7/1	ODSVRA 2007	Y/W/Y:G/Y banded in 2007
Y:B/W	7/18	ODSVRA 2012	

Table D.2. Banded snowy plovers seen at ODSVRA 1 October 2014 to 28 February 2015.
All birds were banded as chicks unless otherwise noted. Chicks banded outside of San Luis Obispo County are noted in order from north to south. Some sites band to brood and can have more than one bird with the same combination. At ODSVRA, the same combination may be on birds hatched in different years. (For a description of color band letter codes see Appendix B.)
ODSVRA=Oceano Dunes SVRA, SLO=San Luis Obispo, VAFB=Vandenberg Air Force Base, SB=State Beach, NWR=National Wildlife Refuge

Band Combination	Origin and Year Banded	County Banded	Dates Seen	Notes
-:Sb	Dunes Overlook 2012	Douglas - Lane boundary, OR	10/13, 12/3, 12/8	Silver on upper leg
AG:GA	Moss Landing Salt Ponds 2014	Monterey, CA	11/3, 10/19, 12/3, 2/9	
AW:RG	Pajaro Spit 2014	Monterey	10/6, 10/14, 10/19, 11/19, 12/3, 12/8	
RO:OY	Salinas River SB 2014	Monterey	10/5, 10/6, 10/14, 10/17, 10/19, 10/22, 10/29, 11/3, 11/10, 11/19, 12/8, 2/25	
OL:GP	Salinas River NWR 2009	Monterey	12/3, 12/8, 12/24, 12/28, 12/29	
WA.BL	Salinas River NWR 2012	Monterey	10/19, 10/28, 11/10, 11/19	
YP:OL	Salinas River NWR 2008	Monterey	10/30, 11/19, 12/8, 12/29, 1/20	
OY:RB	Reservation Road 2014	Monterey	10/5, 10/14, 10/19, 10/22, 10/28, 10/29, 11/13, 11/19, 12/8, 12/28, 12/29, 1/20	
GB:AW	Fort Ord 2013	Monterey	10/5, 10/6, 10/14, 10/19, 10/22, 10/28, 10/30, 11/19, 12/24, 12/29, 1/20, 2/9	
-:BB	ODSVRA 2010	SLO, CA	11/10	
BB:BY	ODSVRA 2005, 2010, or 2013	SLO	10/6, 10/17, 10/19, 10/22, 10/28, 11/19, 12/8, 12/28, 1/20, 2/25	
BB:GB	ODSVRA 2014	SLO	10/6, 10/10, 10/13, 10/14, 10/21, 10/30, 11/1912/3, 12/29	
BB:GG	ODSVRA 2013 or 2014	SLO	10/17, 11/4	
BB:OB	ODSVRA 2010 or 2014	SLO	11/10, 2/25	
BB:OG	ODSVRA 2010 or 2014	SLO	12/28	
BB:PB	ODSVRA 2010 or 2013	SLO	10/11, 10/17, 10/19, 10/22, 10/28, 12/3, 12/28, 1/30, 2/9	
BB:PG	ODSVRA 2013 or 2014	SLO	10/6, 10/11, 10/20, 10/30, 12/28, 12/29, 1/20, 2/25	
BB:PW	ODSVRA 2014	SLO	10/17, 10/28, 11/11, 12/8	
BB:RG	ODSVRA 2007	SLO	12/24	
BB:VR	ODSVRA 2011, 2013, or 2014	SLO	10/13, 10/19, 10/22, 11/19, 12/3, 1/20, 2/4, 2/25	
BB:WW	ODSVRA 2010 or 2013	SLO	10/9, 10/11, 10/13, 10/17, 10/19, 10/28	
BB:WY	ODSVRA 2010 or 2013	SLO	10/10, 10/13, 10/19, 10/22, 11/13, 11/19, 12/29	
BB:YW	ODSVRA 2010 or 2013	SLO	10/5, 10/6, 10/13, 10/17, 10/18, 10/19, 10/21, 10/22, 10/29, 10/30, 11/10, 11/11, 11/13, 12/3, 12/8, 12/29, 1/20, 2/25	

Table D.2. Banded snowy plovers seen at ODSVRA 1 October 2014 to 28 February 2015 (continued).

Band Combination	Origin and Year Banded	County Banded	Dates Seen	Notes
BB:YY	ODSVRA 2010	SLO	10/17, 10/20, 11/11, 11/19, 12/8, 12/29, 1/20, 2/9, 2/25	
GA:BW	ODSVRA 2011 or 2013	SLO	10/17, 10/19, 10/26, 10/30, 12/3, 12/28, 2/4	
GA:GG	ODSVRA 2011, 2013, or 2014	SLO	11/5, 12/8, 12/28, 2/25	
GA:GY	ODSVRA 2012 or 2013	SLO	10/6, 10/11, 101/17, 10/19, 10/21, 11/10, 11/11, 12/3, 12/8, 1/20, 2/4	
GA:RB	ODSVRA 2010	SLO	12/8, 2/4	
GA:VY	ODSVRA 2014	SLO	12/3, 12/28, 12/29, 1/20, 2/9, 2/25	
GA:WY	ODSVRA 2013 or 2014	SLO	10/21, 10/28, 10/30, 11/13, 12/8	
GA:YR	ODSVRA 2014	SLO	10/22, 10/29, 11/5	
GA:YW	ODSVRA 2010 or 2013	SLO	10/5, 10/19, 10/20, 12/3, 12/26, 12/28, 2/4, 2/25	
GG:AG	ODSVRA 2013 or 2014	SLO	10/5, 10/19, 12/28	
GG:AW	ODSVRA 2012 or 2013	SLO	10/28	
GG:AY	ODSVRA 2012 or 2013	SLO	10/10, 10/19, 10/22, 10/29, 12/28, 2/25	
GG:BB	ODSVRA 2005, 2010, or 2013	SLO	11/19	
GG:BR	ODSVRA 2013 or 2014	SLO	10/14, 10/17, 10/21, 10/28, 10/30, 12/8, 12/24, 12/28, 1/20	
GG:GG	ODSVRA 2011 or 2013	SLO	10/9, 10/17, 10/18, 10/19, 10/21, 10/28, 11/6, 11/19, 12/3, 12/8, 12/26, 1/20	
GG:OG	ODSVRA 2013 or 2014	SLO	10/10, 10/14, 10/17, 10/18, 10/19, 10/30, 11/6, 11/10, 11/19, 12/3, 12/28, 1/20, 2/25	
GG:OR	ODSVRA 2014	SLO	10/5, 10/19, 10/22, 10/28, 10/30, 11/19, 12/17, 2/25	
GG:PB	ODSVRA 2012 or 2013	SLO	10/5, 10/11, 10/19, 11/3, 11/19, 11/25, 12/3, 12/8, 1/20, 2/4, 2/9	
GG:PW	ODSVRA 2013 or 2014	SLO	10/6, 10/9, 10/12, 10/13, 10/14, 10/17, 10/18, 10/19, 10/22, 10/30, 11/5, 11/10, 11/13, 11/19, 12/3, 12/8, 12/17, 12/24, 12/29, 1/20, 2/4, 2/25, 2/25	
GG:RW	ODSVRA 2014	SLO	10/6, 10/13, 10/14, 12/3, 12/24, 12/28, 1/20	
GG:VG	ODSVRA 2014	SLO	10/13, 10/17, 10/18, 10/21, 10/30, 11/13, 11/19, 12/8, 12/29, 2/9, 2/25	
GG:VW	ODSVRA 2013 or 2014	SLO	12/3	
GG:VY	ODSVRA 2008, 2011, or 2013	SLO	10/6, 10/9, 10/13, 10/14, 10/17, 10/21, 10/28, 10/30, 11/10, 11/19, 12/8, 12/28, 2/4	
GG:WG	ODSVRA 2014	SLO	11/19, 12/8, 12/22, 1/20	

Appendix D. Banded least terns and snowy plovers (continued.)

Table D.2. Banded snowy plovers seen at ODSVRA 1 October 2014 to 28 February 2015 (continued).

Band Combination	Origin and Year Banded	County Banded	Dates Seen	Notes
GG:YG	ODSVRA 2011 or 2013	SLO	10/10, 12/29, 2/9	
GG:YW	ODSVRA 2013	SLO	12/3	
PG:AB	ODSVRA 2012 or 2014	SLO	11/10	
PG:AG	ODSVRA 2012 or 2014	SLO	10/22, 11/13, 11/19, 12/8, 12/24, 1/20, 2/4	
PG:AR	ODSVRA 2014	SLO	10/6, 10/13, 10/14, 10/17, 10/19, 10/21, 10/22, 10/28, 10/30, 11/10, 11/19, 12/3, 12/8, 12/24, 12/26, 12/29, 1/20, 2/9	Two birds with this band combination.
PG:BR	ODSVRA 2012 or 2014	SLO	10/10, 10/13, 11/6, 11/19	
PG:BW	ODSVRA 2012 or 2014	SLO	10/14, 10/19, 10/22, 10/28, 12/22, 1/20, 2/25	
PG:GG	ODSVRA 2012 or 2013	SLO	10/13, 10/22, 11/13, 11/19, 12/3, 12/28, 12/29, 1/20, 2/9	
PG:GR	ODSVRA 2011 or 2014	SLO	10/6, 10/11, 10/13, 10/17, 10/22, 12/8, 12/24, 12/28, 12/29, 1/20, 1/30, 2/9, 2/25	
PG:OB	ODSVRA 2012 or 2014	SLO	10/17, 10/18	
PG:PG	ODSVRA 2014	SLO	10/9, 10/13, 10/17, 10/20, 10/29, 1/20, 2/25	
PG:VW	ODSVRA 2011 or 2013	SLO	10/13, 12/8, 12/29, 1/20, 2/25	
PG:WG	ODSVRA 2014	SLO	10/11, 10/14, 10/19, 10/22, 11/3, 11/13, 11/19, 12/8, 1/20	
PG:WY	ODSVRA 2014	SLO	11/19	
PG:YW	ODSVRA 2012 or 2014	SLO	11/19	
PV:AB	ODSVRA 2014	SLO	10/17, 10/19, 10/20	
PV:AR	ODSVRA 2014	SLO	2/18, 2/25	
PV:BB	ODSVRA 2014	SLO	10/6, 10/13, 10/17, 10/19, 10/21	
PV:BG	ODSVRA 2011 or 2013	SLO	11/11	
PV:BR	ODSVRA 2007	SLO	11/5, 11/13, 12/3, 12/8, 1/20, 2/4, 2/25	
PV:BW	ODSVRA 2012 or 2014	SLO	10/17, 10/19, 10/21, 10/22, 10/28, 11/10, 11/19, 12/3, 12/28, 12/29	
PV:GG	ODSVRA 2014	SLO	10/7, 10/17, 10/19, 10/21, 10/22, 10/30, 11/3, 11/11, 12/8, 12/28	
PV:RW	ODSVRA 2014	SLO	10/14, 10/17, 10/22, 10/28	
PV:VG	ODSVRA 2013	SLO	10/5, 10/19, 10/30, 11/10, 12/17, 12/28, 12/29, 2/9, 2/25	
PV:VW	ODSVRA 2014	SLO	10/22	
PV:VY	ODSVRA 2009	SLO	10/5, 10/14, 10/17, 10/18, 10/19, 11/19, 12/8, 12/28, 2/9	
PV:WB	ODSVRA 2007 or 2010	SLO	1/20	

Table D.2. Banded snowy plovers seen at ODSVRA 1 October 2014 to 28 February 2015 (continued).

Band Combination	Origin and Year Banded	County Banded	Dates Seen	Notes
PV:WY	ODSVRA 2014	SLO	10/5, 10/6, 10/17, 10/19, 10/28, 11/19, 12/3, 12/26, 12/28	
RR:OY	ODSVRA 2010	SLO	2/25	
RR:PB	ODSVRA 2007 or 2010	SLO	12/28, 12/29, 2/25	
RR:VB	ODSVRA 2008 or 2010	SLO	12/29, 1/20, 2/4	
RR:VW	ODSVRA 2009 or 2011	SLO	10/11, 10/17, 11/5, 12/8, 12/24, 1/20	
RR:YR	ODSVRA 2010	SLO	10/13, 10/17, 10/22, 10/28, 11/6, 11/19, 12/28, 12/29, 1/20	
VG:AB	ODSVRA 2011 or 2013	SLO	10/3, 10/10, 10/22, 11/19, 12/3, 12/24	
VG:AR	ODSVRA 2011	SLO	10/13, 10/19, 10/20, 10/21, 11/3, 11/6, 11/11, 11/13, 12/8, 12/28	
VG:AW	ODSVRA 2011 or 2013	SLO	1/20, 2/4, 2/9, 2/25	
VG:BR	ODSVRA 2013 or 2014	SLO	10/13, 10/19, 11/19, 12/22, 2/25	
VG:GW	ODSVRA 2011 or 2013	SLO	10/10, 10/13, 11/5, 12/24, 12/28, 1/20, 2/25	
VG:OB	ODSVRA 2014	SLO	10/5, 10/13, 10/14, 10/17, 10/19, 10/22, 10/30, 11/10, 2/9	
VG:OG	ODSVRA 2011	SLO	11/19, 12/3, 12/8, 12/28, 1/20, 2/9, 2/25	
VG:PR	ODSVRA 2011	SLO	1/20	
VG:VR	ODSVRA 2009 or 2011	SLO	10/22, 11/19, 12/3, 12/8	
VG:WB	ODSVRA 2012 or 2013	SLO	10/6, 10/13, 10/17, 10/22, 11/19, 12/3, 12/8, 12/24, 12/29, 2/25	
VG:WR	ODSVRA 2012	SLO	10/22, 12/29	
VG:YB	ODSVRA 2014	SLO	2/25	
VV:AA	ODSVRA 2011	SLO	10/5, 10/13, 10/17, 10/20, 10/22, 10/28, 11/11, 11/19, 12/8, 12/29, 1/20, 2/9, 2/25	
VV:BB	ODSVRA 2011 or 2013	SLO	11/3, 12/28, 12/29	
VV:BG	ODSVRA 2009 or 2013	SLO	10/6, 10/19, 11/19, 12/3, 12/8	
VV:GR	ODSVRA 2012 or 2013	SLO	10/19, 10/22, 10/29, 10/30, 11/19, 12/24	
VV:VB	ODSVRA 2011 or 2013	SLO	10/13, 10/19, 10/21, 10/22, 10/28, 11/13, 11/19, 12/3, 2/4, 2/25	
VV:VG	ODSVRA 2009, 2011, or 2013	SLO	10/10, 10/22, 12/28, 12/29, 1/20, 2/25	
VV:VW	ODSVRA 2008, 2011, or 2013	SLO	10/17, 10/30, 12/8, 12/28, 1/20, 2/25	
VV:VY	ODSVRA 2011	SLO	12/24	
VV:WB	ODSVRA 2013 or 2014	SLO	12/8, 12/28, 12/29, 1/20, 2/9	
VV:WG	ODSVRA 2012	SLO	2/4	
VV:WW	ODSVRA 2011 or 2013	SLO	10/6	

Table D.2. Banded snowy plovers seen at ODSVRA 1 October 2014 to 28 February 2015 (continued).

Band Combination	Origin and Year Banded	County Banded	Dates Seen	Notes
VV:WY	ODSVRA 2012 or 2013	SLO	10/5, 10/6, 10/17, 10/19, 10/21, 11/3, 11/13, 11/19, 12/3, 12/8, 12/24, 12/28, 1/20, 2/4, 2/9, 2/25	
VV:YG	ODSVRA 2013	SLO	10/6, 10/9, 10/17, 10/21, 10/28, 10/30, 11/19, 12/8, 12/28	
VV:YR	ODSVRA 2014	SLO	10/13, 10/19	
VV:YW	ODSVRA 2011 or 2013	SLO	10/22, 11/5, 12/3, 12/8, 12/28, 1/20, 2/4, 2/25	
AN:AR	VAFB 2014	Santa Barbara, CA	10/5, 10/17, 12/3, 2/9	
AN:OB	VAFB 2014	Santa Barbara	10/10, 10/13, 11/10, 11/19, 12/8	Read as AN:RB on 10/10, 10/13, 11/10, and 11/19.
AN:RW	VAFB 2014	Santa Barbara	10/17, 11/19	
B-:Y/G	VAFB 2013	Santa Barbara	10/19, 10/30, 12/28	
NB:GR	VAFB 2011	Santa Barbara	2/9	
NB:GR	VAFB 2011	Santa Barbara	12/8	
NB:OW	VAFB 2011	Santa Barbara	10/17, 10/19, 11/19, 12/3, 12/8, 12/29	
NB:PG	VAFB 2011	Santa Barbara	12/28, 2/4	
NO:AG	VAFB 2013	Santa Barbara	10/9, 10/19, 10/22, 10/28, 10/30, 11/6, 11/10, 11/25, 12/3, 12/24, 12/28, 12/29, 1/20	
NO:GB	VAFB 2013	Santa Barbara	10/5, 10/17, 10/19, 10/28, 10/30, 11/11, 11/19, 12/8, 1/20, 2/25	
NO:PG	VAFB 2014	Santa Barbara	10/14	
NO:WG	VAFB 2012	Santa Barbara	10/14	
NO:WY	VAFB 2013	Santa Barbara	10/11, 10/19, 10/22, 11/19, 12/3, 12/8, 2/25	
NS:WW	VAFB 2009	Santa Barbara	12/3, 12/8, 2/9, 2/25	
NW:PG	VAFB 2014	Santa Barbara	10/17	
NW:WG	VAFB 2014	Santa Barbara	10/13, 10/17, 10/19, 10/22, 10/28, 11/11, 11/13, 11/19, 12/3, 12/8, 12/24, 12/28, 2/9, 2/25	
NY:RB	VAFB 2008 or 2013	Santa Barbara	2/4	
NY:RW	VAFB 2012	Santa Barbara	12/29	
O:B/W	VAFB 2014	Santa Barbara	12/29, 2/4, 12/26	
P:W/O/W	VAFB 2013	Santa Barbara	12/3, 12/8, 12/28, 1/20, 2/4	
P-:W/R/W	VAFB 2013	Santa Barbara	10/6, 10/19, 10/22, 10/30	
R:W/B/W	VAFB 2013	Santa Barbara	10/5, 10/18, 10/19, 10/22, 10/28, 11/6, 11/10, 11/13, 1/20	
V:G/W/G	VAFB 2014	Santa Barbara	11/19, 12/8	

Table D.2. Banded snowy plovers seen at ODSVRA 1 October 2014 to 28 February 2015 (continued).

Band Combination	Origin and Year Banded	County Banded	Dates Seen	Notes
W:Y/G	VAFB 2012	Santa Barbara	10/6, 10/7, 10/17, 10/20, 10/28, 11/11, 12/8, 2/25	
Y:G/O/G	VAFB 2013	Santa Barbara	10/13, 10/17, 10/28, 11/6, 11/19, 1/20, 2/4	
B-:OB	Origin Unknown	Unknown	10/5, 10/19, 10/22, 11/19, 12/28, 12/29, 1/20	
OS:PG	Origin unknown	Unknown	12/3, 12/28, 1/20	
RR:R-	Origin Unknown	Unknown	10/19, 10/20, 10/30, 11/11, 11/13, 11/19	
V-:VW	Origin Unknown	Unknown	10/5, 10/17, 10/30, 1/20	
V-:AY	Origin Unknown	Unknown	10/13, 10/20, 11/19, 12/28, 2/4	
V-:BR	Origin Unknown	Unknown	10/17, 11/19, 12/3	

Table D.3. Banded snowy plovers with known origins seen at ODSVRA 1 March to 30 September 2015.
Juveniles fledged from ODSVRA in 2015 are not included. All birds were banded as chicks unless otherwise noted. Chicks banded outside of San Luis Obispo County are noted in order north to south. Some sites band to brood and can have more than one bird with the same combination. (For a description of color band letter codes see Appendix B.)
ODSVRA=Oceano Dunes SVRA, SLO=San Luis Obispo, VAFB=Vandenberg Air Force Base, SB=State Beach, NWR=National Wildlife Refuge
J=Juvenile, F=Female, M=Male

Band	Sex	Origin and Year Banded	County Banded	Dates Seen	Notes
YW:WG	M	New River SB 2012	Coos County, OR	4/4, 4/22, 4/25	Banded as adult male.
BO:OO	J	Sunset SB 2015	Santa Cruz, CA	7/28, 7/29, 7/30	
AO:WO	J	Pajaro Spit 2015	Monterey, CA	8/14	
BG:OG	J	Pajaro Spit 2015	Monterey	9/25	
WA:RW	J	Pajaro Spit 2015	Monterey	8/26	
AG:GA		Moss Landing SP 2014	Monterey	3/5, 3/12, 3/18	
GO:RW		Moss Landing SP 2013	Monterey	6/30	
OY:RO		Moss Landing SP 2011	Monterey	4/27	
RO:OY	M	Salinas River SB 2014	Monterey	3/3, 3/4, 3/7, 3/8, 3/12, 3/21, 5/10, 6/9, 6/10, 6/29, 7/3, 7/4, 7/5, 7/10, 7/28, 8/6, 8/12, 8/13, 9/4	ODSVRA breeding male.
AO:RO	J	Marina SB 2015	Monterey	7/9	
AR:OO	J	Marina SB 2015	Monterey	7/16	
BG:GW	F	Marina SB 2013	Monterey	4/30	ODSVRA breeding female.
OW:RO	J	Fort Ord 2015	Monterey	9/8	
OY:RB	F	Reservation Road 2014	Monterey	3/9, 4/4, 5/18, 5/31, 6/18, 7/27, 8/6, 8/26, 9/4, 9/6	ODSVRA breeding female.
BB:AG	M	ODSVRA 2013	SLO, CA	4/11, 4/29, 5/25, 5/31, 6/28	ODSVRA breeding male.
BB:BY	M	ODSVRA 2010 or 2013	SLO	3/17, 4/18, 5/2, 5/4, 5/12, 5/14, 5/22, 5/30, 5/31, 6/4, 6/11, 6/25, 6/27, 7/18, 7/19, 8/10, 8/13, 8/30, 9/4	ODSVRA breeding male.
BB:GB	M	ODSVRA 2014	SLO	5/6, 6/9, 6/10	ODSVRA breeding male
BB:GG	M	ODSVRA 2013 or 2014	SLO	5/19, 6/9, 6/10	
BB:GR	M	ODSVRA 2012	SLO	4/2, 4/4, 4/19, 4/21, 5/26, 5/30, 5/31, 6/4, 8/5, 8/23, 9/11, 9/29	ODSVRA breeding male.
BB:OY		ODSVRA 2014	SLO	9/3, 9/4	
BB:PB	M	ODSVRA 2013	SLO	3/7, 3/26, 5/17	ODSVRA breeding male.
BB:PG	M	ODSVRA 2013 or 2014	SLO	5/8, 6/9, 6/18, 6/20, 8/14	ODSVRA breeding male.
BB:PR	M	ODSVRA 2011 or 2014	SLO	6/9, 6/24, 6/26, 6/27, 6/28, 6/29, 7/3, 7/8, 7/15, 7/23, 7/28	ODSVRA breeding male.
BB:PW	F	ODSVRA 2010 or 2014	SLO	4/27/2015, 8/6, 8/14	ODSVRA breeding female.
BB:RB		ODSVRA 2010	SLO	4/14	
BB:RW		ODSVRA 2014	SLO	3/1, 8/12, 8/22, 9/11, 9/12, 9/25	

Appendix D. Banded least terns and snowy plovers (continued).

Table D.3. Banded snowy plovers with known origins seen at ODSVRA 1 March to 30 September 2015 (continued).

Band	Sex	Origin and Year Banded	County Banded	Dates Seen	Notes
BB:VR	M	ODSVRA 2011, 2013 or 2014	SLO	3/18, 3/26, 6/30, 7/15, 7/21, 7/23, 7/26	ODSVRA breeding male.
BB:WB	M	ODSVRA 2013	SLO	4/18, 5/6, 5/18, 5/23, 5/31, 6/17, 6/20, 7/9, 7/13, 7/23, 7/28, 7/31, 8/6, 8/12	ODSVRA breeding male.
BB:WG	F	ODSVRA 2010 or 2013	SLO	5/15, 5/19, 7/5	ODSVRA breeding female.
BB:WY		ODSVRA 2010 or 2013	SLO	8/17	
BB:YB		ODSVRA 2013	SLO	4/18, 5/15	
BB:YG		ODSVRA 2011	SLO	3/1, 7/4	
BB:YW	F & M	ODSVRA 2010 or 2013	SLO	3/4, 3/5, 3/17, 3/18, 3/19, 3/22, 3/31, 4/4, 4/19, 4/23, 5/4, 5/8, 5/18, 5/19, 5/25, 5/28, 6/6, 6/8, 6/9, 6/18, 6/27, 6/28, 7/15, 8/7, 8/11, 8/13, 8/14, 8/27, 8/31, 9/3, 9/29	ODSVRA breeding female and male.
BB:YY	M	ODSVRA 2010	SLO	3/16, 4/2, 4/30, 5/5, 5/19, 6/18, 7/15, 7/19, 7/21, 7/28, 7/30, 8/5, 8/7	ODSVRA breeding male.
GA:BG	M	ODSVRA 2011 or 2013	SLO	5/31, 7/21, 7/28, 7/31, 8/18, 8/19	ODSVRA breeding male.
GA:BW	F	ODSVRA 2011 or 2013	SLO	5/26, 5/14, 5/17, 5/21, 7/1, 7/4, 8/18	ODSVRA breeding female.
GA:GB	M	ODSVRA 2012, 2013, or 2014	SLO	3/18, 4/28, 5/11, 7/5, 7/6, 7/30	ODSVRA breeding male.
GA:GG	F	ODSVRA 2011, 2013, or 2014	SLO	3/6, 3/18, 4/6, 4/17, 5/5, 5/18, 5/22, 6/4, 7/1, 8/20, 9/8	ODSVRA breeding female.
GA:GW		ODSVRA 2011 or 2013	SLO	5/19	
GA:GY	M	ODSVRA 2012 or 2013	SLO	5/10, 5/14, 5/23, 6/14, 7/8, 7/10, 7/11, 7/31, 8/2, 8/3, 8/4, 8/6, 8/7, 8/12, 8/17, 9/2, 9/4, 9/10, 9/15	ODSVRA breeding male.
GA:OG	M	ODSVRA 2014	SLO	6/30, 7/5, 7/11, 7/23, 7/30	ODSVRA breeding male.
GA:OW	M	ODSVRA 2013 or 2014	SLO	5/1, 5/4, 5/25, 5/30, 6/20, 8/15, 8/31	ODSVRA breeding male.
GA:OY	M	ODSVRA 2014	SLO	6/9, 8/14	
GA:PY	M	ODSVRA 2010	SLO	5/14, 5/15	ODSVRA breeding male.
GA:RB	F	ODSVRA 2010	SLO	3/4, 7/16	ODSVRA breeding female.
GA:VR	F	ODSVRA 2009	SLO	4/24, 5/30	ODSVRA breeding female.
GA:VW		ODSVRA 2014	SLO	9/8	
GA:VY	M	ODSVRA 2014	SLO	4/4, 5/31, 6/1, 6/9, 7/28, 7/31, 8/2, 8/13, 8/14, 8/15, 8/19, 8/22, 8/23	ODSVRA breeding male.
GA:WB	M	ODSVRA 2012 or 2013	SLO	3/25, 3/27, 4/1, 4/5, 4/20, 4/24, 5/17, 5/30, 7/15, 7/22, 7/24, 7/25, 7/27, 7/28, 7/31, 8/3, 8/4, 8/6, 8/7, 8/10, 8/11, 8/14	ODSVRA breeding male.
GA:YG	F	ODSVRA 2011 or 2013	SLO	3/28, 3/30, 4/11, 4/23	ODSVRA breeding female.
GA:YR	F	ODSVRA 2014	SLO	3/18, 3/21, 4/2, 4/4, 4/19, 4/21, 5/10, 5/18, 5/20, 6/4, 6/9, 7/17, 7/28, 7/30, 8/6, 8/9, 9/8	ODSVRA breeding female.
GA:YW	M	ODSVRA 2010 or 2013	SLO	3/4, 3/25, 6/9, 6/27, 6/28, 6/30, 7/9, 7/23, 7/24	ODSVRA breeding male.

Appendix D. Banded least terns and snowy plovers (continued).

Table D.3. Banded snowy plovers with known origins seen at ODSVRA 1 March to 30 September 2015 (continued).

Band	Sex	Origin and Year Banded	County Banded	Dates Seen	Notes
GG:AG	M	ODSVRA 2013 or 2014	SLO	4/11, 4/17, 4/26, 4/27, 5/3, 7/21, 7/29, 8/9	ODSVRA breeding male.
GG:AR		ODSVRA 2011	SLO	3/23	
GG:AY	F & M (3)	ODSVRA 2012 or 2013	SLO	3/7, 3/18, 3/28, 4/25, 5/3, 5/8, 5/17, 5/19, 5/20, 5/21, 5/31, 6/9, 6/17, 6/25, 6/27, 6/30, 7/7, 7/15, 7/17, 7/25, 7/27, 7/30, 8/6, 8/7, 8/8, 9/4, 9/8	ODSVRA breeding female and three breeding males.
GG:BG		ODSVRA 2013 or 2014	SLO	3/6, 4/22	
GG:BR	M	ODSVRA 2013 or 2014	SLO	3/4, 3/12, 3/17, 3/31, 5/17, 5/20, 5/23, 6/9, 6/14, 6/17, 6/24, 6/27, 7/10, 7/17, 8/11, 8/16, 8/20, 8/28	ODSVRA breeding male.
GG:BY	F	ODSVRA 2014	SLO	5/16	ODSVRA breeding female.
GG:GG		ODSVRA 2011 or 2013	SLO	3/5, 3/13, 3/18, 6/24, 7/9, 9/19	
GG:GR	F	ODSVRA 2011 or 2013	SLO	4/23, 5/19, 6/27, 7/17	ODSVRA breeding female.
GG:GW		ODSVRA 2014	SLO	9/2	
GG:OG		ODSVRA 2013 or 2014	SLO	3/4, 3/5, 3/6, 3/17, 3/21	
GG:OR	M	ODSVRA 2014	SLO	6/28, 6/29, 8/8, 8/20	ODSVRA breeding male.
GG:OW	M	ODSVRA 2014	SLO	6/8, 6/15, 7/4, 7/6, 7/10, 8/13, 8/26	ODSVRA breeding male.
GG:PB	M	ODSVRA 2012 or 2013	SLO	6/26, 8/9, 8/29, 9/14	ODSVRA breeding male.
GG:PG		ODSVRA 2014	SLO	8/13, 9/25	
GG:PW	M (3)	ODSVRA 2013 or 2014	SLO	3/4, 3/4, 3/5, 3/17, 3/18, 5/8, 5/13, 5/16, 5/17, 5/21, 5/30, 5/31, 6/9, 6/29, 7/1, 7/10, 7/11, 7/14, 7/23, 7/27, 7/28, 8/2, 8/3, 8/6, 8/7, 8/9, 8/10, 8/13, 8/16, 8/17, 8/19, 8/21, 9/8, 9/26	Three ODSVRA breeding males.
GG:RW	M	ODSVRA 2014	SLO	3/1, 3/17, 3/19, 4/24, 5/2, 5/3, 5/10, 5/16, 5/18, 5/25, 5/28, 6/8, 6/25, 6/27, 7/2, 7/9, 7/11, 7/16, 7/25, 7/28, 8/6, 8/18, 8/20, 8/26, 8/30, 9/8	ODSVRA breeding male.
GG:RY		ODSVRA 2012 or 2014	SLO	8/19	
GG:VG	M	ODSVRA 2014	SLO	3/4, 3/7, 3/13, 3/15, 3/17, 3/18, 3/25, 4/11, 4/14, 4/25, 5/6, 5/19, 5/24, 5/26, 6/2, 7/10, 7/15, 7/22, 7/27, 7/28, 7/30, 7/31, 8/7, 8/9, 8/10, 8/15, 9/30	ODSVRA breeding male.
GG:VR		ODSVRA 2011 or 2013	SLO	5/19	
GG:VR		ODSVRA 2011 or 2013	SLO	8/12, 8/13	
GG:VY	F	ODSVRA 2008, 2011, or 2013	SLO	3/4, 3/18, 5/18, 5/23, 7/4, 7/15, 8/5, 8/16, 8/30, 9/2	ODSVRA breeding female.
GG:WB	M	ODSVRA 2011 or 2013	SLO	4/19, 5/17, 5/25, 5/31, 6/17, 6/18, 6/27	ODSVRA breeding male.
GG:WG		ODSVRA 2014	SLO	3/12, 3/18	
GG:WW		ODSVRA 2012 or 2013	SLO	3/1	
GG:WY	F	ODSVRA 2012 or 2013	SLO	3/4, 5/17, 5/19, 6/25, 8/8, 8/12, 8/14	ODSVRA breeding female.
GG:YG	F & M	ODSVRA 2011 or 2013	SLO	3/1, 4/14, 5/5, 5/19, 5/21, 5/25, 6/9, 7/9, 7/10, 7/28, 8/2, 8/4, 8/17, 8/18	ODSVRA breeding female and male.

Table D.3. Banded snowy plovers with known origins seen at ODSVRA 1 March to 30 September 2015 (continued).

Band	Sex	Origin and Year Banded	County Banded	Dates Seen	Notes
GG:YW		ODSVRA 2013	SLO	3/18, 8/2, 8/24, 9/8	
PG:AG	F & M	ODSVRA 2012 or 2014	SLO	3/4, 3/6, 3/13, 3/17, 3/21, 4/28, 5/29, 6/2, 6/8, 6/24, 6/25, 6/29, 7/2, 7/5, 7/11, 7/17, 7/28, 8/5, 8/7, 9/14	ODSVRA breeding female and male.
PG:AR	M	ODSVRA 2014	SLO	3/6, 3/13, 3/25, 3/26, 4/4, 8/5, 8/7	ODSVRA breeding male.
PG:BW	F	ODSVRA 2012 or 2014	SLO	3/5, 3/12, 4/11, 6/13	ODSVRA breeding female.
PG:GG	F	ODSVRA 2012 or 2013	SLO	3/4, 4/4, 4/6, 4/23, 4/24, 5/25, 6/9, 7/15, 8/6, 8/11, 8/30, 9/26	ODSVRA breeding female.
PG:GR		ODSVRA 2011 or 2014	SLO	3/4, 3/18, 4/4, 4/17, 7/17	
PG:PB		ODSVRA 2014	SLO	8/7	
PG:PG		ODSVRA 2014	SLO	3/4, 3/5, 5/19, 6/27, 7/12, 7/17, 8/16, 8/17, 8/20, 9/6	
PG:PW	M	ODSVRA 2012 or 2014	SLO	3/10, 3/18, 3/19, 4/29, 5/6, 5/19, 6/10, 6/27, 7/21, 7/27, 8/6, 8/14, 8/15, 8/16, 8/17, 8/18	ODSVRA breeding male.
PG:VG	F	ODSVRA 2014	SLO	6/4, 8/21, 9/8	ODSVRA breeding female.
PG:VW	M	ODSVRA 2011 or 2013	SLO	3/4, 3/18, 4/2, 5/13, 6/29, 7/23, 7/31	ODSVRA breeding male.
PG:WY		ODSVRA 2014	SLO	3/20, 3/21, 4/19, 4/26	
PG:YG	F & M	ODSVRA 2014	SLO	3/28, 3/30, 4/11, 4/23, 4/28	ODSVRA breeding female and male.
PV:AR		ODSVRA 2014	SLO	8/9	
PV:BB		ODSVRA 2014	SLO	7/9	
PV:BG		ODSVRA 2011 or 2013	SLO	3/5, 8/22, 8/30	
PV:BR	M	ODSVRA 2007	SLO	3/18, 4/5, 4/13, 5/14	ODSVRA breeding male.
PV:GG	F	ODSVRA 2014	SLO	3/4, 3/12, 3/25, 5/17, 7/11, 8/12, 8/20, 8/21, 9/8, 9/11	ODSVRA breeding female.
PV:OG		ODSVRA 2011	SLO	5/29, 8/17	
PV:PW	F	ODSVRA 2014	SLO	3/17, 3/22, 4/7, 4/9, 6/18, 7/23, 7/24, 8/13, 8/14	ODSVRA breeding female.
PV:RW		ODSVRA 2014	SLO	4/26	
PV:VG	F	ODSVRA 2013	SLO	3/4, 6/24, 8/6, 8/13, 8/26, 8/30	ODSVRA breeding female.
PV:VY	F	ODSVRA 2009	SLO	3/23, 5/20, 7/10, 7/11, 8/16, 8/21	ODSVRA breeding female.
PV:WB	F	ODSRA 2007 or 2010	SLO	8/3, 8/5, 8/14, 8/16, 8/21, 8/22, 8/24, 9/2, 9/8	ODSVRA breeding female.
PV:YB	M	ODSVRA 2012	SLO	5/1, 5/18, 5/30, 6/4, 6/18, 6/21, 7/31, 8/7, 8/13, 8/16, 8/22	ODSVRA breeding male.
RR:OG	M	ODSVRA 2012	SLO	3/16, 5/18, 5/25, 6/9, 6/27	ODSVRA breeding male.
RR:OR	M	ODSVRA 2010	SLO	3/6, 5/14, 6/24, 7/7	ODSVRA breeding male.
RR:OY	F	ODSVRA 2010	SLO	4/19, 8/20	ODSVRA breeding female.
RR:PB	F	ODSVRA 2010	SLO	3/18, 5/11, 5/14, 5/17, 5/18, 9/25, 9/26	ODSVRA breeding female.

Appendix D. Banded least terns and snowy plovers (continued).

Table D.3. Banded snowy plovers with known origins seen at ODSVRA 1 March to 30 September 2015 (continued).

Band	Sex	Origin and Year Banded	County Banded	Dates Seen	Notes
RR:PW	F	ODSVRA 2014	SLO	3/17, 3/18, 4/29, 5/9, 6/9, 8/13, 8/16, 8/17	ODSVRA breeding female.
RR:RB		ODSVRA 2012	SLO	8/12	
RR:WB	M	ODSVRA 2011	SLO	5/1, 5/8, 5/25, 5/30, 6/9, 6/20, 8/5, 8/7, 8/14, 8/15, 8/17, 8/19	ODSVRA breeding male.
RR:YR		ODSVRA 2010	SLO	3/15	
RR:YY	M	ODSVRA 2010	SLO	4/6, 4/24, 5/20, 6/9, 6/24, 6/25, 6/27, 7/11, 7/23, 7/24, 8/2, 8/10, 8/13, 8/14, 8/17, 8/21, 8/26, 8/27	ODSVRA breeding male.
VG:AW	F	ODSVRA 2011 or 2013	SLO	3/12, 3/17, 6/7, 6/28, 7/2, 7/3, 8/7, 8/15, 8/31	ODSVRA breeding female.
VG:BR		ODSVRA 2013 or 2014	SLO	3/4, 9/2, 9/3, 9/6, 9/17, 9/27	
VG:BW		ODSVRA 2013	SLO	3/16	
VG:GW		ODSVRA 2011 or 2013	SLO	8/17	
VG:GY	M	ODSVRA 2013 or 2014	SLO	5/19, 6/24, 7/11	ODSVRA breeding male.
VG:OB	M	ODSVRA 2014	SLO	3/18, 4/24, 4/27, 5/17, 5/28, 5/31, 7/10, 8/10, 8/12, 8/13, 8/17, 8/20, 8/21, 8/30, 9/3	ODSVRA breeding male.
VG:OG	F	ODSVRA 2011	SLO	3/16, 5/14, 5/21, 5/28, 5/31, 7/16, 8/6, 8/13, 8/21, 9/2, 9/3, 9/11, 9/24, 9/26, 9/30	ODSVRA breeding female.
VG:PY		ODSVRA 2014	SLO	9/4	
VG:WB	M	ODSVRA 2012 or 2013	SLO	4/26, 5/4, 5/5, 5/21, 5/30, 6/9, 7/10	ODSVRA breeding male.
VG:WR		ODSVRA 2012	SLO	3/6, 4/2	
VG:YB	M	ODSVRA 2014	SLO	3/1, 3/18, 4/17, 4/23, 5/2, 6/18	ODSVRA breeding male.
VO:BW	M	ODSVRA 2014	SLO	4/7, 5/5, 5/25, 5/27, 6/9, 7/11, 7/15, 9/8	ODSVRA breeding male.
VV:AA	F	ODSVRA 2011	SLO	3/11, 3/21, 3/24, 4/10, 5/14, 8/6, 8/13, 8/16, 8/30, 9/23, 9/29	ODSVRA breeding female.
VV:AW		ODSVRA 2013 or 2014	SLO	5/29	
VV:BB		ODSVRA 2011 or 2013	SLO	5/17	
VV:BG	F (2)	ODSVRA 2009 or 2013	SLO	5/13, 6/21, 7/16, 7/31, 8/21, 8/23, 8/25, 8/26, 8/27, 9/30	Two ODSVRA breeding females.
VV:BW		ODSVRA 2014	SLO	5/19, 7/24, 8/3, 8/11, 8/20, 9/4, 9/15, 9/30	
VV:BY		ODSVRA 2007 or 2013	SLO	3/17, 4/17, 4/28, 5/5, 5/22, 8/5, 9/4	
VV:GB	M	ODSVRA 2009	SLO	4/16, 4/29, 6/9, 6/10, 6/27, 6/29, 7/11	ODSVRA breeding male.
VV:GR		ODSVRA 2012 or 2013	SLO	8/13, 8/30, 9/3, 9/5	
VV:OB		ODSVRA 2013	SLO	7/22, 8/13	
VV:VB	M	ODSVRA 2011 or 2013	SLO	5/21, 5/27, 6/9	ODSVRA breeding male.
VV:VG	F	ODSVRA 2009, 2011 or 2013	SLO	3/1, 4/9, 7/16, 8/6, 8/14, 8/15	ODSVRA breeding female.
VV:VR	M	ODSVRA 2008	SLO	5/11, 5/28, 6/4, 6/10, 6/15, 6/28, 6/29	ODSVRA breeding male.

Appendix D. Banded least terns and snowy plovers (continued).

Table D.3. Banded snowy plovers with known origins seen at ODSVRA 1 March to 30 September 2015 (continued).

Band	Sex	Origin and Year Banded	County Banded	Dates Seen	Notes
VV:VW	F (2)	ODSVRA 2008, 2011, or 2013	SLO	4/5, 5/5, 5/8, 7/4, 7/8, 7/28, 8/6, 8/7	Two ODSVRA breeding females.
VV:WB	M	ODSVRA 2013 or 2014	SLO	3/7, 3/13, 3/15, 3/17, 3/25, 3/26, 3/28, 4/3, 4/4, 5/17, 6/9, 6/14, 6/24, 7/28, 7/31, 8/5, 8/9, 9/14	ODSVRA breeding male.
VV:WG		ODSVRA 2012	SLO	3/12	
VV:WY	F	ODSVRA 2012 or 2013	SLO	5/19, 7/7, 7/30	ODSVRA breeding female.
VV:YB		ODSVRA 2012 or 2013	SLO	3/20	
VV:YW	M	ODSVRA 2011 or 2013	SLO	4/6, 7/15, 7/21, 7/27, 7/28, 7/30, 8/2, 8/15	ODSVRA breeding male.
AN:BB	J	VAFB 2015	Santa Barbara, CA	9/3	
AN:NB	J	VAFB 2015	Santa Barbara	9/17, 9/30	
B:Y/G		VAFB 2013	Santa Barbara	3/4, 3/12, 3/25,	
NB:OW	F	VAFB 2011	Santa Barbara	3/28	ODSVRA breeding female.
NB:PG	F	VAFB 2011	Santa Barbara	4/13, 4/17, 6/25, 6/26	ODSVRA breeding female.
NO:AB		VAFB 2012	Santa Barbara	8/23	
NO:AG	F	VAFB 2013	Santa Barbara	3/12, 5/25, 5/27, 5/30, 6/1, 6/14, 6/20	ODSVRA breeding female.
NO:GB	F & M	VAFB 2013	Santa Barbara	3/1, 3/4, 3/31, 4/29, 5/20, 5/23, 6/9, 6/17, 6/28, 8/13, 8/17, 9/3	ODSVRA breeding female and male.
NO:PB	M	VAFB 2014	Santa Barbara	4/24, 4/27, 5/9, 5/29, 6/24, 6/26, 8/4, 8/6	ODSVRA breeding male.
NO:WY	F	VAFB 2013	Santa Barbara	7/11, 7/19, 7/27, 7/28, 7/30, 7/31, 8/1, 8/2, 8/4, 8/6, 8/7, 8/17, 8/18, 8/26	ODSVRA breeding female.
NO:YW	J	VAFB 2015	Santa Barbara	9/7	
NR:GB	J	VAFB 2015	Santa Barbara		
NS:WW	F	VAFB 2009	Santa Barbara	5/25, 5/30, 7/15	ODSVRA breeding female.
NW:AW	J	VAFB 2015	Santa Barbara	8/14	
NW:WG		VAFB 2014	Santa Barbara	3/4, 3/13, 3/25, 4/11, 4/26, 8/6, 8/13, 8/30, 9/4, 9/17, 9/25	
NY:GW	J	VAFB 2015	Santa Barbara	7/10	
NY:NR	J	VAFB 2015	Santa Barbara	7/14	
NY:OY	J	VAFB 2015	Santa Barbara	8/14	
NY:RB	F	VAFB 2008 or 2013	Santa Barbara	5/24, 6/29, 8/4, 8/13	ODSVRA breeding female.
NY:WW	J	VAFB 2015	Santa Barbara	7/19	
NY:YR	J	VAFB 2015	Santa Barbara	6/27	
O:B/W		VAFB 2014	Santa Barbara	3/1	
P:W/O/W		VAFB 2013	Santa Barbara	3/10	
R:W/B/W	M	VAFB 2013	Santa Barbara	3/13, 4/28	ODSVRA breeding male.

Appendix D. Banded least terns and snowy plovers (continued).

Table D.3. Banded snowy plovers with known origins seen at ODSVRA 1 March to 30 September 2015 (continued).

Band	Sex	Origin and Year Banded	County Banded	Dates Seen	Notes
W-:Y/G		VAFB 2012	Santa Barbara	3/12	
Y:G/O/G		VAFB 2013	Santa Barbara	3/18, 3/25, 8/13	
GA:Y-	M	Unknown Origin		6/18, 6/29	ODSVRA breeding male.
RR:--	M	Unknown Origin		5/17, 5/19, 6/7, 6/8, 6/9, 6/17, 6/27, 6/29, 7/4, 7/5, 8/12, 8/16	ODSVRA breeding male.
V-:AY	M	Unknown Origin		5/14, 6/17, 6/30, 7/21	ODSVRA breeding male.
V-:BR	M (2)	Unknown Origin		6/21, 6/25, 6/26, 6/27, 7/23, 8/12	Two ODSVRA breeding males.
V-:VW	F	Unknown Origin		5/14, 5/16, 7/31, 8/4, 8/21, 8/30, 9/11, 9/30	ODSVRA breeding female.
Y-:GO	M	Unknown Origin		4/6, 4/8, 5/19, 5/21, 5/25, 5/27, 5/30, 6/4, 6/14, 7/28, 7/29, 8/7, 8/5	ODSVRA breeding male.

Table D.4. Snowy plovers banded as chicks at ODSVRA seen at other sites from 1 October 2014 to 28 February 2015.
This is a partial list based on information received from Point Blue Conservation Science (pers. comm. F. Bidstrup), Morro Bay State Park (pers. comm. R. Orr) and from sightings by ODSVRA staff at nearby sites. ODSVRA bands chicks to brood and some bands have been used multiple years and it is possible to have more than one bird with the same combination. (For a description of color band letter codes see Appendix B.)
VAFB = Vandenberg Air Force Base, SLO = San Luis Obispo, SB = State Beach

Band Combination	Year Banded	Location Seen	County	Dates Seen
RR:PW	2014	Manchester Beach	Mendocino, CA	10/21
VV:OB	2011	Half Moon Bay	San Mateo, CA	12/14
GG:BY	2014	Carmel River Mouth	Monterey, CA	12/31
GA:YG	2011 or 2013	Arroyo Laguna	SLO, CA	10/8, 10/15, 10/29, 11/4, 11/14, 11/18
GG:AG	2013 or 2014	Arroyo Laguna	SLO	10/8, 10/15, 10/22, 11/4, 11/18
GG:AY	2012 or 2013	Arroyo Laguna	SLO	11/4, 11/14,
GG:BG	2013 or 2014	Arroyo Laguna	SLO	10/22, 10/29
GG:PB	2012 or 2013	Arroyo Laguna	SLO	10/8, 10/15, 10/22, 10/29, 11/4, 11/14
GG:VG	2014	Arroyo Laguna	SLO	10/8, 10/15, 11/4, 11/14, 11/18
PG:GR	2011 or 2014	Arroyo Laguna	SLO	11/14
GA:YG	2011 or 2013	San Simeon	SLO	1/7, 1/14, 1/20, 2/4, 2/10
GG:AG	2013 or 2014	San Simeon	SLO	1/7, 1/14, 1/20, 1/28, 2/4, 2/10
GG:AY	2012 or 2013	San Simeon	SLO	1/7, 1/14, 1/20, 1/28
GG:BY	2014	San Simeon	SLO	1/14
GG:PB	2012 or 2013	San Simeon	SLO	1/7, 1/14, 1/20, 1/28, 2/4, 2/10
GG:VG	2014	San Simeon	SLO	1/7, 1/14, 1/20, 2/4
GG:YG	2011 or 2013	San Simeon	SLO	1/28
PV:BW	2012 or 2014	San Simeon	SLO	11/14
VV:YR	2014	San Simeon	SLO	1/7
GA:AG	2012 or 2013	Villa Creek	SLO	10/14, 10/29, 11/4
GG:AG	2013 or 2014	Villa Creek	SLO	2/11
PG:OB	2012 or 2014	Villa Creek	SLO	12/30,2/11
PV:GG	2014	Villa Creek	SLO	2/10
VG:OB	2014	Villa Creek	SLO	12/9,12/17,1/6,1/20,2/3,2/11
VV:YR	2014	Villa Creek	SLO	10/29
GA:AG	2012 or 2013	Morro Strand	SLO	12/3, 12/5, 12/9, 1/6
GA:VR	2009	Morro Strand	SLO	11/4
GG:AG	2013 or 2014	Morro Strand	SLO	11/4, 1/6, 1/20
GG:YB	2009 or 2013	Morro Strand	SLO	10/3, 10/22, 11/4, 11/18, 11/25, 12/3,12/9,12/19

Table D.4. Snowy plovers banded as chicks at ODSVRA seen at other sites from 1 October 2014 to 28 February 2015 (continued).

Band Combination	Year Banded	Location Seen	County	Dates Seen
PG:BB	2011, 2013, or 2014	Morro Strand	SLO	11/4, 11/18, 12/3, 12/5, 12/9
PG:BR	2012 or 2014	Morro Strand	SLO	10/8
PG:GY	2012 or 2014	Morro Strand	SLO	10/15,10/22,11/4,11/18,12/30,1/6,1/20
PG:OB	2012 or 2014	Morro Strand	SLO	11/18,11/19,11/25,12/17,1/6,1/20
PG:YG	2014	Morro Strand	SLO	11/25
PV:GG	2014	Morro Strand	SLO	11/4, 11/18,1/20
PV:RW	2014	Morro Strand	SLO	11/4,12/3,1/6
PV:RW	2014	Morro Strand	SLO	11/25,12/9
PV:W-	2008	Morro Strand	SLO	10/22,11/25,12/3,12/5,12/17,1/6
VG:OB	2014	Morro Strand	SLO	11/4
VV:WB	2013 or 2014	Morro Strand	SLO	10/3,10/15,10/22,11/18,11/25,12/3,12/9, 12/19,12/30,1/6,1/20,
VV:YR	2014	Morro Strand	SLO	11/4,11/18,11/25
GA:AG	2012 or 2013	Morro Bay Sandspit	SLO	12/17, 1/20
GA:VR	2009	Morro Bay Sandspit	SLO	10/8, 10/22, 10/29, 11/25, 12/17, 1/6, 1/20, 2/3, 2/10, 2/18
GA:YR	2014	Morro Bay Sandspit	SLO	11/18, 11/25, 1/6, 1/13, 1/20, 1/27, 2/18
GG:AG	2013 or 2014	Morro Bay Sandspit	SLO	10/15, 10/22, 10/29, 12/9,
GG:OG	2013 or 2014	Morro Bay Sandspit	SLO	10/22, 10/29, 11/18, 11/25, 12/17, 1/6, 1/20, 1/27, 2/3, 2/10, 2/18
GG:PB	2012 or 2013	Morro Bay Sandspit	SLO	2/18
GG:WB	2011 or 2013	Morro Bay Sandspit	SLO	10/8, 10/15, 10/22, 11/18,1/20, 2/3, 2/10, 2/18
GG:YB	2009 or 2013	Morro Bay Sandspit	SLO	10/15, 10/29
PG:BB	2011, 2013, or 2014	Morro Bay Sandspit	SLO	10/15, 10/22,
PG:BW	2012 or 2014	Morro Bay Sandspit	SLO	10/8, 11/25, 1/6, 1/13, 1/20,1/27, 2/3,2/18
PG:GY	2012 or 2014	Morro Bay Sandspit	SLO	12/17
PG:PW	2012 or 2014	Morro Bay Sandspit	SLO	10/22,10/29,11/18,12/9,1/6,1/20,2/3,2/10,2/18
PV:GG	2014	Morro Bay Sandspit	SLO	10/8,11/25,12/17,2/18
RR:WW	2010	Morro Bay Sandspit	SLO	10/8,10/15,10/22,10/29,2/3,2/10,2/18
VG:OB	2014	Morro Bay Sandspit	SLO	10/8,10/22,10/29
VV:GY	2014	Morro Bay Sandspit	SLO	10/8,10/15,11/18,11/25,1/6,1/13,1/20,1/27,2/11
VV:WB	2013 or 2014	Morro Bay Sandspit	SLO	12/17,2/10,2/18
GA:AB	2013	VAFB	Santa Barbara, CA	2/3, 2/16
GA:WB	2012 or 2013	VAFB	Santa Barbara	2/16
GG:WB	2011 or 2013	VAFB	Santa Barbara	11/25, 12/17, 12/28

Table D.4. Snowy plovers banded as chicks at ODSVRA seen at other sites from 1 October 2014 to 28 February 2015 (continued).

Band Combination	Year Banded	Location Seen	County	Dates Seen
GG:YY	2011 or 2013	VAFB	Santa Barbara	11/25
PG:YW	2012 or 2014	VAFB	Santa Barbara	11/24,12/22,1/20
PV:PW	2014	VAFB	Santa Barbara	2/3
PV:VB	2014	VAFB	Santa Barbara	11/24, 2/24
RR:LY	2010	VAFB	Santa Barbara	11/25,12/17,1/20
VG:VR	2009 or 2011	VAFB	Santa Barbara	11/25,12/4,12/17
VV:OA	2011	VAFB	Santa Barbara	1/20,2/3
GA:VG	2012 or 2013	Jalama Beach	Santa Barbara	11/25, 12/20, 12/21, 1/21
GG:VW	2013 or 2014	Jalama Beach	Santa Barbara	11/25, 12/20, 1/21
GG:WY	2012 or 2013	Jalama Beach	Santa Barbara	12/20, 12/21, 1/21
PG:AW	2012 or 2014	Jalama Beach	Santa Barbara	11/25, 12/20, 12/21, 1/21
RR:PB	2007 or 2010	Jalama Beach	Santa Barbara	1/21
GA:OY	2014	Malibu Lagoon	Los Angeles, CA	10/3, 12/28
GG:AR	2011	Malibu Lagoon	Los Angeles	12/28
VV:AW	2013 or 2014	Malibu Lagoon	Los Angeles	10/17
VG:AY	2011 or 2013	Bolsa Chica	Orange, CA	10/22, 12/31
GA:GB	2012, 2013, or 2014	San Quintin	Baja California, Mexico	11/1, 12/11, 1/22
GA:WB	2012 or 2013	San Quintin	Baja California, Mexico	12/11, 1/22
GG:AB	2007	San Quintin	Baja California, Mexico	12/11, 1/22

Table D.5. Snowy plovers banded as chicks at ODSVRA seen at other sites from 1 March to 30 September 2015.
This is a partial list based on information received from Point Blue Conservation Science (pers. comm. F. Bidstrup, J. Miller), Morro Bay State Park (pers. comm. R. Orr), Chevron property in Guadalupe-Nipomo Dunes complex (pers. comm. K. Paradis), and from sightings by ODSVRA staff at nearby sites. Note: ODSVRA bands chicks to brood and some bands have been used multiple years and it is possible to have more than one bird with the same combination. (For a description of color band letter codes see Appendix B.)
SLO = San Luis Obispo, Chevron = Chevron property in Guadalupe-Nipomo Dunes complex, NWR = National Wildlife Refuge, SB = State Beach, VAFB = Vandenberg Air Force Base
J = juvenile, M = male, F = female.

Band Combination	Year Banded	Sex or Age	Location Seen	County	Dates Seen	Notes
GG:OB	2013 or 2014	M	Eel River Wildlife Area	Humboldt, CA	7/15, 7/29	Eel River Wildlife Area breeding male.
VG:AB	2011 or 2013		Eel River Wildlife Area	Humboldt	5/19, 5/29	
GG:OB	2013 or 2014	M	MacKerricher SP	Mendocino, CA	5/2	
VG:BG	2011		Salinas River SB	Monterey, CA	8/15	
GG:AG	2013 or 2014	F	Arroyo Laguna Creek	SLO, CA	9/17, 9/24	
PV:BY	2015	J	Arroyo Laguna Creek	SLO	9/3	
PV:YW	2015	J	Arroyo Laguna Creek	SLO	8/25, 9/3	
VV:YR	2014 or 2015		Arroyo Laguna Creek	SLO	9/24	
GA:YG	2011 or 2013	F	San Simeon	SLO	3/5, 3/21	
GG:AG	2013 or 2014	F	San Simeon	SLO	3/25, 4/2, 4/15, 4/17, 4/22	
GG:AG	2013 or 2014		Villa Creek	SLO	3/4, 3/12	
PG:OB	2012 or 2014	F	Villa Creek	SLO	3/6, 3/26	
PG:YB	2015	J	Villa Creek	SLO	7/29	
PV:W-	2008	M	Villa Creek	SLO	3/10, 3/11, 3/18, 3/20, 3/23, 3/26, 3/30, 4/8, 4/9, 4/14, 4/16, 4/22, 4/24, 4/28, 4/30, 5/3, 5/5, 5/6, 5/7, 5/8, 5/12, 5/14, 5/15, 5/18, 5/19, 5/20, 5/22, 5/26, 5/27, 5/28, 6/1, 6/4, 6/5, 6/8, 6/9, 6/10	Villa creek breeding male. Banded in 2008 as PV:PW. On 21 August and 22 September, observed with missing pink band on left leg. Now banded V-:W-.
PV:WR	2015	J	Villa Creek	SLO	9/3	
VG:OB	2014	F	Villa Creek	SLO	3/16, 3/18, 3/20, 3/23, 3/30, 4/2, 4/6, 4/9, 4/13, 4/14, 4/15, 4/16, 4/22, 4/24, 4/27, 4/28, 4/29, 4/30, 5/1, 5/3, 5/4, 5/5, 5/6, 5/8, 5/12, 5/13, 5/14, 5/15	Villa Creek breeding female.
VG:VB	2015	J	Villa Creek	SLO	7/13	
VV:RG	2015	J	Villa Creek	SLO	7/28	
GA:GR	2015	J	Morro Strand SB	SLO	9/1	
GA:PG	2015	J	Morro Strand SB	SLO	9/3	
GG:AB	2015	J	Morro Strand SB	SLO	9/1	

Table D.5. Snowy plovers banded as chicks at ODSVRA seen at other sites from 1 March to 30 September 2015.

Band Combination	Year Banded	Sex or Age	Location Seen	County	Dates Seen	Notes
PV:AB	2014 or 2015		Morro Strand SB	SLO	9/3, 9/10, 9/24	
V-:W-	2008	M	Morro Strand SB	SLO	8/21	Originally banded PV:PW
VG:VB	2015	J	Morro Strand SB	SLO	7/11, 7/14	
VV:RW	2015	J	Morro Strand SB	SLO	9/1	
BB:GR	2015	J	Morro Bay Sandspit	SLO	8/6, 8/7, 8/28	
BB:RB	2015	J	Morro Bay Sandspit	SLO	8/7	
GA:AR	2015	J	Morro Bay Sandspit	SLO	8/7, 8/25, 8/28, 9/1, 9/10, 9/22, 9/24	Tape is peeling on red band.
GA:OY	2015	J	Morro Bay Sandspit	SLO	8/27, 8/28, 9/1, 9/10, 9/22, 9/24	
GA:VR	2009	F	Morro Bay Sandspit	SLO	3/3, 8/25, 8/27, 9/17, 9/22	
GA:VW	2015	J	Morro Bay Sandspit	SLO	7/27, 7/28	
GA:VY	2015	J	Morro Bay Sandspit	SLO	9/3	
GA:YR	2014	F	Morro Bay Sandspit	SLO	3/3, 8/25	
GG:BR	2013 or 2014	F	Morro Bay Sandspit	SLO	5/22	
GG:GW	2015	J	Morro Bay Sandspit	SLO	7/28, 8/4, 8/5, 8/7, 8/9	
GG:OG	2013 or 2014	M	Morro Bay Sandspit	SLO	3/11, 3/26, 3/31, 4/8, 4/9, 4/14, 4/22, 4/23, 4/27, 4/28, 4/30, 5/1, 5/4, 5/5, 5/6, 5/11, 5/12, 5/15, 5/18, 5/19, 5/20, 5/25, 5/26, 5/27, 6/3, 6/5, 6/6, 6/8, 6/9, 6/12, 6/15, 6/16, 6/18, 6/19, 7/1, 7/7, 7/9, 8/9, 8/27, 9/8, 9/10, 9/22, 9/24	Morro Bay Sandspit breeding male.
GG:PB	2012 or 2013	F	Morro Bay Sandspit	SLO	3/3, 3/11, 3/12, 3/16, 3/31, 4/9, 4/10, 4/13, 4/17, 4/20, 4/22, 4/23, 4/27, 4/29, 4/30, 5/5, 5/13, 5/15, 5/18, 5/19, 5/22, 5/25, 5/26, 5/27, 5/29, 6/3, 6/4, 6/9, 6/12, 7/16, 8/9, 8/21, 8/28, 9/3, 9/17	Morro Bay Sandspit breeding female.
GG:VG	2014	F	Morro Bay Sandspit	SLO	7/14	
GG:WB	2011 or 2013	F	Morro Bay Sandspit	SLO	3/3, 3/4, 3/10, 3/13, 3/16, 3/17, 3/18, 3/20, 8/25, 8/27, 8/28, 9/3	Morro Bay Sandspit breeding female.
GG:WG	2015	J	Morro Bay Sandspit	SLO	7/30, 8/8, 8/20, 8/25, 9/15, 9/17	
PG:BW	2012 or 2014	M	Morro Bay Sandspit	SLO	3/3, 3/4, 3/26, 4/14, 4/16, 4/29, 5/5, 5/7, 5/8, 5/12, 5/13, 5/15, 5/19, 5/21, 5/26, 5/27, 6/3, 6/9, 6/11, 6/18, 7/3, 7/9, 7/11, 7/16, 8/9, 8/18, 8/25, 9/3, 9/22, 9/24	Morro Bay Sandspit breeding male.
PG:GW	2015	J	Morro Bay Sandspit	SLO	7/15, 7/17	
PG:GY	2012 or 2014	F	Morro Bay Sandspit	SLO	3/13	
PG:OB	2012 or 2014	F	Morro Bay Sandspit	SLO	3/11, 3/17, 4/14, 4/21, 4/28, 5/18, 5/21, 5/26, 5/27, 5/28, 6/11, 6/12, 6/15, 6/19, 7/16, 8/9, 8/18, 8/25, 9/22, 9/24	Morro Bay Sandspit breeding female.
PG:OW	2015	J	Morro Bay Sandspit	SLO	9/22	
PG:PW	2014	M	Morro Bay Sandspit	SLO	3/3	

Table D.5. Snowy plovers banded as chicks at ODSVRA seen at other sites from 1 March to 30 September 2015.

Band Combination	Year Banded	Sex or Age	Location Seen	County	Dates Seen	Notes
PG:WG	2015	J	Morro Bay Sandspit	SLO	9/15, 9/22, 9/24	
PG:WW	2015	J	Morro Bay Sandspit	SLO	8/6, 8/20	
PG:YB	2015	J	Morro Bay Sandspit	SLO	7/30, 8/3, 8/5, 8/13, 8/19, 8/20	
PG:YG	2014	M	Morro Bay Sandspit	SLO	4/24	
PG:YY	2015	J	Morro Bay Sandspit	SLO	9/3, 9/10	
PV:AB	2014 or 2015		Morro Bay Sandspit	SLO	4/22, 8/20, 8/21, 8/27, 9/15, 9/17	
PV:AR	2014 or 2015		Morro Bay Sandspit	SLO	9/22, 9/24	
PV:BY	2015	J	Morro Bay Sandspit	SLO	9/8, 9/22	
PV:GG	2014 or 2015		Morro Bay Sandspit	SLO	3/3, 7/30	
PV:PB	2015	J	Morro Bay Sandspit	SLO	8/1, 8/3, 8/5, 8/12, 8/13, 8/28, 9/8, 9/22	
PV:RY	2015	J	Morro Bay Sandspit	SLO	8/19, 8/20, 9/8	
PV:VR	2015	J	Morro Bay Sandspit	SLO	8/27, 9/22	
PV:W-	2008	M	Morro Bay Sandspit	SLO	7/7, 7/11	Banded in 2008 as PV:PW. On 21 August and 22 September, observed with missing pink band on left leg. Now banded V-:W-.
PV:WR	2015	J	Morro Bay Sandspit	SLO	8/25, 9/15	
PV:WY	2014	M	Morro Bay Sandspit	SLO	4/6	
PV:YG	2015	J	Morro Bay Sandspit	SLO	9/3, 9/8, 9/10, 9/15	
PV:YW	2015	J	Morro Bay Sandspit	SLO	8/18, 8/19, 8/21	
RR:WW	2010	M	Morro Bay Sandspit	SLO	3/3, 3/4, 3/5, 3/6, 3/9, 3/10, 3/16, 3/20, 3/25, 3/31, 4/1, 4/9, 4/21, 5/7, 5/12, 5/14, 5/26, 5/27, 5/29, 6/2, 6/9, 6/11, 6/30, 7/9, 7/13, 7/14, 8/19, 8/20, 8/25	Morro Bay Sandspit breeding male.
V-:W-	2008		Morro Bay Sandspit	SLO	9/22	Originally banded PV:PW.
VG:BR	2013 or 2014	F	Morro Bay Sandspit	SLO	4/20, 4/23, 4/24, 5/1, 5/7, 5/12, 5/19, 5/26, 5/27, 6/9, 6/11, 6/17, 6/18, 7/9, 7/14, 8/9, 8/19, 8/27, 8/28	Morro Bay Sandspit breeding female.
VG:PY	2015	J	Morro Bay Sandspit	SLO	9/15, 9/17, 9/22, 9/24	
VV:GR	2012 or 2013	F	Morro Bay Sandspit	SLO	3/25, 3/31, 4/1, 5/12, 5/19, 5/22, 6/9, 7/1, 7/7	
VV:GY	2014	M	Morro Bay Sandspit	SLO	3/4, 3/31, 4/1, 4/23	Morro Bay Sandspit breeding male.
VV:RG	2015	J	Morro Bay Sandspit	SLO	7/30	
VV:WB	2013 or 2014	M	Morro Bay Sandspit	SLO	3/10, 3/17, 4/1, 4/3, 4/4, 4/14	Morro Bay Sandspit breeding male.
PG:GY	2012 or 2014		Diablo Power Plant	SLO	3/20	Carcass found.

Table D.5. Snowy plovers banded as chicks at ODSVRA seen at other sites from 1 March to 30 September 2015.

Band Combination	Year Banded	Sex or Age	Location Seen	County	Dates Seen	Notes
GG:RG	2012 or 2014	F	Guadalupe-Nipomo Dunes NWR	SLO	5/20, 6/19	
PG:PG	2014	M	Guadalupe-Nipomo Dunes NWR	SLO	5/20, 7/17	NWR breeding male.
PV:PY	2014	F	Guadalupe-Nipomo Dunes NWR	SLO	5/20	
VV:BB	2011 or 2013	M	Guadalupe-Nipomo Dunes NWR	SLO	5/20	
BB:GY	2006	M	Chevron	SLO	3/18, 3/20, 3/25, 4/3, 4/6, 4/10, 4/13, 4/15, 4/17, 4/20, 4/22, 4/29, 5/8, 5/12, 5/13, 5/15, 5/18, 5/20, 6/15	Chevron breeding male.
BB:LY	2010	F	Chevron	SLO	6/8, 6/19	
BB:OW	2015	J	Chevron	SLO	7/8	
BB:OY	2015	J	Chevron	SLO	7/24, 7/27	
BB:PG	2013 or 2014		Chevron	SLO	7/20	
BB:RW	2015	J	Chevron	SLO	8/19	
BB:WG	2010 or 2013	F	Chevron	SLO	3/23, 3/25, 3/27, 3/30, 4/6, 4/10, 4/13, 4/15, 4/17, 4/20, 4/27	Chevron breeding female.
BB:YG	2011	F	Chevron	SLO	4/8, 7/22	
GA:PW	2015	J	Chevron	SLO	8/25, 9/8	
GG:AB	2015	J	Chevron	SLO	7/17	
GG:AY	2012 or 2013	M	Chevron	SLO	4/24	
GG:GR	2011 or 2013	M	Chevron	SLO	5/18, 5/20, 5/22, 5/26	
GG:GW	2014	M	Chevron	SLO	7/15	
GG:LY	2012	F	Chevron	SLO	3/13, 3/16, 3/18, 3/20, 3/23, 3/30, 4/1, 4/6, 4/8, 4/15, 4/17, 4/20, 4/22, 5/20, 5/29, 6/26, 7/2, 7/8, 9/10	Chevron breeding female.
GG:WB	2011 or 2013	M	Chevron	SLO	4/20	
GG:WG	2014	F	Chevron	SLO	4/22	
GG:WR	2014	M	Chevron	SLO	4/20, 4/22	
PG:AB	2012 or 2014	M	Chevron	SLO	3/20, 4/15, 4/17, 5/29, 6/1	
PG:AG	2012 or 2014	F	Chevron	SLO	3/11, 3/13, 3/16, 3/18, 3/20, 3/23, 4/1, 4/3, 4/10, 4/15, 4/24, 4/27, 5/12, 5/13, 5/18, 5/20, 6/3, 6/12, 6/15, 7/2, 7/8, 7/15, 7/29	Chevron breeding female.
PG:GR	2011 or 2014	F	Chevron	SLO	3/18	
PG:PY	2014	M	Chevron	SLO	5/12, 5/13, 5/18, 5/20, 5/27, 5/29, 6/3, 6/8, 6/12, 6/17, 6/19, 6/24, 7/2, 7/3, 7/8, 7/10, 7/15, 7/17	
PG:RY	2014	M	Chevron	SLO	4/22, 4/29, 5/5, 5/6, 6/26, 7/3, 7/29, 7/31	

Table D.5. Snowy plovers banded as chicks at ODSVRA seen at other sites from 1 March to 30 September 2015.

Band Combination	Year Banded	Sex or Age	Location Seen	County	Dates Seen	Notes
PG:WG	2014		Chevron	SLO	8/27, 9/1, 9/8	
PV:AB	2014 or 2015	F	Chevron	SLO	7/29	
PV:BY	2015	J	Chevron	SLO	8/27	
PV:GW	2015	J	Chevron	SLO	8/12	
PV:WY	2015	J	Chevron	SLO	9/8	
RR:BY	2010	M	Chevron	SLO	4/29	
RR:WG	2012	M	Chevron	SLO	3/13, 3/16, 3/20, 3/23, 3/25, 3/30, 4/3, 4/6, 4/10, 4/15, 4/17, 4/22, 4/27, 6/1, 6/3, 6/5, 6/12, 6/26, 7/6, 7/10, 7/17, 7/20, 7/22, 7/24	
VG:AW	2011 or 2013	F	Chevron	SLO	6/26	
VG:OY	2015	J	Chevron	SLO	9/8, 9/10	
VG:VW	2011 or 2013	M	Chevron	SLO	4/8, 4/10, 4/20, 4/27, 5/15, 5/20, 5/22, 6/3, 6/12, 6/19, 6/24, 6/26, 7/3, 7/6	Chevron breeding male.
VG:VY	2015	J	Chevron	SLO	7/29	
VG:WR	2012 or 2015		Chevron	SLO	9/10	
VV:AW	2013 or 2014		Chevron	SLO	7/3	
VV:BW	2015	J	Chevron	SLO	7/22, 7/24	
VV:GW	2009	F	Chevron	SLO	7/6	
VV:GY	2014		Chevron	SLO	9/8	
VV:OY	2015	J	Chevron	SLO	9/2, 9/8, 9/10	
VV:WG	2012	F	Chevron	SLO	3/30, 4/1, 4/6, 4/8, 4/10, 4/13, 4/15, 4/17, 4/22, 5/18, 6/3, 6/19, 7/10, 7/24, 9/10	Chevron breeding female.
VV:WR	2015	J	Chevron	SLO	7/29	
BB:RB	2015	J	VAFB	Santa Barbara	8/18	
BB:RW	2015	J	VAFB	Santa Barbara	8/12	
GA:AB	2013	F	VAFB	Santa Barbara	3/10, 5/5	VAFB breeding female.
GA:GR	2015	J	VAFB	Santa Barbara	8/18, 8/20	
GA:WB	2012 or 2013	F	VAFB	Santa Barbara	3/10, 7/22, 8/7	VAFB breeding female.
GG:AG	2013 or 2014	F	VAFB	Santa Barbara	6/19, 8/27, 9/3	
GG:AY	2012 or 2013		VAFB	Santa Barbara	3/10, 3/16, 3/30, 8/20, 9/2, 9/9, 9/14	
GG:WB	2011 or 2013	M	VAFB	Santa Barbara	6/12, 8/5, 8/7, 8/12, 8/24	VAFB breeding male.
PG:BB	2011, 2013, or 2014		VAFB	Santa Barbara	7/21	
PG:GR	2011 or 2014		VAFB	Santa Barbara	8/26, 9/2, 9/14	
PG:OB	2012 or 2014	M	VAFB	Santa Barbara	3/10	
PG:PG	2015	J	VAFB	Santa Barbara	8/20	

Table D.5. Snowy plovers banded as chicks at ODSVRA seen at other sites from 1 March to 30 September 2015.

Band Combination	Year Banded	Sex or Age	Location Seen	County	Dates Seen	Notes
PG:RW	2012		VAFB	Santa Barbara	7/1	
PG:VB	2015	J	VAFB	Santa Barbara	8/20	
PG:YW	2012 or 2014	F	VAFB	Santa Barbara	3/11, 3/19, 3/26, 6/30, 9/14	
PV:AG	2015	J	VAFB	Santa Barbara	8/13	
PV:AR	2014 or 2015		VAFB	Santa Barbara	8/18	
PV:BB	2014		VAFB	Santa Barbara	3/30	
RR:LY	2010	M	VAFB	Santa Barbara	3/9, 3/13, 3/18, 3/20, 3/23, 3/27, 3/30, 6/12, 8/5, 8/10, 8/12, 8/18, 8/24, 9/1, 9/9, 9/23	
RR:WY	2010		VAFB	Santa Barbara	3/9	
VG:WR	2015	J	VAFB	Santa Barbara	8/20, 8/24	
VG:YB	2015	J	VAFB	Santa Barbara	8/4, 8/20	
VV:AW	2013 or 2014	F	VAFB	Santa Barbara	3/13, 3/18, 3/20, 3/23, 3/27, 3/30, 5/18, 6/12, 8/5, 8/7, 8/12, 8/18, 8/27, 9/1, 9/9, 9/23	
VV:OA	2011	F	VAFB	Santa Barbara	3/11, 3/19, 3/26, 3/30	
VW:BB	2015	J	VAFB	Santa Barbara	8/20, 8/26, 9/14	
GA:VG	2012 or 2013		Jalama Beach	Santa Barbara	8/19	
PG:AW	2012 or 2014		Jalama Beach	Santa Barbara	8/19	
GA:OY	2014	F	Coal Oil Point	Santa Barbara	5/22	Coal Oil Point breeding female.
GA:YR	2014	F	Coal Oil Point	Santa Barbara	5/22	
GG:GG	2011 or 2013	M	Coal Oil Point	Santa Barbara	5/22	Coal Oil Point breeding male.
GA:GR	2015	J	Point Mugu	Ventura	8/25	
PV:VW	2015	J	Malibu Lagoon SB	Los Angeles	8/29	
GA:AB	2013 or 2015		Hermosa Beach	Los Angeles	7/29	
PG:RW	2012		Hermosa Beach	Los Angeles	7/11	
PV:RW	2014 or 2015		Hermosa Beach	Los Angeles	8/28	
VV:BW	2014 or 2015		Huntington Beach	Orange	7/29	
GA:OY	2014		Bolsa Chica	Orange County	6/20	
GG:AB	2015	J	Carlsbad SB	San Diego	7/24	
VG:GY	2013 or 2014	M	Cardiff SB	San Diego	5/4	
BB:YR	2015	J	Camp Pendleton	San Diego	7/18	
PG:BR	2012 or 2014		Camp Pendleton	San Diego	7/4	
RR:YY	2010		Silver Strand SB	San Diego	3/15	
BB:BG	2015	J	Tijuana River Mouth	San Diego	8/13, 8/16	
GA:AB	2013 or 2015		Tijuana River Mouth	San Diego	7/30,8/13	

Appendix E. Addendums to snowy plover nesting success.

Table E.1. Nesting success of snowy plovers in identifiable areas at ODSVRA, 2001-15.
Nests from unknown locations (identified only by presence of broods) are not included in table. Percent nests hatching is calculated using number of hatching nests from known location divided by number of known location and fate nests. Those chicks whose specific area where hatching could not be identified are not included in table. Beginning in 2006, an additional 0.4 mile of shoreline at the southern end of the park has been monitored by ODSVRA (a survey conducted by the Guadalupe-Nipomo Dunes NWR in 2005 determined this area was part of the ODSVRA and not the refuge, as was previously thought). Between 1998-2003, increases occurred in the size of the seasonal Southern Exclosure; size has remained consistent since 2004. Information on areas in table is provided in the report Site Description section on page 3.
Excl. = Exclosure, BY = Boneyard

Year	Area	No. known location nests	No. nests with known location and known fate	No. nests with known location hatching	% nests hatching	No. chicks from known location	No. chicks from known location and with known fate	No. chicks from known location and with known fate fledged	% chicks known fledged
	Open Riding Area	1	1	0	0	0	0	0	0
	Arroyo Grande Excl. [1]	3	3	3	100	9	9	0	0
	Southern Exclosure	25	24	21	88	56	56	2	4
	Oso Flaco	4	2	2	100	6	6	1	17
2001	**Total**	**33**	**30**	**26**	**87**	**71**	**71**	**3**	**4**
	Southern Exclosure	33	33	25	76	62	62	35	56
	Oso Flaco	2	2	0	0	0	0	0	0
2002	**Total**	**35**	**35**	**25**	**71**	**62**	**62**	**35**	**56**
	Dune Preserve	1	1	1	100	3	3	0	0
	Open Riding Area	1	1	1	100	3	3	3	100
	Pipeline Revegetation	3	3	2	67	4	4	2	50
	East of BY Exclosure [2]	2	2	1	50	3	3	2	67
	Southern Exclosure	74	73	52	71	136	135	92	68
	Oso Flaco	13	13	5	38	11	11	7	64
2003	**Total**	**94**	**93**	**62**	**67**	**160**	**159**	**106**	**67**
	Open Riding Area	1	1	0	0	0	0	0	0
	Pipeline Revegetation	1	1	1	100	3	3	0	0
	Southern Exclosure	113	111	87	78	208	205	59	29
	Oso Flaco	27	27	17	63	40	39	7	18
2004	**Total**	**142**	**140**	**105**	**75**	**251**	**247**	**66**	**27**
	East of BY Exclosure [2]	2	2	2	100	6	6	2	33
	Southern Exclosure	79	79	60	76	142	142	57	40
	Oso Flaco	22	22	18	82	49	49	23	47
2005	**Total**	**103**	**103**	**80**	**78**	**197**	**197**	**82**	**42**
	Open Riding Area	1	1	0	0	0	0	0	0
	Southern Exclosure	87	84	65	77	173	173	8	5
	Oso Flaco	29	29	22	76	57	57	9	16
2006	**Total**	**117**	**114**	**87**	**76**	**230**	**230**	**17**	**7**
	Southern Exclosure	76	76	61	80	159	157	58	37
	Oso Flaco	15	15	9	60	20	20	4	20
2007	**Total**	**91**	**91**	**70**	**77**	**179**	**177**	**62**	**35**
	Southern Exclosure	100	100	73	73	172	172	64	37
	Oso Flaco	19	19	8	42	19	19	5	26
2008	**Total**	**119**	**119**	**81**	**68**	**191**	**191**	**69**	**36**

Appendix E. Addendums to snowy plover nesting success (continued).

Table E.1. Nesting success of snowy plovers in identifiable areas at ODSVRA, 2001-15 (continued).

Year	Area	No. known location nests	No. nests with known location and known fate	No. nests with known location hatching	% nests hatching	No. chicks from known location	No. chicks from known location and with known fate	No. chicks from known location and with known fate fledged	% chicks known fledged
	Pismo Lagoon	1	1	0	0	0	0	0	0
	Southern Exclosure	125	124	86	69	221	221	79	36
	Oso Flaco	23	22	8	36	22	22	2	9
2009	**Total**	**149**	**147**	**94**	**64**	**243**	**243**	**81**	**33**
	Carpenter Creek	1	1	0	0	0	0	0	0
	Arroyo Grande Creek	3	3	0	0	0	0	0	0
	Open Riding Area	1	1	1	100	2	2	2	100
	Southern Exclosure	126	123	95	77	234	234	86	37
	Oso Flaco	22	22	13	59	33	33	15	45
2010	**Total**	**153**	**150**	**109**	**73**	**269**	**269**	**103**	**38**
	Open Riding Area	2	2	2	100	5	5	1	20
	Southern Exclosure	140	135	113	84	300	300	129	43
	Oso Flaco	23	23	16	70	40	40	18	45
2011	**Total**	**165**	**160**	**131**	**82**	**345**	**345**	**148**	**43**
	Open Riding Area	3	3	0	0	0	0	0	0
	Southern Exclosure	194	186	143	77	353	353	85	24
	Oso Flaco	14	14	9	64	21	21	4	19
2012	**Total**	**211**	**203**	**152**	**75**	**374**	**374**	**89**	**24**
	Southern Exclosure	147	144	115	80	288	288	147	51
	Oso Flaco	23	23	15	65	39	39	25	64
2013	**Total**	**170**	**167**	**130**	**78**	**327**	**327**	**172**	**53**
	Open Riding Area	1	1	0	0	0	0	0	0
	Southern Exclosure	201	194	173	89	428	428	142	33
	Oso Flaco	44	44	33	75	86	86	35	41
2014	**Total**	**246**	**239**	**206**	**86**	**514**	**514**	**177**	**34**
	Arroyo Grande Creek[3]	1	-	1	-	2	2	0	0
	Southern Exclosure	182	175	153	87	401	401	215	54
	Oso Flaco	20	20	14	70	39	39	24	62
2015	**Total**	**203**	**195**	**168**	**86**	**442**	**442**	**239**	**54**

[1]Arroyo Grande Excl.: A seasonal exclosure (with two-inch by four-inch wire mesh fencing and closed from the riding area) in use in 2001 and 2002, but not subsequently. This area had three nests in 2001, none in 2002.

[2]East of BY Exclosure: Area closed to vehicles year-around and open to pedestrians. There were two nests in 2003 and two nests in 2005. All nests had a single nest exclosure (10-foot by 10-foot exclosure).

[3]Brood with approximately one-day-old chicks found in Arroyo Grande Creek area, likely from an unknown nest nearby.

Appendix E. Addendums to snowy plover nesting success (continued).

Table E.2. Nest protection used at ODSVRA in 2015.
Nests with unknown location and unknown fate nests are excluded. The large seasonal exclosure is the portion of 6, 7, 8, Boneyard exclosures, and North Oso Flaco that is protected with predator fencing (does not include the shoreline). Any use of single nest circular exclosures (used in conjunction with symbolic rope fencing) occurred on the shoreline of the 6, 7, 8 exclosures, North Oso Flaco, and South Oso Flaco. Percent in parentheses is percent nests hatched. un=unknown predator; av=avian; rav=common raven; pre=abandoned pre-term; pos=abandoned post-term; ukp=abandoned unknown pre- or post-term; win=abandoned, suspected wind; unk=failed, cause unknown.

Area	Large seasonal exclosure		Symbolic fencing	
	No additional fencing	Bumpout	No additional fencing	Circular
6 exclosure	59	4	11	0
Nests hatched	53 (90%)	4 (100%)	9 (82%)	
Nests depredated				
Nests failed other causes	6 (5 pre, 1 ukp)		2 (1 pos, 1 ukp)	
7 exclosure	32	1	20	0
Nests hatched	29 (91%)	1 (100%)	18 (90%)	
Nests depredated				
Nests failed other causes	3 (2 pre, 1 win)		2 (1 pre, 1 ukp)	
8 exclosure	33	1	5	0
Nests hatched	29 (88%)		4 (80%)	
Nests depredated	1 (1 rav)			
Nests failed other causes	3 (2 pre, 1 ukp)	1 (1 pre)	1 (1 unk)	
Boneyard	9	0		
Nests hatched	6 (67%)			
Nests depredated	2 (2 av)			
Nests failed other causes	1 (1 unk)			
SOUTHERN EXCLOSURE TOTALS	133	6	36	0
Nests hatched	117 (88%)	5 (83%)	31 (86%)	
Nests depredated	3 (2 av, 1 rav)			
Nests failed other causes	13 (9 pre, 2 ukp, 1 win, 1 unk)	1 (1 pre)	5 (1 pre, 1 pos, 2 ukp, 1 unk)	
North Oso Flaco	0	0	4	3
Nests hatched			2 (50%)	3 (100%)
Nests depredated			2 (1 un, 1 rav)	
Nests failed other causes				
South Oso Flaco			8	5
Nests hatched			4 (50%)	5 (100%)
Nests depredated			2 (2 rav)	
Nests failed other causes			2 (1 pre, 1 unk)	
OSO FLACO TOTALS	0	0	12	8
Nests hatched			6 (50%)	8 (100%)
Nests depredated			4 (1 un, 3 rav)	
Nests failed other causes			2 (1 pre, 1 unk)	
GRAND TOTAL	133	6	48	8
Nests hatched	117 (88%)	5 (84%)	37 (77%)	8 (100%)
Nests depredated	3 (2 av, 1 rav)		4 (1 un, 3 rav)	
Nests failed other causes	13 (9 pre, 2 ukp, 1 win, 1 unk)	1 (1 pre)	7 (2 pre, 1 pos, 2 ukp, 2 unk)	

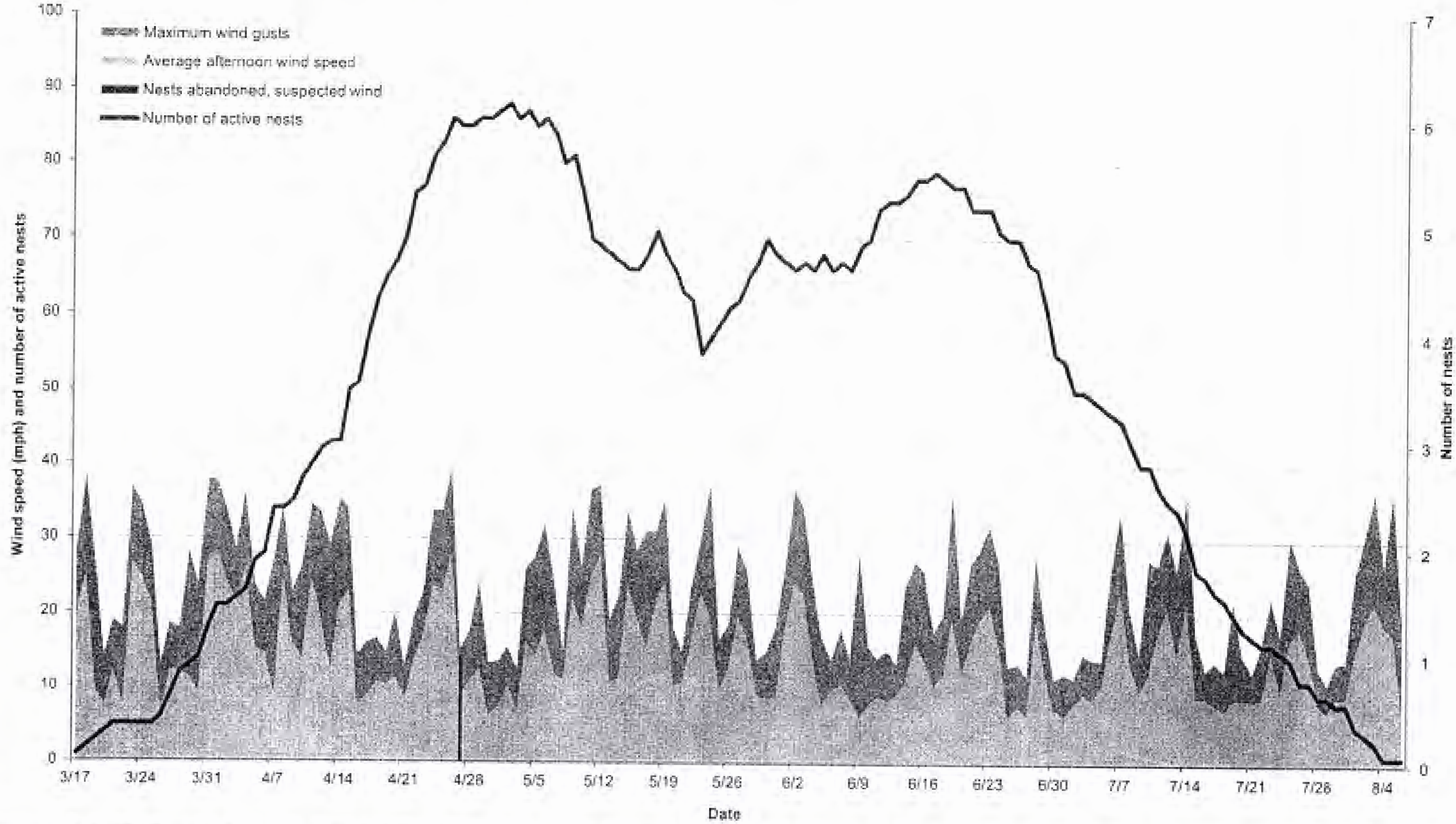


Figure E.1. Daily wind speed data (daily afternoon average and daily maximum wind gust) and snowy plover nest loss attributed to wind at ODSVRA from 17 March to 6 August 2015.

The left y-axis corresponds to wind speed in miles per hour (mph) and total number of active nests. The right y-axis corresponds to number of nests lost with fate abandoned, suspected wind. Wind speed was collected at the S1wind tower, located approximately 375 feet east of 6 exclosure since 2011, from an anemometer at 10 meters height. The daily afternoon average wind speed is calculated from the average of the hours 1:00 pm – 5:00 pm. The maximum wind gust represents the maximum wind speed for the entire day.

Appendix F. Predator summary tables and figures.

Table F.1. Summary of predators detected in the Southern Exclosure and Oso Flaco at ODSVRA in 2015.

Observations from 1 March - 10 September (a 194-day period). Contracted predator management specialists were essentially done and observer presence in field by park staff was reduced after the first week of September (no remaining chicks). Min no. individ. = minimum number of different individuals identified during season. This number was not determined for mammals or owls as these species are primarily nocturnal with occurrences detected by tracks.

Species	First date observed	Last date observed	No. days detected	Min no. individ.	Notes
Mammalian					
Bobcat	11 Mar	9 Aug	9	-	Tracks encountered in South Oso Flaco on four days. Noted inside the predator fencing of the Southern Exclosure on four days and outside the predator fencing in Boneyard exclosure on one day.
Coyote	12 Mar	10 Sep	99	-	Common on the Southern Exclosure shoreline and North and South Oso Flaco shoreline. Noted inside the predator fencing of the Southern Exclosure on 41 days. Five coyotes were lethally removed this season.
Domestic dog	9 Mar	29 Aug	26	-	Documented by tracks and five sightings. Twenty-six occurrences on 6 shoreline and one on 8 shoreline. Most of these were short trespasses onto 6 exclosure shoreline.
Opossum	10 Mar	18 Aug	4	-	Activity noted in North Oso Flaco, 6 and 8 exclosures.
Raccoon	2 Mar	10 Sep	56	-	Highest occurrences within the predator fencing of 6 exclosure. Less frequently noted in 7 and 8 exclosures and on shoreline, and North and South Oso Flaco. On 13 June one tern nest, LT43, was taken by raccoon.
Skunk	10 May	8 Sep	17	-	Activity primarily noted in 8 exclosure. Tracks also seen in North and South Oso Flaco and on two days in 6 exclosure.
Avian					
Osprey	Common throughout the season				Although not documented as a predator of plovers or least terns, ospreys are included in this table due to the disturbance they can cause when perched for long periods of time in sensitive areas. Primarily observed flying over 6, 7 and 8 exclosures and occasionally perched and eating fish. Two osprey present at the same time was not uncommon.
Northern harrier	6 Mar	9 Sep	26	3	Almost all observations in flight and/or hunting. Minimum of 3 individuals (based on age and sex characteristics) observed during season: one adult male, one sub-adult female and one juvenile female. On 23 April, one sub-adult female was trapped and relocated.
Red-tailed hawk	3 Mar	31 Aug	65	4	Observed primarily perch-hunting in north end of North Oso Flaco, 7.5 revegetation area, and South Oso Flaco. Minimum of four individuals (based on age characteristics) observed during this season: two adults, one juvenile and one immature.
American kestrel	2 Mar	9 Sep	18	3	Observed perch-hunting primarily in North and South Oso Flaco. Perched on 6 and 7 exclosure fences on eight days.
Merlin	12 Mar	8 Apr	16	2	Observed hunting throughout Southern Exclosure and over shoreline, as well as North and South Oso Flaco. On 12 March, an adult male merlin was observed with snowy plover prey in 7 exclosure (see Appendix G).

Appendix F. Predator summary tables and figures (continued).

Table F.1. Summary of predators detected in the Southern Exclosure and Oso Flaco at ODSVRA in 2015 (continued).

Species	First date observed	Last date observed	No. days detected	Min no. individ.	Notes
Peregrine falcon	2 Mar	9 Sep	64	6	Observed throughout the Southern Exclosure, North Oso Flaco and South Oso Flaco in flight and perching, sometimes over an extended time period. Observed multiple times pursuing and/or consuming prey on the shoreline and inside the exclosure. Peregrines were documented taking three plover adults in 2015 (see Table G.1 in Appendix G). Minimum of 6 individuals (based on age and sex characteristics) observed during season: one adult male, one unbanded adult female, one VID banded adult female "17D," one unbanded sub-adult male, and two juveniles. On 8 May, one unbanded sub-adult male was trapped, banded with VID band "50AB", and relocated. This bird returned to ODSVRA by 14 August.
Large owl spp.	21 Apr	10 Sep	5	-	Primarily identified by tracks, believed to be from great horned owl. Noted inside 7 exclosure on two days.
Gull spp.	Present daily throughout season				The maximum number for a monthly count of gulls in the entire park was 3,225 on 2 July. This includes birds in flight, foraging on shoreline, and roosting. On 5 June, a first winter western gull repeatedly picked up and dropped a small plover chick before flying with it to the waterline where it wet the chick. It is suspected that the chick was then eaten by the gull. An agitated adult plover was present.
American crow	8 Jun	5 Jul	2	1	Observed flying over 8 and Boneyard exclosures, and North Oso Flaco on two days.
Common raven	2 Mar	4 Jul	7	2	Observed in flight over South Oso Flaco and over 6, 7 and 8 exclosures. Two ravens observed taking one plover nest on 22 May. Four nests total documented depredated by raven. One raven was removed lethally off-site on 1 June.
White-tailed kite	15 Mar	28 May	2	1	Observed on two days in flight or kiting in South Oso Flaco.

Appendix F. Predator summary tables and figures (continued).

Table F.2. Mammalian and avian predators removed under predator management actions for least terns and snowy plovers at ODSVRA in 2015.

Five coyotes and one raven were lethally removed. All other animals were live-trapped and relocated. When the live-trapped date differs from the relocation date, the relocation date is given in parentheses. All animals trapped or removed were within ODSVRA boundaries with the exception of one raven.

Date	Species	Age/Sex	Location
Lethally removed			
21 Apr	Coyote	Female	Oso Flaco Creek
15 May	Coyote	Male	East side of Boyscout Revegetation Area (Open Riding Area)
26 May	Coyote	Female	Oso Flaco Creek
1 Jun	Coyote	Female	Maidenform Revegetation Area (Open Riding Area)
1 Jun	Common Raven		Rancho-Guadalupe Dunes County Park (off-site, south end of dunes complex)
2 Jun	Coyote	Female	Boyscout Revegetation Area (Open Riding Area)
Live-trapped and relocated			
23 Apr	Northern harrier	Sub-adult/female	South end of North Oso Flaco foredunes
4 May (8 May)	Peregrine falcon	Sub-adult/male	South Oso Flaco

Appendix F. Predator summary tables and figures (continued).

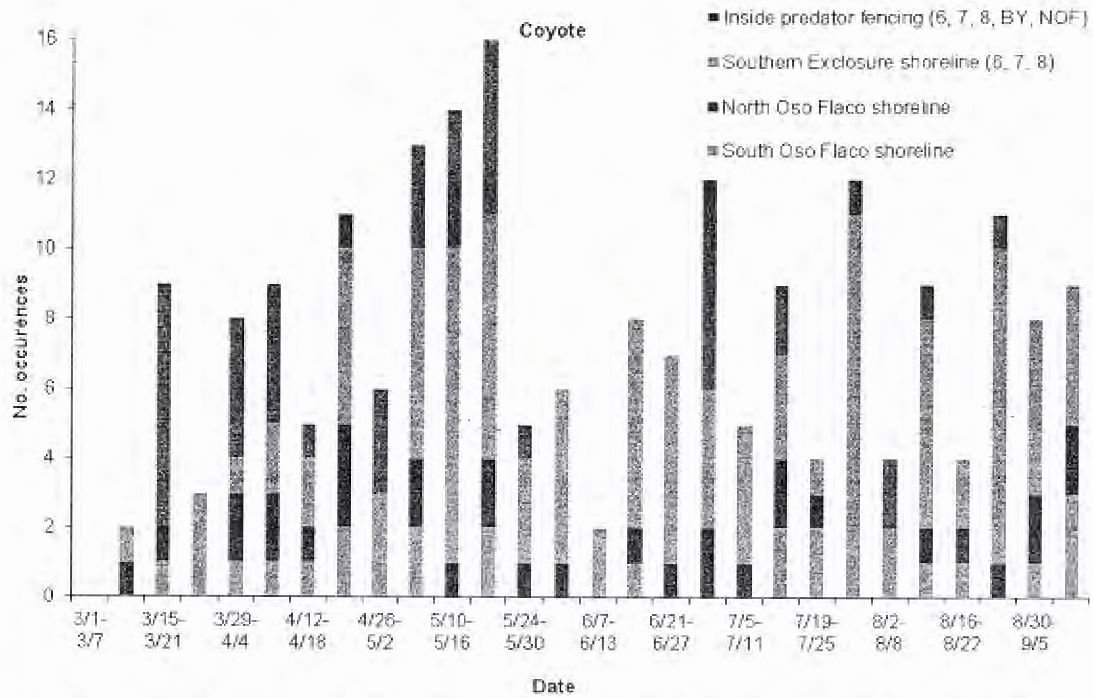


Figure F.1. Coyote occurrences documented in the Southern Exclosure and Oso Flaco at ODSVRA in 2015.

Observations from 1 March - 10 September (a 194-day period). Coyote presence is documented for the Southern Exclosure shoreline (6, 7, and 8 exclosures), North Oso Flaco shoreline, South Oso Flaco shoreline, and inside the predator fencing of the Southern Exclosure (6, 7, 8, Boneyard, and North Oso Flaco) as separate occurrences. For the Southern Exclosure (6, 7, 8, and Boneyard exclosures) and North Oso Flaco, a distinction is made between the shoreline and inside the predator fencing of the exclosures because coyotes are typically excluded from the area protected by predator fencing.

Appendix F. Predator summary tables and figures (continued).

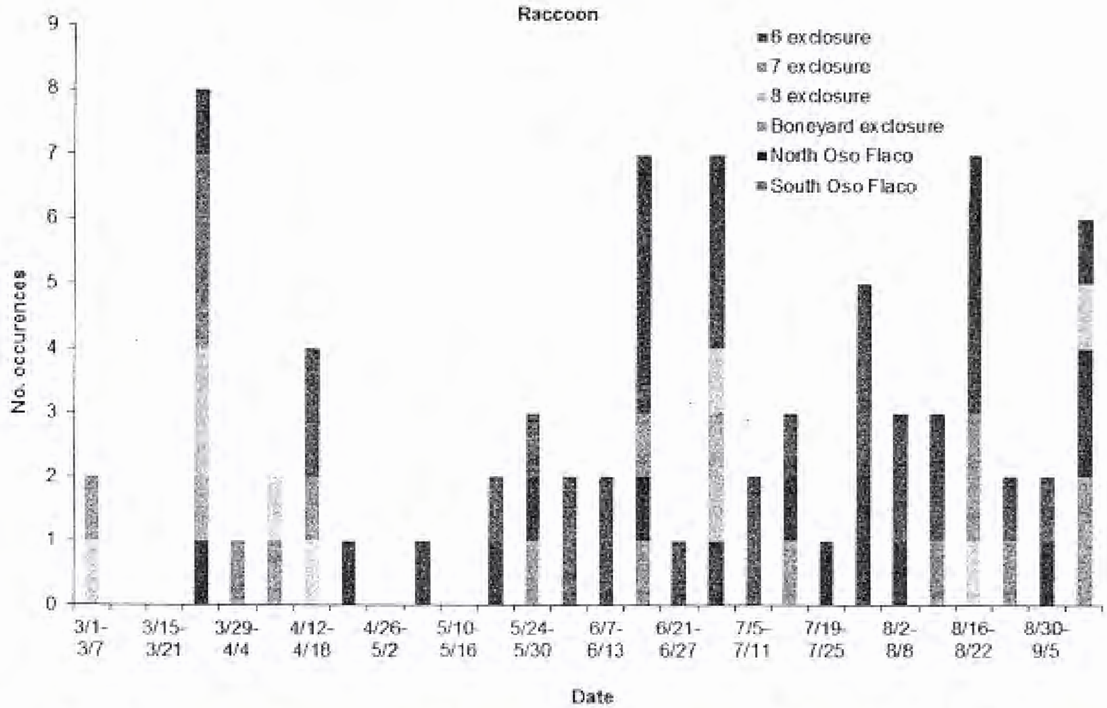


Figure F.2. Raccoon occurrences documented in the Southern Exclosure and Oso Flaco at ODSVRA in 2015.

Observations from 1 March - 10 September (a 194-day period). Raccoon presence is documented for each of the areas of the Southern Exclosure (6, 7, 8, and Boneyard exclosures), North Oso Flaco, and South Oso Flaco as separate occurrences. No distinction is made between the shoreline and inside the predator fencing of the exclosure since raccoons are able to climb over the predator fencing.

Appendix F. Predator summary tables and figures (continued).

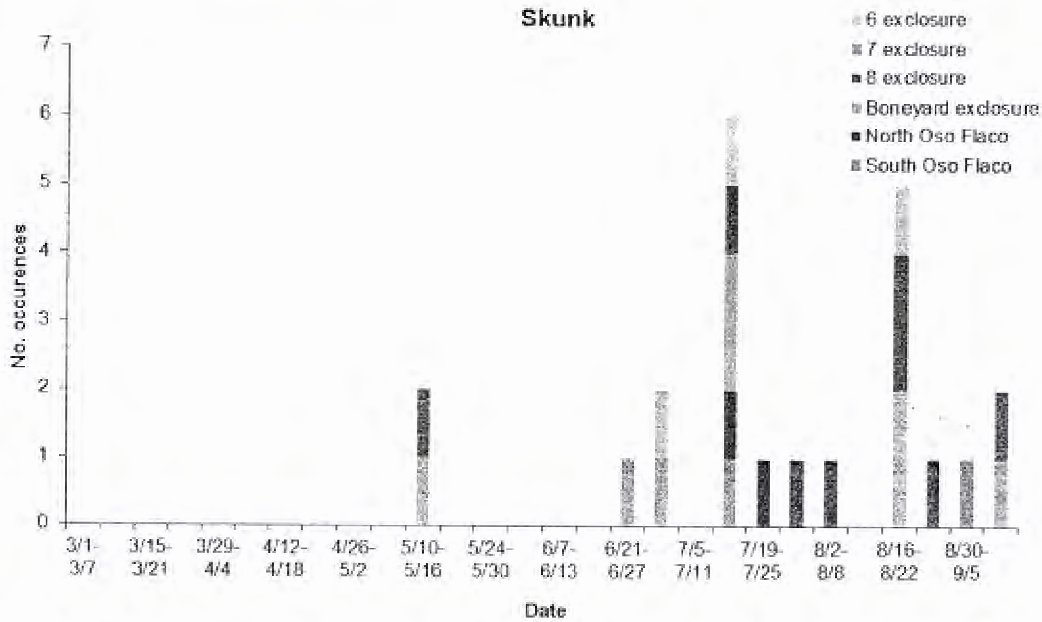
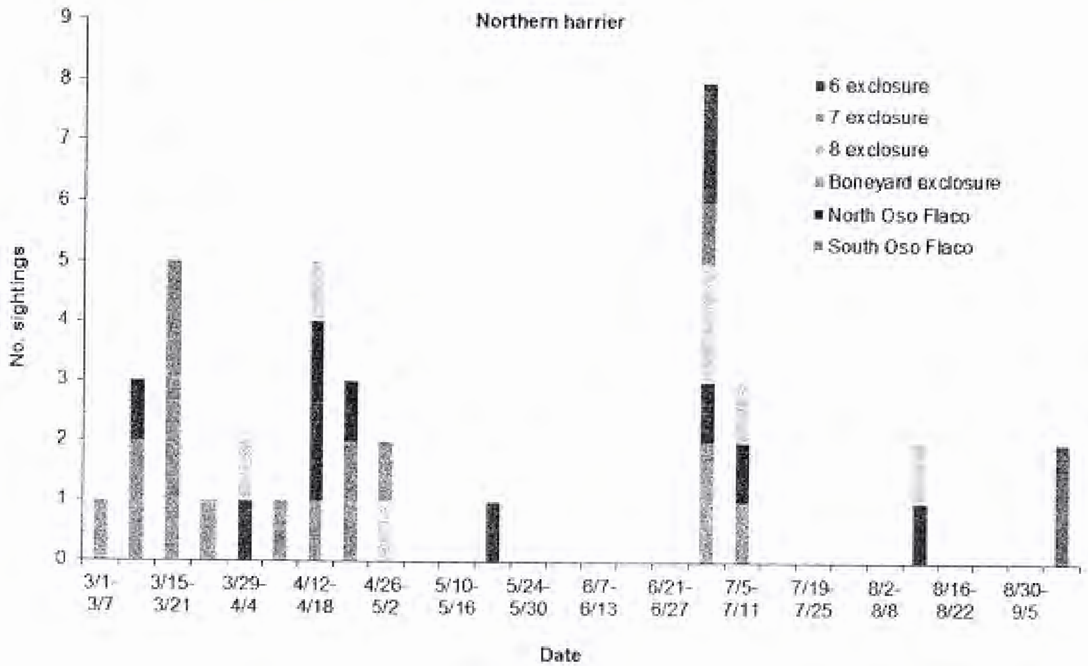


Figure F.3. Skunk occurrences documented in the Southern Exclosure and Oso Flaco at ODSVRA in 2015.

Observations from 1 March - 10 September (a 194-day period). Skunk presence is documented for each of the areas of the Southern Exclosure (6, 7, 8, and Boneyard exclosures), North Oso Flaco, and South Oso Flaco as separate occurrences. No distinction is made between the shoreline and inside the predator fencing of the exclosure since skunks are able to pass through predator fencing.

Appendix F. Predator summary tables and figures (continued).



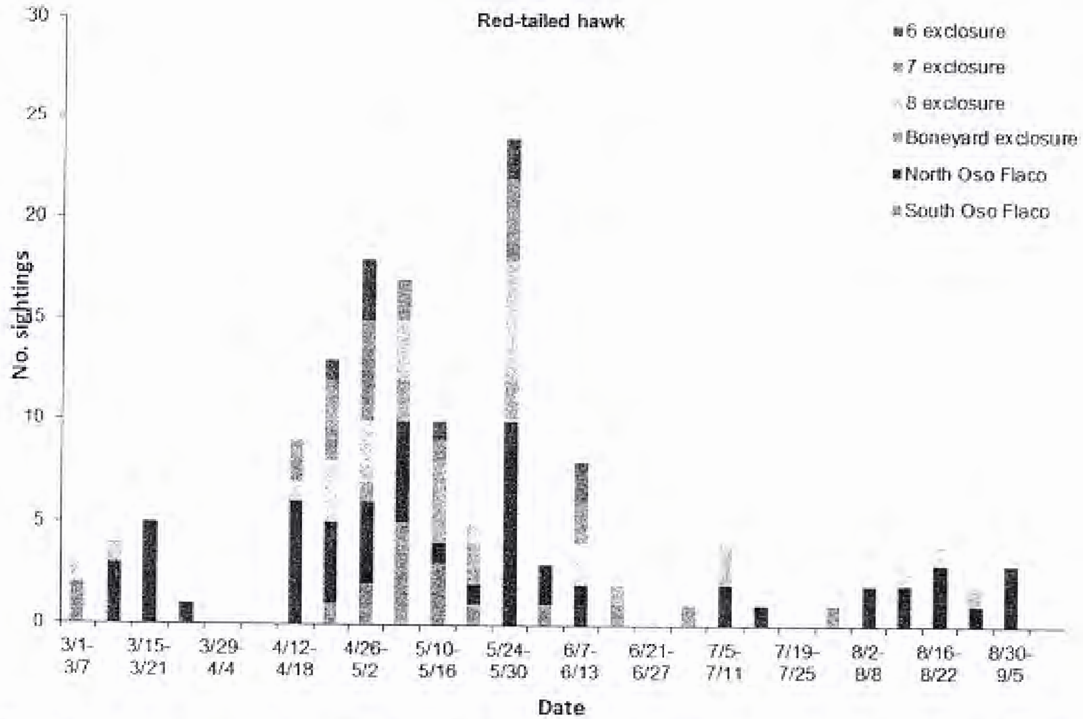


Figure F.4. Avian predator sightings documented in the Southern Exclosure and Oso Flaco at ODSVRA in 2015.

Observations from 1 March - 10 September (a 194-day period).

Appendix F. Predator summary tables and figures (continued).

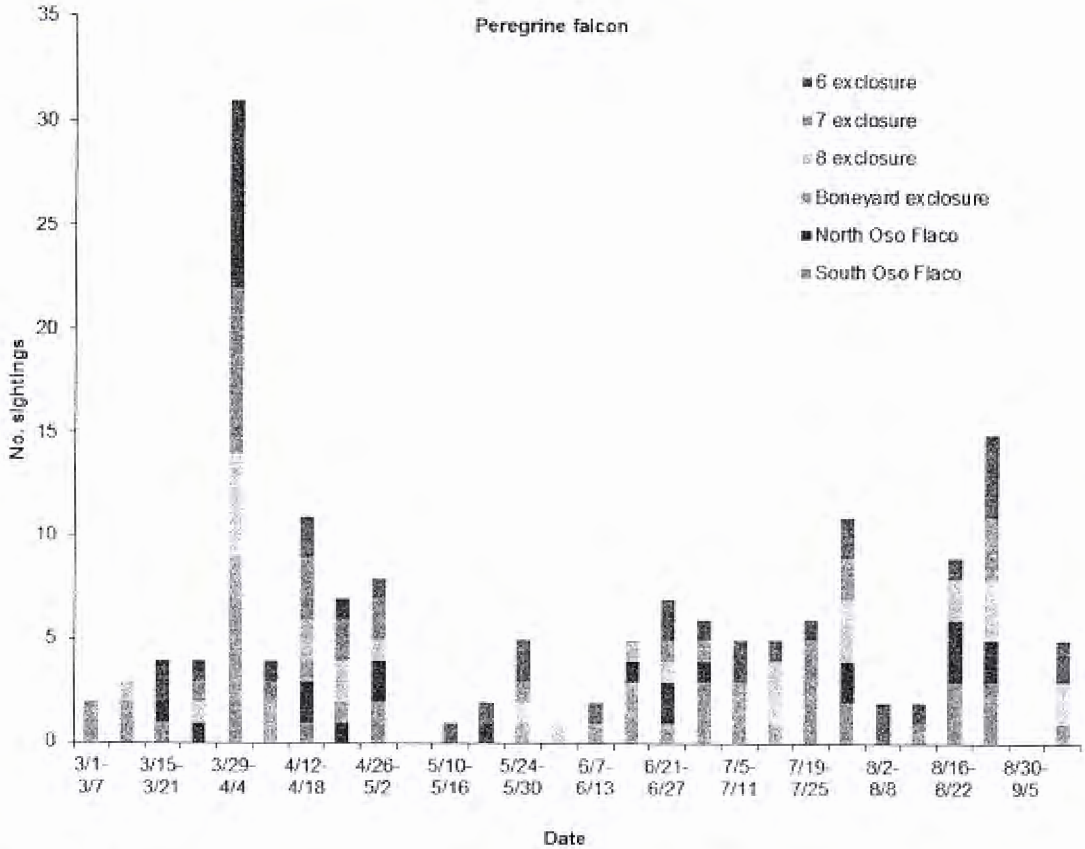


Figure F.4. Avian predator sightings documented in the Southern Exclosure and Oso Flaco at ODSVRA in 2015 (continued).
Observations from 1 March - 10 September (a 194-day period).

Appendix F. Predator summary tables and figures (continued).

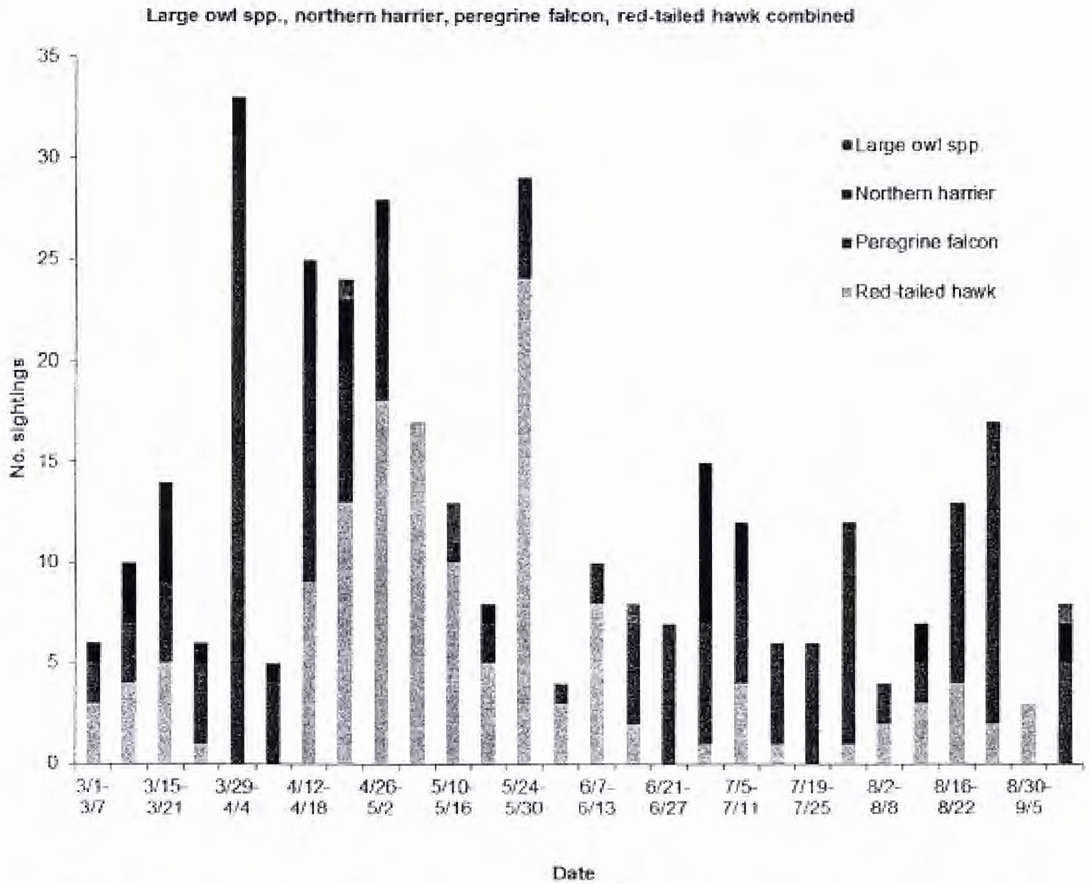


Figure F.4. Avian predator sightings documented in the Southern Exclosure and Oso Flaco at ODSVRA in 2015 (continued).
Observations from 1 March - 10 September (a 194-day period).

Appendix G. Documented mortality of California least tern and snowy plover chicks, juveniles, and adults at ODSVRA.

There was no documented predation of least tern chicks, juveniles, or adults in 2015.

Table G.1. Documented predation of snowy plovers from 1 March to 30 September 2015.

No. (age)	Predator	Location	Notes
1 (adult)	Merlin	7 exclosure	On 12 March, an adult male merlin was observed eating an adult plover banded GG:WW on 7 exclosure shoreline. A plover with this combination was previously seen on 1 March with a flock of 124 plovers roosting between marker post 2 and marker post 3 in the open riding area. A chick banded at ODSVRA with this combination was known to have fledged in each of the years 2002, 2008, 2012, and 2013.
1 (adult)	Peregrine falcon	8 exclosure	On 28 April, an unbanded sub-adult male peregrine falcon was observed eating an adult plover in 8 exclosure. This peregrine was trapped on 4 May, banded, and relocated off-site on 8 May (see Predator section).
1 (chick)	Western gull	6 exclosure	On 5 June, a first winter western gull repeatedly picked up and dropped a small plover chick before flying with it to the waterline where it dipped the chick in water. It is suspected that the chick was then eaten by the gull. An agitated adult plover was present.
1 (adult)	Peregrine falcon	8 exclosure	On 18 August, a juvenile male peregrine falcon was observed eating a small prey item on 8 exclosure shoreline. Feathers were collected at the prey site and identified as belonging to an adult plover.
1 (adult)	Peregrine falcon	6 exclosure	On 28 August, the returning sub-adult male peregrine falcon banded and relocated on 8 May caught and ate a banded plover on the 6 exclosure shoreline (see Predator section).

Table G.2. Mortality, other than documented predation, of least terns from 1 March to 30 September 2015.
See Notes section and attached necropsy reports for more detail. All remains not suitable for necropsy were saved to be provided to a designated depository.

No. (age)	Location	Notes
1 (juvenile)	7 exclosure	On 21 July, the intact decomposed carcass of a juvenile least tern (L:Y/G from LT9) was found in 7 exclosure with ventral surface to the ground and wings folded in a natural position. The left wing chord measured 158 mm. This bird was last seen alive on 10 June on the day it hatched.
1 (juvenile)	7 exclosure	On 22 July, a live unbanded juvenile least tern was observed with a likely broken left wing (wing twisted and outer portion of wing pointed forward) and drooping right wing in 7 exclosure. Although a carcass was not recovered it is assumed that this bird did not survive.

Table G.3. Mortality, other than documented predation, of snowy plovers from 1 March to 7 October 2015.
See Notes section and attached necropsy reports for more detail. All remains not suitable for necropsy were saved to be provided to a designated depository.

No. (age)	Location	Notes
2 (chicks)	6 exclosure	On 3 June, the one to two-day-old two-chick brood with attending male from SP134 was directed southward from Arroyo Grande Creek to the Southern Exclosure (a distance of over 2.6 miles) by resource staff, both on foot and in vehicles. Upon being directed onto 6 exclosure shoreline both chicks were repeatedly attacked by plover adults with broods in the area and were assumed to not survive the incident (see Notes section).
1 (chick)	6 exclosure	On 5 June, one four-day-old GA:VY chick from the three-chick SP88 brood was picked up and pecked repeatedly by an adult with the nearby SP32 nest on the 6 exclosure shoreline. The chick was observed motionless for twenty minutes and assumed dead after the attack as this brood was only seen with two chicks after the incident. Later in the day a sub-adult California gull was seen picking up and dropping a plover chick, unknown if dead or alive, in the same location before carrying it away. The chick was banded but combination not determined (a green band was noted). This may have been the GA:VY chick suspected killed earlier by an adult plover.
1 (chick)	6 exclosure	On 12 June, one unbanded chick was observed dead on 6 exclosure shoreline but could not be recovered due to proximity of young plover broods.
2 (chicks)	6 exclosure	On 6 July, the two banded chicks from SP152 were attacked aggressively by an adult male plover that alternated between attacking the chicks and incubating the remaining egg at the nest. Chicks were attacked and not brooded for a sustained period. All three chicks from this brood were seen the following morning, but the two banded chicks were not seen subsequently and were believed to have died as a result of the incident.
1 (chick)	8 exclosure	On 8 September, the desiccated carcass of a small GG.RW chick from SP90 was collected on the 8 exclosure shoreline. This brood was last seen with all three chicks on 1 June at two days old (two chicks known to fledge).
1 (chick)	7 exclosure	On 8 September, the desiccated carcass of a large unbanded chick was collected on the 7 exclosure shoreline.
1 (chick)	6 exclosure	On 10 September, the desiccated carcass of a small PV:OB chick from SP41 was collected on the 6 exclosure shoreline. This brood was last seen with all three chicks on 15 May at one day old (one chick known to fledge).
1 (chick)	6 exclosure	On 10 September, the desiccated carcass of a small unbanded chick was collected on the 6 exclosure shoreline.
1 (adult)	7 exclosure	On 12 September, the desiccated carcass of an unbanded adult plover was collected in 7 exclosure.
1 (juvenile)	ORA (8 exclosure)	On 7 October, the desiccated carcass of an unbanded large chick or young fledging was found three feet west of the 6 exclosure west fence in the riding area during fence removal. The carcass was not in tire tracks, and was slightly buried and very dry. The last unbanded chick fledged on 30 August.
1 (juvenile)	ORA (8 exclosure)	On 7 October, the carcass of a juvenile plover (VG:PB from SP36) was found a few feet west of the 8 exclosure shoreline west fence in the riding area during fence removal. The carcass did not appear to have been driven over, lacked eyes, and was full of maggots, but was otherwise whole and intact. This juvenile was known to fledge from ODSVRA on 9 June and was last seen alive on 8 exclosure shoreline 1 October.

Attachment 5

Oceano Dunes State Vehicular Recreation Area

2015 Predator Management Report

Submitted To:

Ronnie Glick
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340 James Way, Suite 270
Pismo Beach, CA 93449

Submitted By:

Barry Lowry, Wildlife Specialist
&
Eric Covington, District Supervisor
San Luis District
CA Wildlife Services Program

Introduction

Prior to the 2015 California Least Tern (*Sternula antillarum browni*)(CLTE) and Western Snowy Plover (*Charadrius nivosus nivosus*)(SNPL) nesting season, USDA-APHIS-Wildlife Services entered into an agreement with Oceano Dunes State Vehicular Recreation Area (ODSVRA) to conduct predator management activities in the CLTE and SNPL nesting areas. Wildlife Services Specialist (WSS) Barry Lowry was assigned to the ODSVRA project to monitor, or selectively remove, mammalian and avian predators for protection of nesting CLTE and SNPL.

WSS Barry Lowry began working the ODSVRA project March 9, 2015. WSS Lowry underwent mandatory APHIS-WS training (firearms, trapping, defensive driving, civil rights, all aspects of safety, and all other USDA mandatory training) used during the project.

Methods of Predator Management

Many methods were used for CLTE and SNPL protection throughout their nesting season. Methods included surveying, hazing, trapping, calling, shooting, and spotlighting.

Daytime surveys were performed by either hiking or driving on the dunes and shoreline in an attempt to locate predators through track identification and binoculars or spotting scope. Wildlife Services stayed in communication with State Park resource staff in order to stay up to date on their observations of predator activity. Predator surveys were conducted in Eucalyptus, Table Top, Pipeline revegetation, Boy Scout, Maidenform, Southern Exclosure, North Oso Flaco and the South Oso Flaco areas (Appendix 1).

Hazing was conducted throughout the season in an attempt to harass predatory birds away from the SNPL and CLTE exclosures. WS would fire pyrotechnics at the bird until it left the site. The type of pyrotechnic that was used was a 15 mm noisemaking pyrotechnic called a "Bird Whistler®" manufactured by Zink-Feuerwerk for Sutton Agricultural Enterprises. They were fired from a Model RJ 1 "Scare Away Launcher®" manufactured by Reed-Joseph International". "Bird Whistlers®" emit a high pitched whistle, bright light, and a trail of smoke when fired (Appendix 2).

Trapping was the most commonly used method for predator management. Trapping methods included the use of Bridger #3 padded jaw leg-hold traps for mammalian predators such as coyotes. Traps were baited with commercially available lures made from different scents, glands and meat based baits as well as dry and canned cat food. Calling and shooting was another method used for predator management, mainly coyotes. Calling is most effective at dawn or dusk. Calling is done by producing a sound that imitates a wounded prey animal and entices the predator to seek out the source of the noise. Once the coyote was positively identified, it would be lethally removed by shooting. The type of call most commonly used was a "Wildfire® model WF1" manufactured by FOXPRO Inc. The type of rifle used to remove the coyotes was a Browning A-bolt Medallion chambered in .25-06 caliber firing 90 grain Hornady Superformance® non-lead ammunition.

Spotlighting is a common method of predator management. It is usually done while driving a vehicle and shining a high powered spotlight looking for the reflective eye shine of the predator caused by light reflecting off the tapetum lucidum layer in the back of the predator's eyes. Once eye shine has been located, positive identification of the predator can then be made with the use of binoculars. Once positive identification is made, removal can take place if the animal is a target predator. The spotlight used to locate predators was a one million candle power SL 70 Styker® by Lightforce Optics. Binoculars used in identifying predators were 10 X 42mm Goldring® by Leupold Optics.

Results of Predator Management Methods

When predator management efforts by Wildlife Services began in 2015, the SNPL nesting season was just beginning. The main mammalian predation concern was coyote presence along the shoreline near SNPL and CLTE habitat. Coyotes appeared to be hunting and scavenging along the shoreline looking for food sources in areas where SNPL chicks often fed. Coyotes have been documented taking SNPL eggs and chicks at ODSVRA. In 2012, four coyote scats were found to contain a total of 11 bands (representing a minimum of one plover chick, two unknown age plovers, and one unknown age tern). Scat surveys were conducted during the 2015 nesting season, but no SNPL bands were discovered in coyote scat. Initial trapping efforts during the 2015 nesting season were focused in the Oso Flaco boardwalk area where coyote tracks originated that were traveling along the shoreline.

Coyotes presented a predation threat to CLTE and SNPL nesting success in 2015. One concern stemmed from predation problems during past nesting seasons. Chicks had been missing with no direct evidence to suggest why. It was suspected that coyotes could have been responsible for predation since coyote tracks were observed along the shoreline each morning. Scat surveys were conducted during the 2015 nesting season, but no SNPL bands were discovered in coyote scat. Initial trapping efforts during the 2015 nesting season were focused in the Oso Flaco boardwalk area where coyote tracks originated that were traveling along the shoreline.

Five coyotes were lethally removed during the 2015 season (Table 1). Two of the coyotes were removed from the Oso Flaco Creek area where coyotes had been traveling from the fore dunes to the shoreline. One coyote was removed from the Maidenform area. The other two coyotes were removed from the Boy Scout area, where it was determined they were traveling to, after exiting the shoreline in the mornings. The first coyote was trapped on April 21st near the mouth of Oso Flaco Creek. The second coyote was called in and removed on May 15th near the east fence of the Boy Scout area. On May 26th, a coyote was trapped in the dunes north of the Oso Flaco Boardwalk. The fourth coyote was called in and removed on June 1st in the Maidenform area. The fifth and last coyote was called in and removed from a small stand of trees in the middle of the Boy Scout area on June 2nd after being tracked there from the shoreline. While trapping coyotes two bobcats were inadvertently captured near the Oso Flaco boardwalk and were released unharmed.

Avian predators were also a major concern to CLTE and SNPL chicks in 2015. Many raptors, as well as ravens and gulls posed a threat to a successful nesting season.

Early in the season, raven predation of multiple SNPL nests was documented at the Chevron Guadalupe Restoration Project and Rancho Guadalupe Dunes County Park located south of ODSVRA and in the same dune complex. In past seasons, ravens that have been observed on neighboring properties have made the short flight to the ODSVRA to forage for food. On May 22, 2015 two ravens was observed flying over the ODSVRA nesting exclosures and predated four SNPL nests. WSS Lowry responded to the call but was unable to get in position to remove the ravens. Working with the Rancho Guadalupe Dunes County Park and the Chevron Guadalupe Restoration Project WSS Lowry was able to pattern the ravens hunting path and set #1 ½ padded leg hold traps around fake nest sets under their normal flight pattern. On June 1st, WSS Lowry was successful at lethally removing one of the ravens with a 12 gauge shotgun while checking traps at the Rancho Guadalupe Dunes Preserve. Raven sightings substantially decreased at all sites after the one raven was removed.
Predation by gulls of SNPL chicks of all ages, as well as young fledglings, has been documented at ODSVRA, and gull surveys and monitoring were conducted during the entire 2015 nesting season. On June 5th, a western gull was observed picking up and dropping a small plover chick. The gull flew to the waterline with the chick where it is suspected to have eaten the chick. Adult plovers were observed harassing and displaying in front of gulls foraging higher on the beach. Additionally a California gull was observed scavenging a likely dead plover chick on the 6 exclosure shoreline. WSS Lowry responded but was unsuccessful in relocating the western gull suspected of eating the plover chick. There were no other gull predation sightings during the 2015 nesting season.

Peregrine Falcons and Northern Harriers were periodically observed in and around SNPL and CLTE exclosures. Peregrine Falcons were observed perched on exclosure fences and inside the exclosures on many occasions. WSS Lowry often located avian predators and assisted Park Staff and Paul Young, with Ventana Wildlife Society, in hazing efforts. WSS Lowry also assisted Young with raptor trapping efforts throughout the season.

Table 1: Predator Removal Summary

Date	Species	Sex	Location
4/21/2015	Coyote	Female	Oso Flaco Creek
5/15/2015	Coyote	Male	Boy Scout
5/26/2015	Coyote	Female	Oso Flaco Creek
6/01/2015	Coyote	Female	Maidenform
6/01/2015	Raven	Unknown	Rancho Guadalupe Dunes
6/02/2015	Coyote	Female	Boy Scout

Future Recommendations

WS recommends educating the public about the importance of not feeding wildlife to help reduce attracting predators.

WS recommends that all garbage containers have reinforced lids to prevent garbage consumption by wildlife.

WS recommends the State Park continues to maintain the height and strength of the perimeter fence surrounding the enclosures during the nesting season. Maintenance of fencing, where sand has shifted to create low spots or places where mammalian predators can go over, should be conducted on a regular basis to prevent predators from entering enclosures.

WS recommends the State Park continues to enforce the leash law for pets on the beach, which is crucial during nesting season.

WS recommends the State Park continues to remove dead animal carcasses from the beach to eliminate alternate food sources that serve as a lure to scavenging predators such as coyotes.

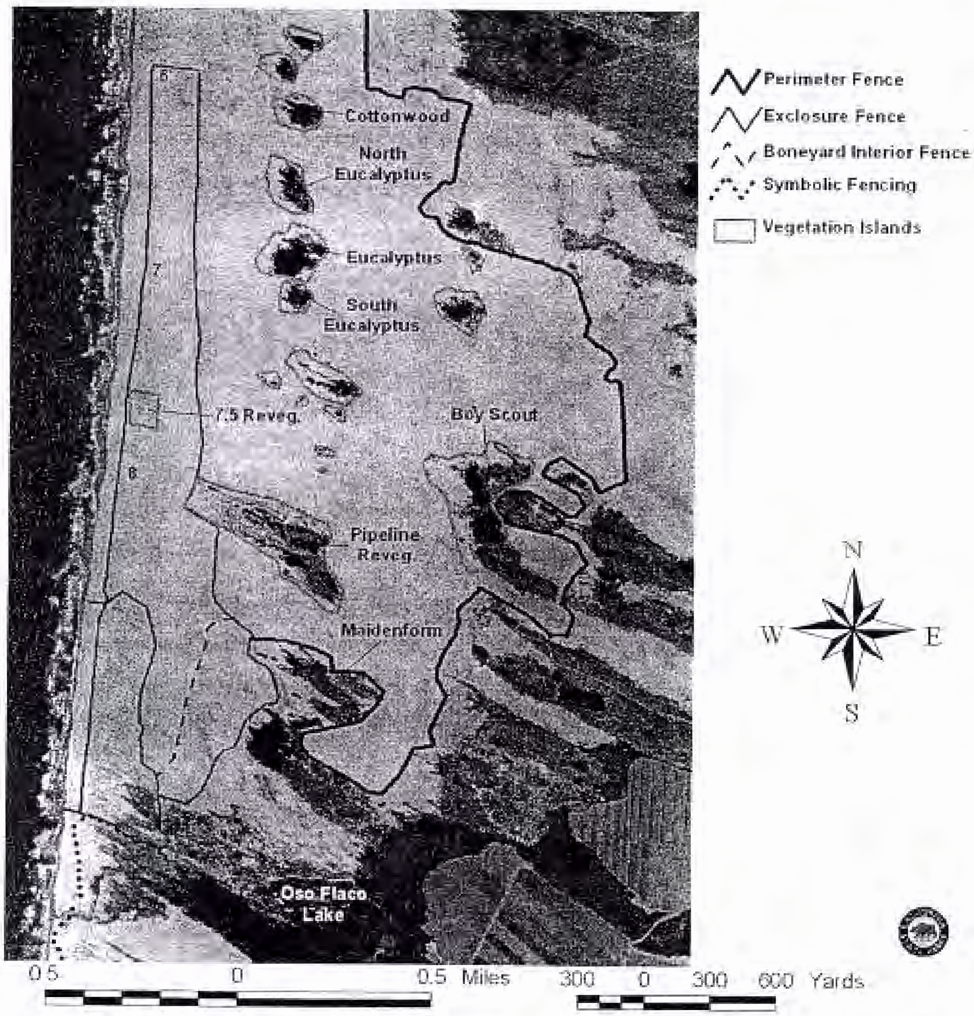
WS recommends the selective removal of predators that are a potential or known threat to the CLTE and SNPL breeding population at ODSVRA. Removal of problem predators prior to predation should be the goal to protect CLTE and SNPL nesting and chick rearing areas.

WS recommends the State Park continues to train WS Specialists so they can be added to permits that allow entrance into areas where predators are threatening the productivity of CLTE and SNPL as well as areas where predators travel, such as the shoreline and South Oso Flaco Dunes. The ability to capture the problem predators where they are located without having to be escorted by ODSVRA staff increases WS efficiency in removing problem predators.

Barry Lowry, Wildlife Specialist
San Luis District
CA Wildlife Services

Eric Covington, District Supervisor
San Luis District
CA Wildlife Services

Appendix 1: Map of ODSVRA SNPL and CLTE Nesting Exclosures and Adjacent Areas



USDA United States Department of Agriculture

Animal and Plant Health Inspection Service

Wildlife Services

P.O. Box 255348
Sacramento, CA 95865-5348

Oceano Dunes State Vehicular Recreation Area

2007 Predator Management Report

Submitted To:

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Submitted By:

Blair Simms, Wildlife Specialist
&
Eric Covington, Acting District Supervisor
San Luis District
CA Wildlife Services Program

Introduction:

Prior to the 2007 nesting season for the California Least Tern (LETE) and the Western Snowy Plover (SNPL), USDA-APHIS-Wildlife Services (WS) entered into an agreement with the Oceano Dunes State Vehicular Recreation Area (ODSVRA) to conduct predator management activities in the LETE and SNPL nesting area. The San Luis District Supervisor Joe Bennett completed a categorical exclusion prior to the beginning of the project. Wildlife Services consulted with Terry Palmisano, Senior Wildlife Biologist with California Department of Fish and Game (CDFG), concerning the project.

In past nesting seasons, problems have surfaced concerning predation on nesting SNPL and LETE. As a result, Wildlife Services Specialist (WSS) Blair Simms was assigned to the ODSVRA to assist in predator monitoring and the removal of select predators during the 2007-nesting season.

WSS Simms began work on March 5 and spent the first week in mandatory training involving firearms safety, humane euthanasia, safe operation of ATVs, defensive driving, computer information, Wildlife Services reporting procedures, civil rights, and safety issues.

On March 15, WSS Simms attended a meeting with Senior Environmental Scientist (SES), Ronnie Glick and Assistant District Supervisor Eric Covington, to discuss ODSVRA expectations of Wildlife Services during the 2007 nesting season. WSS Simms attended a meeting with SES Ronnie Glick and Resource Ecologist Joanna Iwanicha to discuss the upcoming nesting season. WWS Simms met with State Parks Resource staff, Doug George of PRBO Conservation Science (PRBO) and Paul Young of the Santa Cruz Predatory Bird Research Group (SCPBRG) on March 28 and attended a two-day mammalian tracking class given by James C. Lowery, author of The Tracker's Field Guide.

Methods:

WSS Simms employed pole traps, calling, spotlighting, shooting, and padded leg-hold traps in an effort to provide predator management for SNPL and LETE. WSS Simms also conducted daylight surveys, scent station surveys and spotlight surveys to monitor predator activity in the ODSVRA.

Daytime surveys were conducted by searching for predators with binoculars. Positive identification was made after locating a predator. WSS Simms completed fourteen daytime surveys throughout the season. Surveys were conducted near the Pipeline, Maidenform, Eucalytpus, Eucalyptus South, Boy Scout Camp, Boneyard, the number 8 exclosure, North Oso Flaco Fore Dunes, Oso Flaco revegetation areas as well as in the Campground. (Table 1 & Appendix 1).

Scent station surveys were conducted by driving a 2-foot long rebar stake through a can of cat food to anchor it to the ground. An area 10 feet in diameter was smoothed out around the bait enabling predator tracks to be identifiable. Scent stations were baited each evening then checked the following morning. Eight scent station surveys were conducted throughout the project. Scent stations were placed at Boy Scout Camp, Eucalyptus Tree, Maidenform, Oso Flaco and Cottonwood areas (Table 2 & Appendix 1).

Spotlight surveys were conducted by driving a vehicle through the dunes at night and shining a spotlight to scan for predators. The eye shine of predators was observed with the use of a spotlight. After location of eye shine, positive identification was then made with binoculars. Spotlight surveys were conducted from Pavillion Hill to the Maidenform re-vegetation area and the fore dunes near Oso Flaco Creek (Table 3 & Appendix 1). WSS Simms conducted eight spotlight surveys throughout the season. WSS Simms reported all predators observed on spotlight surveys.

Daytime Survey 2007

Dates	Campground	Eucalyptus	Pipeline Reveg.	N. Oso Flaco Fore Dunes	Oso Flaco	Maidenform	Boy Scout Camp	Bone Yard	8 Exclosure
3/23	X	X	3 Coyotes 1 RT Hawk	X	X	X	X	X	X
4/23	X	X	X	X	X	X	X	X	1 Deer
4/24	X	X	X	X	X	1 RT Hawk	X	X	X
4/30	X	X	X	1 C Hawk	X	X	X	X	X
5/1	X	X	X	1 Raven	X	X	X	X	X
5/8	X	X	X	X	X	X	X	X	5 Ravens
5/16	X	X	X	X	X	X	X	1 Raven	X
5/31	X	X	X	X	X	X	2 WT Kites	X	X
6/6	X	X	X	X	X	X	1 Coyote	X	X
6/8	X	X	X	X	X	2 Coyotes	1 WT Kite 3 Deer	X	X
6/21	1 Red Fox	X	X	X	X	X	X	X	X
7/2	X	X	X	X	X	X	X	X	1 P Falcon
7/12	X	1 WT Kite	X	X	X	X	X	X	X
8/8	X	X	X	X	Mt. Lion	X	X	X	X

Table 1: Predators observed during daytime surveys during the 2007-nesting season.
C Hawk = Cooper's Hawk
P Falcon = Peregrine Falcon
RT Hawk = Red-tailed Hawk
WT Kite = White-tailed Kite
Mt. Lion = Mountain Lion

Scent Stations 2007

Dates	Boy Scout Camp	Eucalyptus	Maidenform	Oso Flaco	Cottonwood
4/4	Coyote	Coyote	Opossum Coyote	X	X
4/12	X	X	Skunk Coyote	X	X
7/22	X	X	Coyote	Coyote	X
7/23	X	X	X	X	X
7/25	X	X	X	X	X
7/26	X	X	X	X	X
7/27	X	X	X	Opossum	X
7/28	X	X	X	Opossum	X

Table 2: Predator tracks observed during scent station surveys during the 2007-nesting season.

Spotlight Surveys 2007

Dates	Pavillion Hill	Eucalyptus	Cottonwood	Boy Scout Camp	Pipeline Re-Veg.	Maidenform	Oso Flaco
4/11	X	X	X	X	X	X	X
4/12	1 Coyote	X	X	X	X	X	X
4/13	2 Coyotes	X	X	X	X	X	X
4/17	X	X	X	X	X	X	X
4/26	X	X	X	X	5 Coyotes	X	X
6/4	X	X	X	X	X	X	X
6/10	X	X	1 Coyote	X	X	X	X
6/11	X	X	X	X	X	X	X

Table 3: Predators observed during spotlight surveys during the 2007-nesting season.

Results:

WSS Simms began working at ODSVRA on March 15. Removal efforts were directed at targeting individuals that were determined to pose a threat to SNPL and LETE nesting success. WSS Simms, Paul Young, Doug George, along with ODSVRA staff monitored predator activities on a daily basis.

On April 3, Paul Young observed a Common Raven flying southeast while he was in the North Oso Flaco fore dunes area. On April 27, a raven predated a SNPL nest containing three eggs in the North Oso Flaco fore dunes. On April 28, a raven predated a second SNPL nest from the number 8 exclosure. On April 29, WSS Simms and Paul Young began to actively pursue the raven in the North Oso Flaco fore dunes. Methods used by WSS Simms included nest boxes in the North Oso Flaco fore dunes and along the shoreline, padded leg hold traps in the number 8 exclosure and shooting. The nest boxes were pre-baited with boiled chicken eggs in an attempt to lethally remove the ravens with the avicide DRC-1339. The padded leg-hold traps were set around quail eggs that resembled a SNPL nest in an attempt to capture target ravens. On May 1, WSS Simms and Paul Young observed a raven flying from the south over the North Oso Flaco fore dunes. The raven had changed direction, over the shoreline after spotting Simms and Young. The raven continued to fly north until it was out of sight. The next raven sighting was on May 5, when five ravens flew south over the number 8 exclosure. The final raven sighting was on May 16 when WSS Simms observed a raven flying west of the interior Boneyard fence. WSS Simms continued setting the padded leg-hold traps in the number 8 exclosure until May 22. No ravens were observed after May 16.

Coyotes were observed entering SNPL and LETE nesting exclosures throughout the season. Coyotes were also observed entering other areas such as the shoreline where SNPL forage. WSS Simms' observations of coyotes entering the exclosures and the shoreline were reported to SPRE Field Lead or to Doug George. WSS Simms continuously monitored coyote activity and the locations of their entrance and withdrawals from the exclosure and the shoreline areas.

Throughout the nesting season, coyote tracks were observed entering into the SNPL and LETE nesting exclosures. On the fifth intrusion into the SNPL and LETE nesting areas, a SNPL nest containing two eggs was predated in the North Oso Flaco fore dunes. A coyote then entered from the Pipeline revegetation area into the number 8 exclosure. After consulting with Ronnie Glick on April 26, it was decided that coyote removal was necessary. One adult female coyote was removed that evening by WSS Simms from the southwest corner of the Pipeline re-vegetation area. An adult male coyote was removed from the Cottonwood re-vegetation area on May 16 after WSS Simms had followed its tracks back from the shoreline near the number 6 exclosure.

On June 19, WSS Simms attended a meeting with Ronnie Glick, Joanna Iwanicha, and Doug George. At the meeting, it was reported that there was higher than expected SNPL chick loss for the second year in a row. It was decided that WSS Simms would monitor coyote activity on the shoreline. WSS Simms was able to observe four different adult coyotes hunting on the shoreline between the Oso Flaco Boardwalk and the number 6 exclosure. On June 16, WSS Simms was asked to remove coyotes that were traveling along the shoreline. WSS Simms began to pursue coyotes in the Oso Flaco/Maidenform area that were hunting the shoreline. While checking equipment and going through coyote scat, WSS Simms found three different SNPL bands in coyote scat in the same area. Doug George identified all three bands and determined they could have been from SNPL chicks hatched during the 2007 season. WSS Simms was able to remove an adult female coyote from southeast Maidenform area. On August 3, WSS Simms found six additional SNPL bands in different coyote scat around the east Boneyard area. WSS Simms removed one adult male coyote on August 7 east of the Boneyard/Oso Flaco area. WSS Simms then captured an adult female coyote on August 11 in the Oso Flaco area. Due to lack of funding, WSS Simms was instructed to remove equipment on August 20 which was WSS Simms' last day on site. A map showing locations of SNPL bands in coyote scat can be found in Appendix 2.

During the 2007 SNPL and LETE nesting season, gulls did not present a known threat at the ODSVRA site. One Gull observed by Paul Young and ODSVRA Resource Ecologists was suspected of suspicious behavior. WSS Simms spent two days pursuing the gull but was unable to locate it.

Throughout the season, Great Horned Owl tracks were observed in or near SNPL and LETE nesting exclosures. WSS Simms pursued the Great Horned Owl but was unsuccessful.

On August 18, WSS Simms observed a mountain lion at 6:30am in the Oso Flaco area. The mountain lion was sitting approximately 20 feet from one of WSS Simms' coyote traps. WSS Simms informed ODSVRA Resource Ecologists of the sighting. The mountain lion was not captured in any traps.

Recommendations:

WS recommends the ongoing maintenance and lifting of perimeter fencing. When the wind blows, sand builds up under the fencing in some areas giving predators easier access across the fencing.

WS recommends continued maintenance by eliminating all food sources, including carrion and trash leftover by visitors, which may attract predators.

WS recommends public education that discourages wildlife feeding.

WS recommends that State Parks continue to enforce the leash law on the beach, especially during nesting season.

WS recommends that all garbage containers within the park have reinforced lids, to prevent inadvertent wildlife feeding.

WS recommends removal of known SNPL and LETE predator species in and around nesting areas prior to predation occurring. WS conducts active predator removal programs at several SNPL and LETE nesting sites along California's coast. Sites with proactive predator removal programs often times have less predation problems than those with reactive or no predator removal programs.

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Acting District Supervisor
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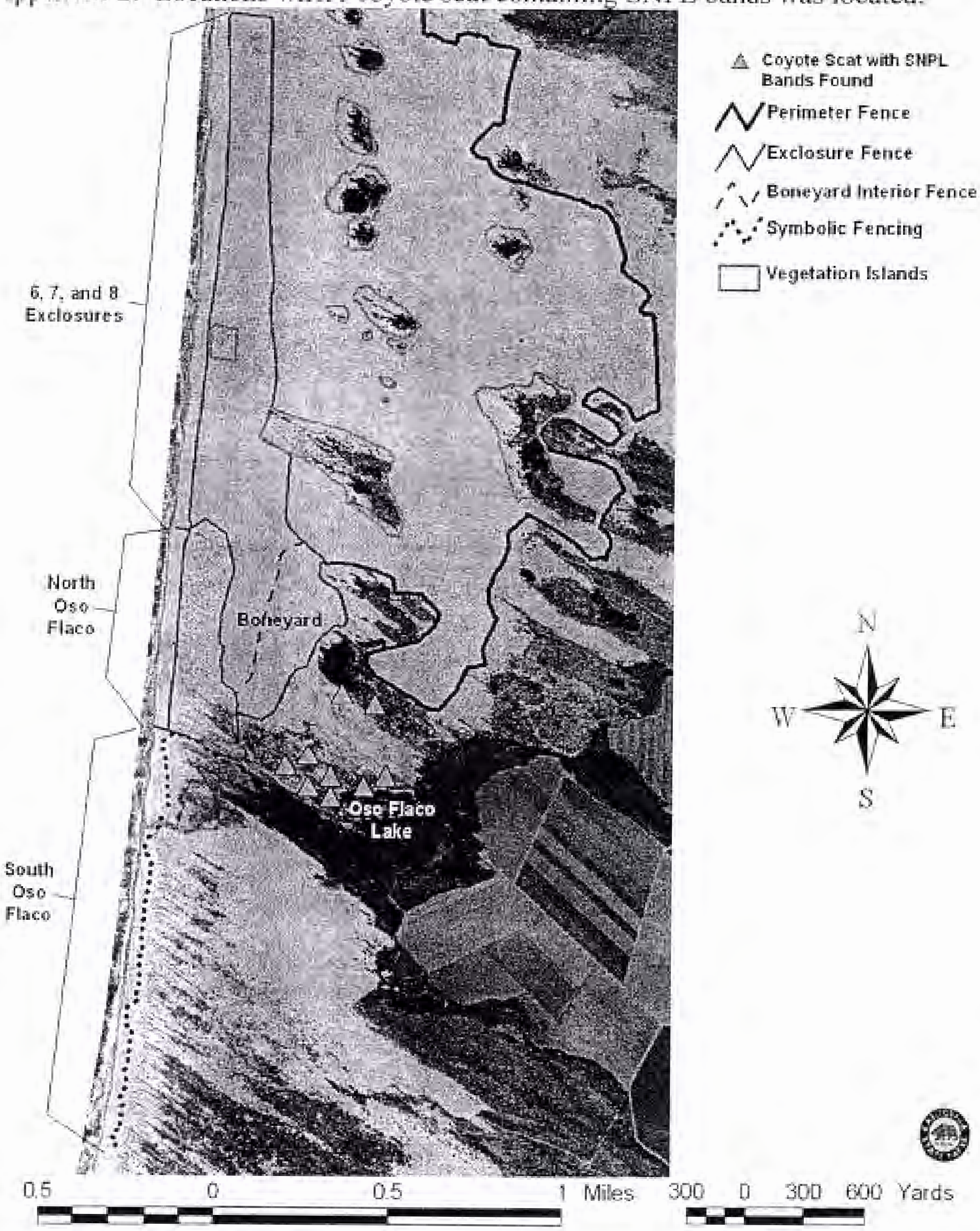
CA Wildlife Services Program

Appendix 1: Locations of scent station surveys during the 2007 SNPL and LETE nesting season.

Appendix 2: Locations where coyote scat containing SNPL bands was located.



NESTING OF THE
CALIFORNIA LEAST TERN AND WESTERN SNOWY PLOVER AT THE OCEANO DUNES STATE VEHICULAR RECREATION AREA, SAN LUIS OBISPO COUNTY, CALIFORNIA
2009 SEASON

Prepared for
California Department of Fish and Game
United States Fish and Wildlife Service

Prepared by
California Department of Parks and Recreation
Off-Highway Motor Vehicle Division
Oceano Dunes District

November 2009

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SUMMARY

Staff of Oceano Dunes State Vehicular Recreation Area (Oceano Dunes SVRA, ODSVRA) and PRBO Conservation Science (PRBO) monitored breeding California least terns (*Sternula antillarum browni*) (least tern, tern) and western snowy plovers (*Charadrius alexandrinus nivosus*) (snowy plover, plover) at ODSVRA, San Luis Obispo County, California in 2009.

All least tern nests were inside a large seasonally fenced exclosure in the southern portion of the vehicle riding area. There was a minimum of 25 breeding pairs. This is the lowest number of breeding pairs since 2002 and compares to 55 pairs in 2008. Twenty-three of the 26 (88%) nests hatched. Of the three nests that failed, one was abandoned pre-term (prior to the expected hatch date), one was abandoned post-term (on or after the expected hatch date), and one nest was unknown if abandoned pre- or post-term. Forty-three chicks hatched and 37 of these were color-banded to individual. Twenty-nine of the 37 banded chicks are known to have fledged, from identification of color-banded juveniles in the field, for a chick fledging rate of 78% and 1.16 chicks fledged per pair. In addition, four of the six unbanded chicks are believed to have fledged, and if included would result in a fledge rate of 77% and 1.32 chicks fledged per pair.

There was a minimum of 114 breeding snowy plovers (66 males and 48 females), compared to 95 in 2008. Fifty-one banded birds were documented as breeding; 45 of these were banded as chicks and fledged from ODSVRA from 2003-08. There were 150 known nesting attempts, 125 were in the southern riding area seasonal exclosure (Southern Exclosure), 23 in Oso Flaco, one north of Grand Ave. near Pismo Creek lagoon, and one from an unknown location (nesting known only by detection of brood). Ninety-four of the 147 known location and fate nests hatched, for a nest hatching rate of 64%. Fifty-three nests failed, attributed to the following causes: abandoned pre-term (13), nonviable eggs (3), unknown cause (3), overwashed by tide (2), unidentified predator (10), unidentified avian predator (17), gull (2), crow (1), northern harrier (1), and skunk (1) (see Table 11). Of the 245 hatching chicks, 234 were color-banded to brood, and the fate of eleven unbanded chicks is known (none fledged). Eighty-one of 245 chicks with known fate fledged for a chick fledging rate of 33%. One chick fledged per breeding male is the estimated number needed to prevent the population from declining (assuming approximately 75% annual adult survival and 50% juvenile survival) (U.S. Fish and Wildlife Service 2007). In 2009, an estimated 1.23 juveniles fledged per male at ODSVRA, providing for population growth. For the eight-year period 2002-09, average productivity was 1.31 juveniles fledged per breeding male.

INTRODUCTION

Oceano Dunes SVRA, located in southern coastal San Luis Obispo County, California, is a popular park with high attendance and was visited by over 1.8 million people in 2008 for a variety of recreational opportunities, including driving vehicles on the beach and dunes.[1] In 2008, an estimated 251,814 street-legal vehicles and 225,015 off-highway vehicles were driven on the shoreline and dunes in the designated riding area of the park.[2] Within ODSVRA there is extensive breeding habitat for two special-status ground-nesting birds, the state and federally endangered California least tern and the federally threatened Pacific coast population of the western snowy plover. Monitoring of the least tern and snowy plover at ODSVRA during the

[1] ODSVRA 2008 Annual Attendance figures (source ODSVRA)
[2] ODSVRA 2008 Monthly Carrying Capacity Summaries (source ODSVRA)

breeding season began in 1991 and 1992, respectively. Least terns are present at ODSVRA only during the breeding season, migrating to wintering areas well south of California. The snowy plover population at the park is comprised partly of resident birds, present year-round, and partly of migrant birds, present only during the breeding or wintering season.

This report summarizes the results of the 2009 nesting season for least terns and snowy plovers at ODSVRA. Maps in figures and appendices use digital satellite photos taken in 2007, unless otherwise noted.

SITE DESCRIPTION

ODSVRA is part of the 18-mile-long Guadalupe-Nipomo Dunes complex (Figure 1). The Oceano Dunes District, California Department of Parks and Recreation manages approximately 4,900 acres with approximately 9.1 miles of ocean shoreline on the western edge. On the northern border of the park is the city of Pismo Beach. To the east of the park are ConocoPhillips refinery, the cities of Grover Beach and Oceano and private lands that consist of dunes, coastal scrub, and agricultural fields. The southern border of the park abuts the Guadalupe-Nipomo Dunes National Wildlife Refuge. Inside the park, dunes that are open to vehicles extend inland in some areas for over one mile. Eight numbered marker posts, located approximately 0.5 miles apart, are located along the coastal strand of the riding area to orient park visitors and staff. Street-legal vehicles are allowed throughout the riding area. Off-highway vehicles, as well as overnight camping, are allowed along the beach and dunes south of marker post 2 (approximately one mile south of Pier Avenue). In the southern portion of ODSVRA is Oso Flaco Lake Natural Area (Oso Flaco) with a shoreline of approximately 1.7 miles. Pedestrians are allowed at Oso Flaco but it is closed to camping, equestrian, dog, and vehicle use. The beach at Oso Flaco west of the foredunes is narrower than those in the riding area.

The following are descriptions of sites and terms as used in this report (Figure 2).

ODSVRA: All areas that are administered by the Oceano Dunes District, including the Oceano Dunes SVRA, Pismo State Beach, Pismo Dunes Natural Preserve (Dune Preserve), and Oso Flaco Lake Natural Area. Management of the Dune Preserve and Pismo State Beach was transferred to the Oceano Dunes District in December 2004. ODSVRA provided tern and plover monitoring for the Dune Preserve in the past and continues to do so. Pedestrian and equestrian use is permitted in the Dune Preserve, but vehicles and dogs are not allowed.

Riding area: The area within ODSVRA that is open to recreational vehicles. This area changes in size based on seasonal restrictions. Street-legal vehicles are allowed along approximately 5.3 miles of beach, from the Grand Avenue north park entrance to the south boundary of the riding area (approximately 0.4 mile south of marker post 8). Off-highway vehicles are only allowed south of marker post 2.

Open riding area: The area within ODSVRA open to recreational vehicle use during the nesting season.

Southern Exclosure: A single contiguous area within the southern portion of the riding area that is fenced and closed to entry during the breeding season to protect nesting terns and plovers. The adjoining shoreline is also part of the Southern Exclosure and is closed to public entry during the nesting season. From 2001 to 2004, the amount of seasonally protected nesting habitat in the riding area has periodically increased in size. Subsequent to 2004 there has been no increase in size of this protected area. Individually identified areas (Figure 2) within the Southern Exclosure include the following:

6 exclosure: The area from marker post 6 to marker post 7, north of 7 exclosure (approximately 0.5-mile shoreline length), first incorporated into the Southern Exclosure for a full season in 2004. Vegetation within the exclosure is very sparse.

7 exclosure: The area from marker post 7 to the south side of 7.5 revegetation area (approximately 0.4-mile shoreline length). Habitat includes extensive areas of bare sand, limited areas of vegetated hummocks, limited areas of organic surface debris (shells, driftwood, dried algal wrack), and moderate to heavy vegetation in the small 7.5 revegetation area located within the 7 exclosure.

8 exclosure: The area from the south side of the 7.5 revegetation area to the North Oso Flaco fencing south of marker post 8 (approximately 0.5-mile shoreline length). Habitat includes extensive areas of bare sand, limited areas of vegetated hummocks, and limited areas of organic surface debris (shells, driftwood, and algal wrack).

Boneyard exclosure: The area east of the North Oso Flaco dunes. Habitat is primarily bare sand and active sand dunes. This inland area does not have a shoreline component. A portion of the west side has been closed year-round for the past four years due to the presence of a cultural resource area. The area has developed small vegetated hummocks. Straw bales placed within the protected cultural area for sand stabilization are still present.

Oso Flaco: The shoreline and dunes in ODSVRA located south of the riding area. The approximately 1.7 miles long beach is narrow, and the dunes are typically heavily vegetated, relative to the riding area. The area is part of the Oso Flaco Lake Natural Area, open to pedestrian use but closed to vehicles. For purposes of discussion in this report, Oso Flaco is divided into the following two areas, North Oso Flaco and South Oso Flaco (Figure 2).

North Oso Flaco: The area extending south from 8 exclosure to the boardwalk entrance at the Oso Flaco shoreline (approximately 0.5-mile shoreline length). Beginning in 2002, the upper beach and dunes were closed to pedestrians during the nesting season with symbolic fencing. Since 2005, predator fencing has replaced symbolic fencing and the shoreline has been closed to the public during the nesting season.

South Oso Flaco: Extends from the boardwalk to the ODSVRA southern boundary (approximately 1.2 miles shoreline length). The shoreline is open to the public and symbolic fencing and signage designates the seasonally closed upper beach and dune habitat.

Pipeline revegetation area: Located east of 8 exclosure. The area is heavily vegetated.

MONITORING METHODS

Typically there was a minimum of three monitors in the field during the morning and early afternoon each day and two monitors during evening shifts. Monitoring goals included locating all tern and plover nests in ODSVRA, providing additional protection for nests when necessary, ascertaining nest fate, and banding tern and plover chicks to document fledging success. Least tern and snowy plover clutch hatching dates were estimated from egg-laying dates when known. For plovers, floating eggs provided a means to estimate hatch date when egg-laying dates were unknown. A nest was considered to have hatched if at least one egg hatched. Each brood of plover chicks was given a unique color band combination. Plover chicks surviving to 28 days or older from the time of hatch were considered fledged. All tern chicks received a federal numbered aluminum band on the left leg, and a single plastic bicolor band (white over blue) on the right leg. Color tape was placed on the federal band to create color band combinations unique to each chick. Tern chicks surviving to 21 days or older were considered fledged.

Monitors mapped the locations of nests and exclosures using a Global Positioning System (GPS). The presence of potential mammalian and avian predators was detected by direct observation of the predators and their signs (e.g., tracks, scat, prey remains, depredated nests). The integrity of exclosure fencing was checked regularly and necessary repairs were made by monitors and maintenance staff.

The open riding area was monitored by vehicle on a daily basis as any nest initiated in this area would be at risk from recreational activities and require immediate protection. The Dune Preserve area was monitored on foot. Oso Flaco was monitored both on foot and by vehicle. The Southern Exclosure was monitored by periodic entry on foot as well as extensive observations with binoculars and spotting scopes from outside the exclosure. Using a vehicle as a blind proved very effective for monitoring the shoreline of the Southern Exclosure and Oso Flaco. Vehicle surveys were conducted during low tide by driving very slowly on the smooth, hard-packed sand in the lower exposed intertidal zone. Observations were made from the parked vehicle with the area in front of the vehicle carefully scanned before proceeding to the next observation point. When a monitor entered the 6 or 7 exclosure on foot, one to two monitors in their vehicles were positioned in the open riding area along the east side of the exclosure. Here they would watch over the exclosure for movement of chicks, keep the monitor inside the exclosure informed and, if necessary, direct chicks away from the open riding area.

Monitoring was conducted in a manner to minimize disturbance or adverse effects to adult birds, nests, and chicks. Monitoring activities at ODSVRA were conducted under U.S. Fish and Wildlife Service (USFWS) permits 10(a)(1)(A) TE-815214-5 (ODSVRA), 10(a)(1)(A) TE-807078-10 (PRBO), and a Memorandum of Understanding (MOU) from the California

Department of Fish and Game. Banding activities were conducted by PRBO under Federal Bird Banding Laboratory Bird Banding Permit 09316 and California Department of Fish and Game Scientific Collecting Permit SC-006691.

MANAGEMENT ACTIONS

ODSVRA continued to implement protective measures for least terns and snowy plovers that were in place in the 2008 season. In addition to intensive monitoring, management actions in 2009 included the following:

Southern Exclosure Protected Area
This approximately 300-acre area was fenced during the nesting season (1 March to 30 September) to limit vehicle and human disturbance. Prior to 2006, wire fencing five feet high (bottom eight inches buried) with two inch by four inch mesh was used to discourage entry by large mammalian predators. Beginning in 2006, an additional layer of fence material was attached to overlap the lower fence, increasing fence height above the surface to approximately six feet. This was done to increase the effectiveness of the fence in deterring coyotes. In 2008 and 2009, additional tall posts with large stop signs were installed in the intertidal area of post 6, with rope and additional signage extending between the shoreline posts to clearly designate a closed shoreline. The east fence of Boneyard exclosure was not maintained as predator fencing due to rapidly shifting sands of the open dunes in the area. Instead, a seasonal interior fence has been maintained since 2005 to limit predator access into the west portion of Boneyard exclosure and the rest of the Southern Exclosure (Figure 20).

Oso Flaco Protected Area
Beginning in 2005, all of North Oso Flaco, including the shoreline, has been closed to public entry during the nesting season. The upper beach and dunes of North Oso Flaco were enclosed by wire mesh predator fencing identical to that used in the Southern Exclosure. Posts and rope extend into the intertidal area at the southern boundary of North Oso Flaco to designate a closed shoreline.

South Oso Flaco, as in previous years, remained partly open to pedestrians, and snowy plover nests received individual nest exclosure. Since 2002, symbolic fencing, consisting of a single strand of rope strung between posts to close and protect upper beach and dune habitat, has been employed. The lower beach and shoreline remained open to pedestrian use.

Habitat Enhancement
Early in the breeding season, driftwood, woodchips, and surf-cast kelp (wrack) (collected in the open riding area) were distributed in selected areas within the 6, 7, and 8 exclosures and shoreline to provide disruptive cover for tern and plover adults, juveniles, and chicks. This was done on a limited basis because of the limited time available between the closure to vehicles and when nesting began, as well as the limited availability of natural materials. Woodchips were spread in scattered patches of approximately a quarter-acre or less in size in areas of barren sand and over some thinning woodchip patches remaining from previous years. There was some distribution of sea rocket (*Cakile maritima*) and beach-bur (*Ambrosia chamissonis*) seed and planting of container plants in an effort to provide scattered plant cover. Plovers and terns were observed using the scattered plants and plant-covered hummocks when these features were available. Kelp was distributed on the shoreline in specific areas throughout the season and

inoculated with wrack-dependent invertebrates during the early season. The resulting invertebrate dispersal and abundance was studied by a research group from the University of California Santa Barbara. Invertebrates associated with wrack can be an important prey source for plovers.

Least Tern Chick Shelters

There were 249 tern chick shelters placed in the 6 and 7 exclosures in 2009 to provide chicks with some available cover and there were numerous observations of chick use. These simple designs were of two pieces of plywood screwed together to form either an A-shape shelter (six inches high by 12 inches long by 11 inches wide), L-shape shelter (seven inches high by 19 inches long by 14 inches wide), or T-shape shelter (12 inches by 12 inches flat roof with a center support partially buried in sand).

Single Nest Exclosures

The protocol for a nest found in the open riding area calls for a 164 foot diameter circular exclosure consisting of two inch by four inch mesh wire fencing with a height of five feet (bottom eight inches buried). There were no nests found in the open riding area in 2009. A single nest exclosure of this configuration was installed around one snowy plover nest located north of Grand Avenue. Smaller individual exclosures (but larger than the 10 foot by 10 foot) were used in Oso Flaco and the Southern Exclosure shoreline to protect nests.

10 Foot by 10 Foot Exclosure

A small square nest exclosure was selectively used around snowy plover nests in 2009 to provide protection from roosting gull flocks and for protection from avian predators. The 10 foot by 10 foot exclosure was built with sides five feet high using two inch by four inch mesh wire fence (bottom eight inch buried if required). A net top consisting of 1/2 inch by 1/2 inch plastic mesh was added to exclosures when avian predator threats were high. These exclosures were only used around plover nests and not tern nests, as terns fly to approach and leave a nest. This design was used only in specific circumstances, as incubating adults may be more vulnerable to predators keying into a small exclosure.

Predator Management

The exclosure fencing was regularly monitored and maintained to discourage large mammalian predators (e.g., coyotes) from entering protected breeding habitat. Individual nest exclosures were erected when a nest was found outside of the large exclosure, such as on the shoreline west of the exclosure or in south Oso Flaco. Individual 10 foot by 10 foot exclosures, some with net tops, were erected when necessary. Seabird and marine mammal carcasses were removed from the shoreline to reduce food sources attracting scavengers that might also prey on tern and plover eggs and chicks. Predator management also provided for the limited and selective relocation or removal of avian and mammalian predators threatening reproductive success of least terns and snowy plovers. Such actions were the responsibility of contracted predator control specialists from The Bird Group (funded by the Ventana Wilderness Society) and the U.S. Department of Agriculture (USDA) Wildlife Services.

Information/Education for Park Visitors

Interpretive panels at access points and signs identifying closed areas served to increase public awareness of threats to nesting terns and plovers. These measures also informed the public of the park's management efforts to protect these special-status species. The public could also access a low wattage radio station with a repeated recording of park information, including information about protection of sensitive species.

Enforcement of Resource Protection Regulations
All closed areas were signed in English and Spanish. State Park rangers had the responsibility of enforcing park regulations enacted to protect terns and plovers. In addition, resource staff monitors contacted visitors violating park regulations and, when appropriate, contacted rangers.

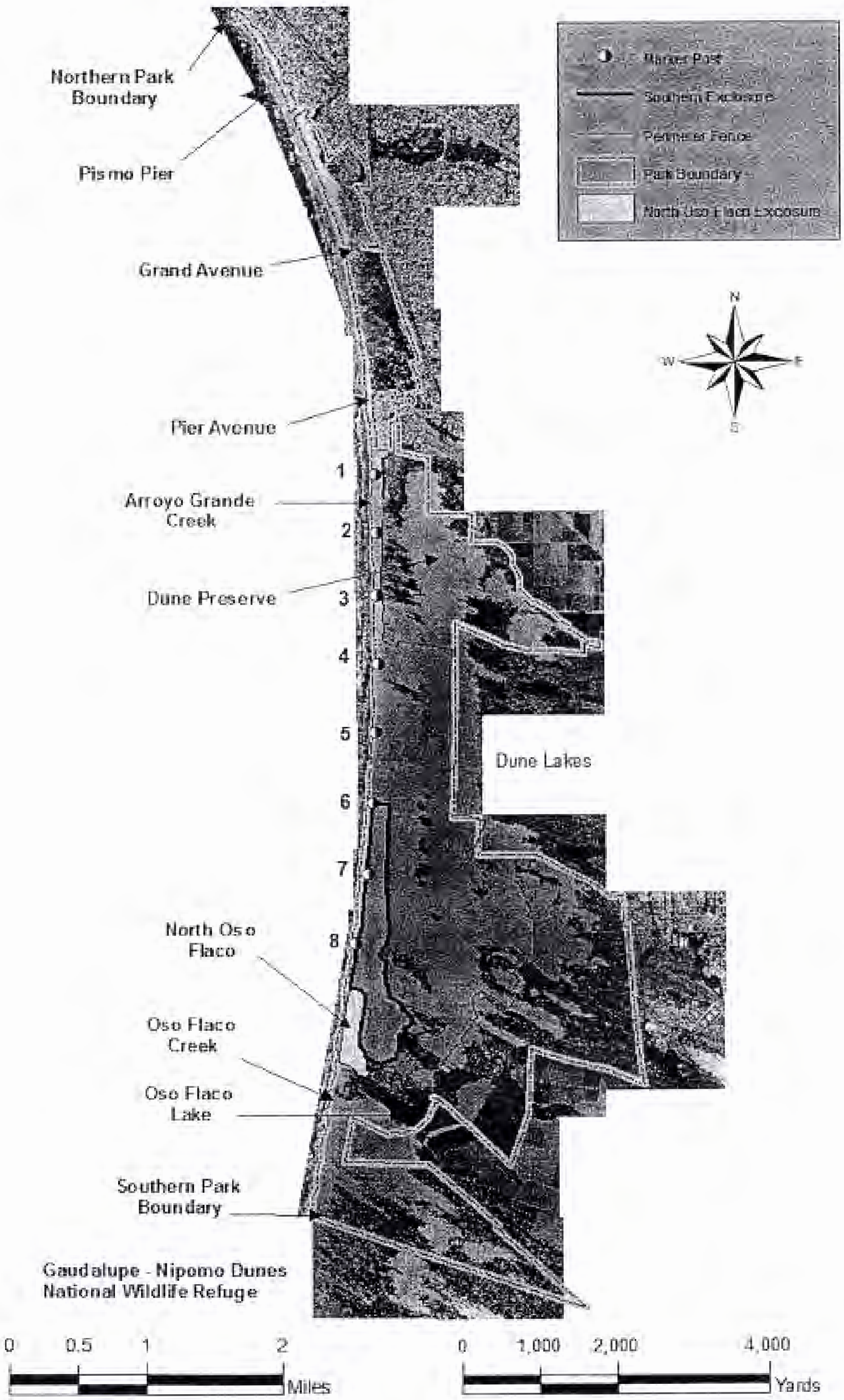


Figure 1. ODSVRA site map.

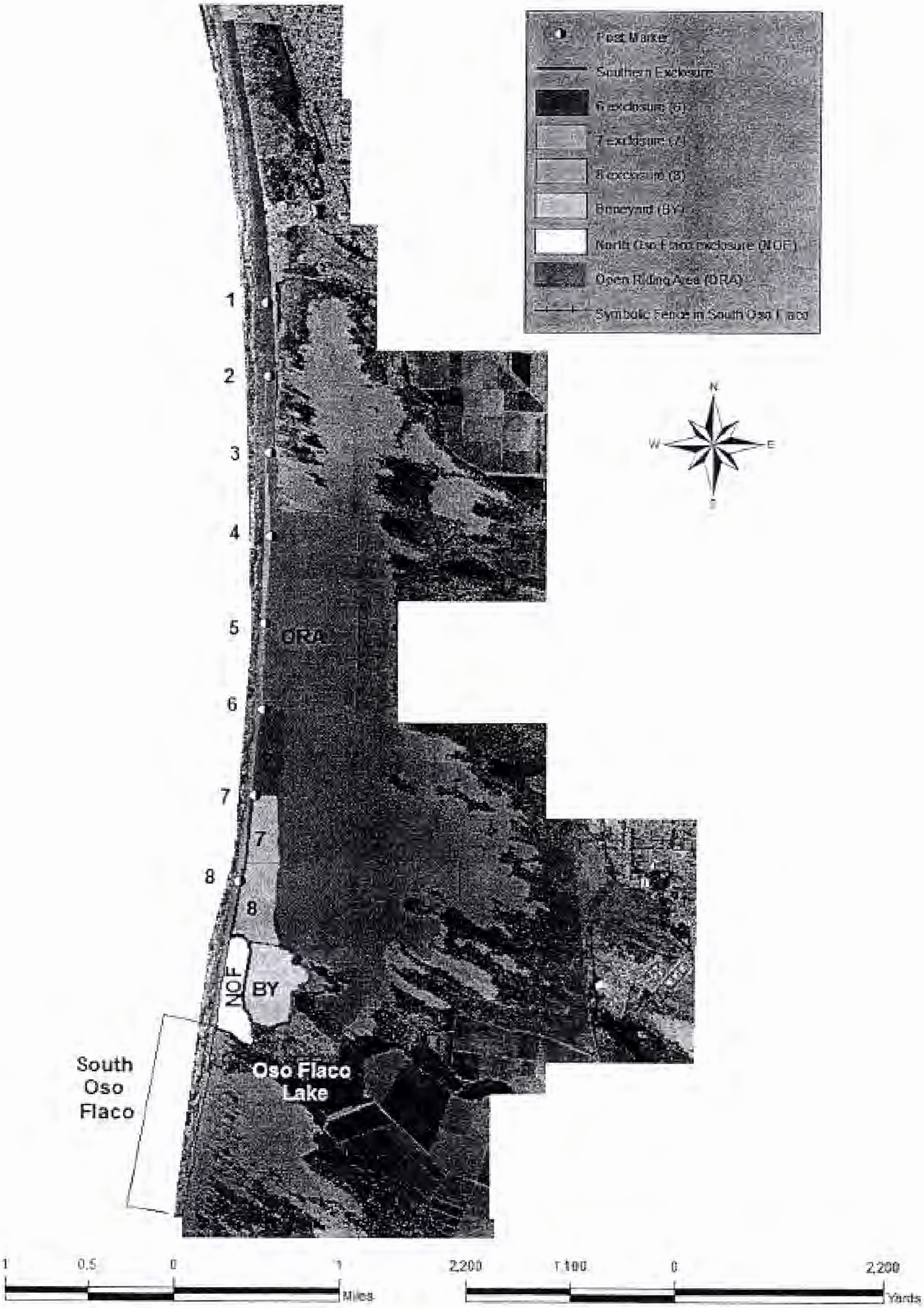


Figure 2. ODSVRA Southern Exclosure and Oso Flaco seasonally protected areas for breeding California least terns and snowy plovers in 2009.

RESULTS AND DISCUSSION

CALIFORNIA LEAST TERN

In 2009 the first least tern was seen at ODSVRA on 2 May (one in flight). Terns were next seen 11 May (two on the ground) and from 13 May on were seen or heard daily. From 2002-08 terns were first seen between 8 April and 15 May (median=7 May). Terns were last seen 24 September (two juveniles and two adults at Oso Flaco Lake) and 25 September (one in flight), a later departure than the previous seven years when last seen between 22 August and 10 September (median=2 September). There was a minimum of 25 breeding pairs based on a same day high count of the number of active nests added to the number of active broods (24) plus one additional nest that could not be accounted for by re-nesting. This is the lowest number of breeding least terns documented at ODSVRA since 2002 (20 pairs) and is less than half the 55 breeding pairs in 2008 and below the range of 31-54 (median=47) during the period 2003-07 (Table 1, Figure 3). It is not clear why there were fewer breeding pairs in 2009. For the six-year period 2004-09 night roost counts tended to correlate with the number of breeding pairs on site. In 2009, night roost counts were low relative to the previous two years. The extent and apparent quality of available breeding habitat was comparable to 2008. Insufficient information was collected to examine if food availability may have been a limiting factor.

Nine banded adults were documented: four were banded as chicks at ODSVRA (three in 2006 and one in 2007), and five had only a federal aluminum band without color tape and banding origins not known (identification would require reading the unique number sequence stamped in the aluminum band). Breeding was documented for seven of the nine banded adults: four whose origins were not identified and three banded as chicks at ODSVRA in 2006. This compares to 19 banded adults documented in 2008, including 15 banded as chicks at ODSVRA (four in 2005, nine in 2006, and two in 2007). Least terns typically first begin to breed when three years old (less commonly at two years old) (USFWS 1985).

The first nest was initiated 6 June, within the 31 May – 8 June (median=3 June) range when first nests were initiated at ODSVRA during the previous seven years. There were 26 nesting attempts documented. Estimated nest initiation dates ranged from 6 June – 21 July with 24 of 26 nests initiated on or after 20 June (Appendix A). This compares to an average of 55 nests (range=22-79) for the seven-year period 2002-08 and 12 nests for 1991-2001 (range=0-40) when nesting occurred during nine of 11 years (Table 1, Figure 3). In 2009 there was a single one-egg clutch and 22 two-egg clutches. There were three nests whose egg number was not checked, but each had a minimum of two eggs as two chicks hatched from each nest. These nests were not approached and chicks not banded due to their close proximity to young snowy plover broods that in turn were near gull flocks. The average number of eggs in known completed clutches was 1.96 (range=1-2, n=23). This compares to an average of 1.77 for 2003-08 (range=1.55-2.05), and statewide averages of 1.62 and 1.75 in 2007 and 2008, respectively (Marschalek 2008, 2009). All nests were located inside the Southern Exclosure and distributed throughout 6 exclosure (20 nests, 77% of total), 7 exclosure (3, 12%), 8 exclosure (2, 8%), and Boneyard exclosure (1, 4%) (Table 2) (Appendix C).

Table 1. Nesting success of California least terns at ODSVRA, 1991-2009. Information is derived from ODSVRA annual reports. For some years, the estimated numbers of breeding pairs in this table are higher than those given in earlier reports. These revised estimates are based on the number of concurrently active nests and broods added together. The numbers in parentheses are the number of nests whose fate (hatch or fail) was determined.

Year	Estimated no. breeding pairs	No. nests	No. nests known hatched	Percent known fate nests hatched	No. chicks	No. juveniles[1]	Juveniles fledged per pair
1991	4	6 (6)	2	33	4	2	0.5
1992	3	4 (4)	1	25	2	1	0.33
1993	0	0 (0)	0	-	0	0	–
1994	2	2 (2)	0	0	0	0	0
1995	1	1 (1)	0	0	0	0	0
1996	0	0 (0)	0	-	0	0	–
1997	16	21 (10)	3	30	6	4	0.25
1998	33	40 (32)	26	81	40	24	0.73
1999	28	34 (30)	21	70	38	17	0.61
2000	4	5 (5)	4	80	8	4	1
2001	12	18 (18)	13	72	22	12	1
2002	20	22 (19)	15	79	27	10	0.5
2003	53	79 (77)	60	78	101	37	0.7
2004	47	63 (60)	44	73	69	25	0.53
2005	47	59 (59)	39	66	66	20	0.43
2006	31	38 (38)	28	74	45	36	1.16
2007	54	66 (66)	51	77	90	70	1.3
2008	55	56 (56)	50	89	99	70	1.27
2009	25	26 (26)	23	88	43[2]	29-33[3]	1.16-1.32[3]

[1] Method of fledge count varied among years: single day high count for 1991 to 1997, 2000, and 2001, single day high count at Oso Flaco Lake for 1998; count method for 1999 is unknown; three-week interval day count conducted from 2002 to 2004 (chicks only banded to site in 2003 to 2004); in 2005 chicks were color-banded to brood and in 2006 to 2009 chicks were color-banded to individual and this has resulted in a more accurate documentation of fledge rate than the three-week interval estimation method. Earlier estimates prior to banding to individuals may represent substantial under counts or over counts.

[2] Six of the 43 chicks produced at ODSVRA were unbanded.

[3] Twenty-nine banded and four unbanded juveniles were observed at ODSVRA so the number of juveniles and juveniles fledged per pair is reported as a range. Four of the six unbanded chicks were tracked to approximately three weeks old and were identified based on their location relative to the locations of banded chicks.

Table 2. Distribution of least tern nests as a percentage of total nests at ODSVRA from 2004-09. The 6 exclosure was first put up very late in the 2003 season and was first available for a full season in 2004. Note: percentages may not add up to 100 due to rounding.

Year	6 exclosure	7 exclosure	8 exclosure	Boneyard exclosure	Open Riding Area	Unknown location
2004		22.2%	63.5%	11.1%	1.6%[1]	1.6%
2005	6.8%	22.0%	52.5%	17.0%	1.7%[2]	
2006	52.6%	15.8%	31.6%			
2007	37.9%	42.4%	13.6%	6.0%		
2008	57.1%	23.2%	17.9%	1.8%		
2009	76.9%	11.5%	7.7%	3.8%		

[1] One nest located approximately 340 feet east of 7 exclosure.

[2] One nest located at Arroyo Grande Creek, approximately 1.5 miles north of Southern Exclosure.

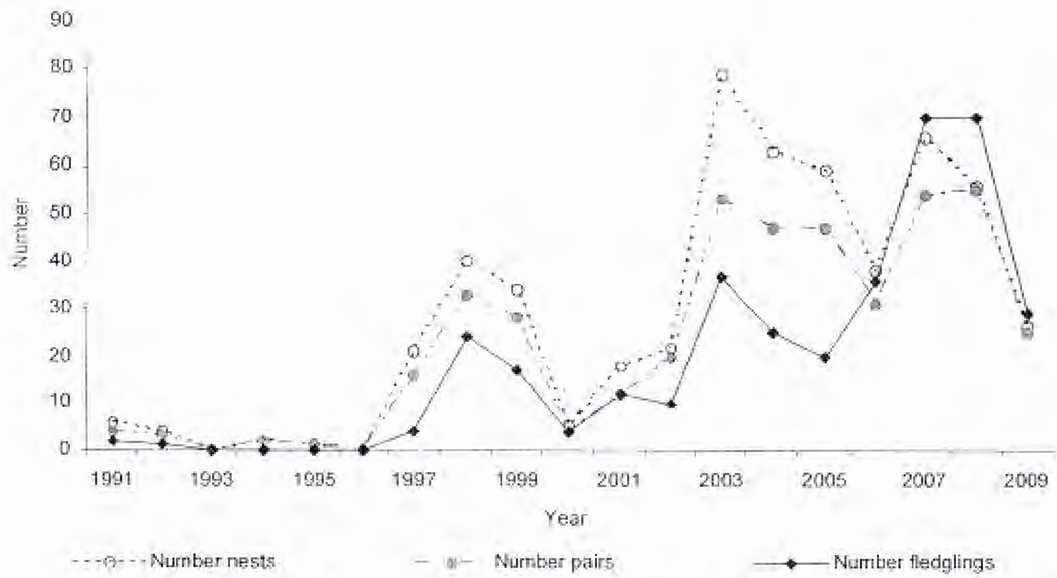


Figure 3. Number of California least tern nests, pairs, and fledglings at ODSVRA from 1991-2009. Four unbanded fledglings seen on site in 2009 are not included in this graph.

When monitoring on foot in areas where tern chicks were present additional monitors were posted east of the exclosure to watch for any potential chick movement. Chicks moving east and near to the fence (or through the fence on one occasion involving four chicks) were directed to the west and away from the open riding area. This movement has been observed more in the narrower north portion of the Southern Exclosure. As fledglings began to fly they were occasionally seen flying over the adjoining open riding area. At times young fledglings were on the ground in the open riding area up to 300 feet east of the exclosure, with a maximum of five seen at the same time. When present, monitors responded quickly to flush fledglings seen on the ground in the open riding area and the fledglings flew back into the exclosure. Direct observations and tracks indicated these fledglings were typically flying into the open riding area and not walking from the exclosure. Fledgling movement into the open riding area was a natural behavior and occurred when there was no monitoring on foot inside the exclosure.

Clutch hatching rate

Of the 26 nests, 88% (23/26) hatched and 12% (3/26) failed (Table 3). This compares to an average clutch hatching rate of 78% (range=66-89%) during the period 2002-09, and 43% (range=0–80%) during the period 1991-2001, when nests were found in nine of 11 years (Table 1). In 2009 all three failed nests were abandoned and with eggs remaining on the surface. One nest was abandoned prior to the expected hatch date, one at or after the expected hatch date, and one unknown relative to expected hatch date. Prior to 2003, nest abandonment information is limited. For the eight-year period 2002-09, abandonment accounted for 75% (62/83) of documented nest loss, with 67% (36/54) of abandonment, when known if pre- or post-term, occurring prior to the expected hatch date (Table 4). From 2003-09, 59% (20/34) of the nests abandoned pre-term were found with eggs on the surface and 21% (7/34) were found with eggs buried. For seven of the 34 nests information identifying if eggs were found on surface or buried was not available. Nests abandoned pre-term with eggs on surface indicate causes for failure other than wind and wind-blown sand.

Table 3. Nesting success of California least terns at different sites within the Southern Exclosure at ODSVRA in 2009. Number of chicks fledging and juveniles fledging per nest are reported as a range with 29 banded chicks confirmed fledging and an additional four unbanded chicks likely fledging.

Area	No. nests	No. eggs laid	No. nests hatching	% nests hatching	No. chicks	No. chicks fledging	% banded chicks fledging	Juveniles fledged per nest
Southern Exclosure								
6 exclosure	20	min. 40	17	85.0%	32	23-27	88.5%	1.15-1.35
7 exclosure	3	6	3	100.0%	6	5	83.3%	1.67
8 exclosure	2	3	2	100.0%	3	0	0.0%	0.00
Boneyard exclosure	1	2	1	100.0%	2	1	50.0%	1.00
TOTAL SOUTHERN EXCLOSURE	26	min. 51	23	88.5%	43	29-33	78.4%	1.12-1.27

Table 4. Causes of California least tern nest loss at ODSVRA from 2002-09. Nests abandoned pre-term were abandoned prior to the expected hatch date. Nest abandoned post-term were abandoned after the expected hatch date and include nests with nonviable eggs. Numbers in parentheses are percent of all nests that failed. Note: percentages may not add up to 100 due to rounding.

Year	Abandoned pre-term	Abandoned post-term	Abandoned, unknown if pre- or post-term	Failed, cause unknown	Coyote	Gull	Unknown predator	Chick dies in egg during hatch	No. failed nests
2002	1	1			2				4
2003	6	3			1		2		12
2004	9	1			2		1		13
2005	7	3	4	4			1	1	20
2006	3	3	3				1		10
2007	6	4		5					15
2008	3	2				1			6
2009	1	1	1						3
TOTAL 2002-2009	36 (43.4%)	18 (21.7%)	8 (9.6%)	9 (10.8%)	5 (6.0%)	1 (1.2%)	5 (6.0%)	1 (1.2%)	83

Chick fledging rate and juveniles

Thirty-seven of 43 known hatching chicks were banded with a unique color combination. Six chicks from three nests were not banded to avoid disturbance to young plover broods near roosting gulls. Twenty-nine of 37 banded chicks are documented to have fledged, by identification of color band combinations in the field, for a chick fledging rate of 78%. This compares to 71% in 2008, and a range of 30-37% during the period 2002-05 and 78-80% during the period 2006-07. It is important to note that due to variability in banding efforts and fledgling count methods, the accuracy of fledgling estimates is not consistent between all years. A three-week interval day count was conducted from 2002 to 2004 (chicks were not banded in 2002 and only banded to site in 2003 and 2004) and possibly underestimated fledgling success. In 2005 chicks were color-banded to brood and in 2006 to 2009 chicks were color-banded to individual.

This has resulted in increased documentation of fledge success compared to the three-week interval estimation method. Ninety percent of the chicks fledging in 2009 did so within the 10-day period 1 – 10 August. Of 20 two-chick broods 60% (12/20) fledged both young. This compares to two-chick broods in 2006, 2007, and 2008, when 63% (10/16), 62% (24/39), and 54% (22/41), respectively, fledged both young. In addition to the 29 banded chicks fledging, four of the six unbanded chicks are believed to have fledged and if included would result in a fledge rate of 77% (33/43). A range of 29-33 fledglings produced in 2009 results in 1.16-1.32 fledglings per breeding pair, and compares to 1.27 in 2008 and an average of 0.82 (range=0.43-1.30) for the five-year period 2003-07 (Table 1). For each of the last four years, productivity has exceeded one fledgling per pair at ODSVRA. For all least tern colonies in California the average number of fledglings per pair (given in a range) was 0.23-0.36, 0.35-0.52, 0.33-0.39, and 0.29-0.37 in 2005-08, respectively (Marschalek 2006, 2007, 2008, 2009).

Providing least tern chicks with individual color band combinations has significantly increased the ability to detect juveniles at ODSVRA, track associated banded adults with known broods, and provide a more accurate documentation of fledging rate. In the absence of such banding, one method used to estimate the number of juveniles produced at least tern sites in California is to add together high counts of juveniles that are seen on dates at intervals of three weeks or more (Marschalek 2009). This is based on the assumption that juveniles typically depart the colony with their parents within two to three weeks of fledging (at 21 days old) and that any juveniles seen are not from other sites. In 2009 at ODSVRA, this three-week count method resulted in a combined high count of 22 juveniles (22 juveniles seen simultaneously on 6 August added to zero seen on 27 August). The count of 22 is an overestimation because it exceeds the maximum possible number of juveniles on that day and was due to observers identifying older chicks as juveniles. Even with this over count, the three-week count estimation is only 76% of the number of fledglings documented by detection of individual color bands and 67% of banded fledglings plus four unbanded fledglings.

Color banding chicks to brood in 2005, and to individual in 2006-09, has also provided information on juvenile length of stay at ODSVRA (Figures 4 and 5, Table 5). It is of interest to note that 70% (14/20), 47% (16/34), 41% (26/69), 15% (10/68) and 14% (4/28) of the juveniles in 2005-09, respectively, whose ages could be tracked, were documented remaining at ODSVRA three weeks or longer[3]. Over the five-year period 2005-09, 219 fledglings were tracked at ODSVRA with 32% (70/219) remaining 21 days or longer post-fledging. This is in contrast to the assumption in the three-week count method of most fledglings departing the colony site prior to the end of the third week after fledging. Similar findings are reported from a two-year study of three least tern colony sites in the eastern United States that found that methods dependent upon counting non-individually identified fledglings tend to underestimate fledgling production and residency time compared to information available from counting individually banded fledglings (Bailey and Servello 2008).

During the chick rearing period, adult least terns were noted foraging over the ocean and at nearby small freshwater lakes (Oso Flaco Lake, Dune Lakes, and Cypress Ridge Lake) and returning with fish to the colony. Of the freshwater sources noted, only Oso Flaco Lake is

[3] These numbers differ from numbers in reports for 2007 which included fledglings seen off-site at nearby Cypress Ridge Lake.

located within the park. Although least tern adults were seen foraging and feeding fledglings at Oso Flaco Lake, use of this site appeared limited. Dense algae was noted during many of the monitoring visits to the lake, which could make foraging difficult for the terns. There is also concern that activities occurring outside the park increase sediment and contaminants in the lake which have degraded water quality. ODSVRA is currently working with the Coastal San Luis Resource Conservation District, regulatory agencies, and neighboring landowners to address water quality conditions in Oso Flaco Lake.

In 2007, monitors became aware of least terns using Cypress Ridge Lake, located approximately 3.2 miles from the tern colony site. In 2009, adult terns were seen to forage and successfully catch fish at the lake. Over the course of 11 surveys, a total of 19 individually banded ODSVRA fledglings were seen. When fledglings were present, adults caught small fish that they ate or fed to the fledglings. The high count was on 18 August with 34 least terns present at the same time: 16 fledglings banded at ODSVRA, three unbanded fledglings, four banded adults, and 11 unbanded adults. Two of the banded adults were identified to have been banded as chicks at ODSVRA.

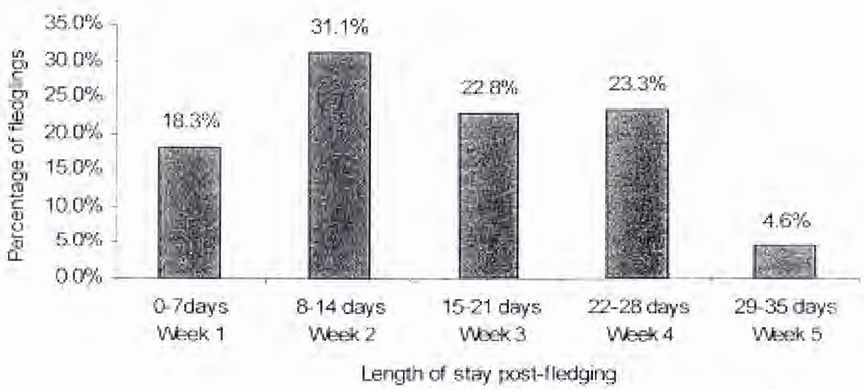


Figure 4. Length of time after reaching fledge age (21 days) California least tern fledglings hatched at ODSVRA continued to be seen on-site, 2005-09. During the five-year period 2005-09, 219 fledglings were identified (seen at 21 days of age or older). Fledgling identity and age were identified by color band combinations. Lengths of stay at ODSVRA are minimums as fledgling behavior or field conditions can limit opportunities to read band combinations. Data does not include fledglings that died or were removed from site due to injury.

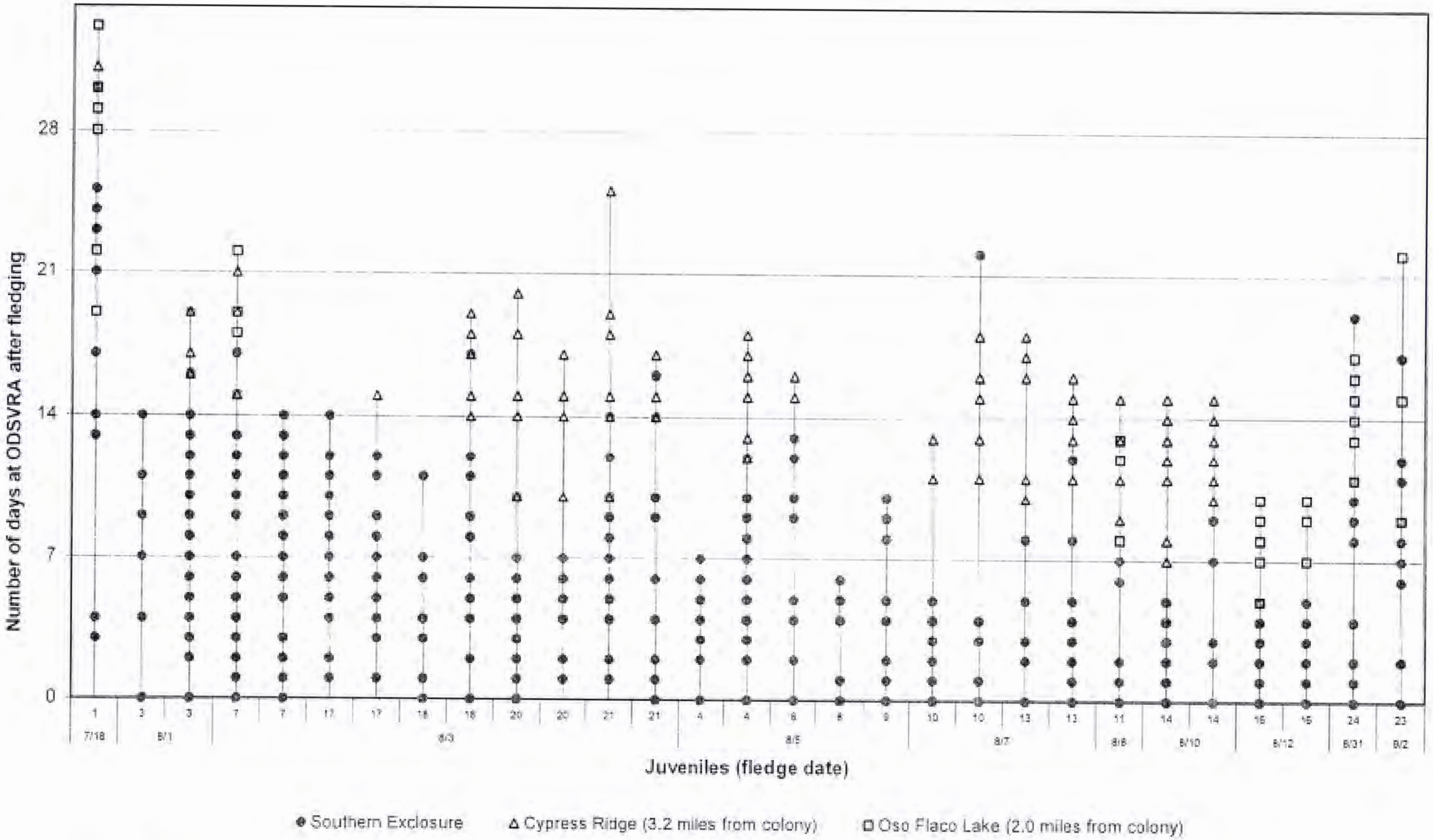


Figure 5. Number of days after reaching fledge age (21 days old) California least tern juveniles known to remain at ODSVRA in 2009.

Nest from which each fledgling hatched is provided as the nest number on the horizontal axis.

One injured fledgling from nest number eight was captured in the southern exclosure and removed for rehabilitation six days after reaching fledge age. This is not considered to have survived to leave the natal colony and is not included in length of stay information.

Four unbanded chicks at ODSVRA are believed to have fledged but are not included on this graph as no length of stay information is available.

Table 5. Number of weeks that color-banded California least tern fledglings hatched at ODSVRA remained on-site prior to departure in each year during the five-year period 2005-09. During this period, 219 fledglings (21 days old or older) were tracked at ODSVRA (sightings at Cypress Ridge Lake are not included). The number of weeks post-fledge represents a period of seven days within which the fledgling were last seen: one week post-fledge represents zero to seven days with zero being the fledge date, two weeks is eight to 14 days, three weeks is 15 to 21 days, four weeks is 22 to 28 days, and five weeks is 29 to 35 days. Data does not include fledglings that died or were removed from site due to injury. Numbers in parentheses are percent of all fledglings for the year. Note: percentages may not add up to 100 due to rounding.

Year	1 week post-fledge	2 weeks post-fledge	3 weeks post-fledge	4 weeks post-fledge	5 weeks post-fledge
2005	0 (0%)	4 (20%)	5 (25%)	9 (45%)	2 (10%)
2006	5 (15%)	4 (12%)	10 (29%)	13 (38%)	2 (6%)
2007	13 (19%)	16 (23%)	16 (23%)	19(28%)	5 (7%)
2008	18 (27%)	28 (41%)	15 (22%)	7 (10%)	0 (0%)
2009	4 (14%)	16 (57%)	4 (14%)	3 (11%)	1 (4%)
TOTAL 2005-09	40 (18%)	68 (31%)	50 (23%)	51 (23%)	10 (5%)

Night roost

During the breeding season adult least terns not engaged in incubation or chick care may assemble in a communal night roost and are often joined by fledglings later in the breeding season. Reduced exposure to disturbance from predators is likely an important factor in the selection of a night roost location. There can be a high degree of site fidelity, both within a breeding season and between years, with birds continuing to use the same location for a night roost. In 2009, the night roost continued to be in northern 6 exclosure in the same area used since 2004 (when 6 exclosure first became available as protected habitat during a complete season) but was not seen as consistently as in previous years (Appendix C). Terns were seen flying in at dusk, singly or in groups, to form a flock on the ground and would still be present when it became too dark to see. There was a season high count of 37 birds at the night roost on 19 May (Figure 6). This maximum count compares to high counts of 95 in 2007 and 63 in 2008. Both adults and juveniles were seen but it typically was too dark to distinguish plumage characteristics. Counts at the night roost are minimums, as birds would commonly arrive after it was too dark to count individuals.

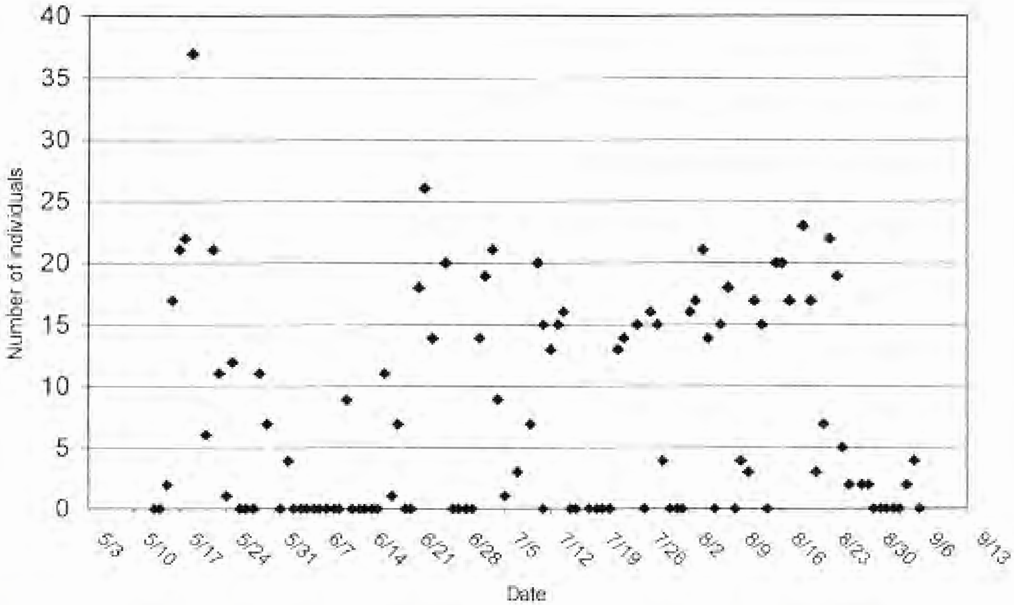


Figure 6. Number of California least terns counted at the ODSVRA 6 exclosure night roost in 2009. On occasions when zero terns were observed at the night roost, vocalizations were often heard as terns arrived after dark.

Importance of ODSVRA least tern breeding colony

The ODSVRA least tern breeding colony has benefited from the increased level of protection and management actions provided since 2002. The colony is important in meeting statewide recovery goals as loss of breeding habitat has resulted in a fragmented population distribution and a limited number of remaining breeding sites (USFWS 1985, 2006). On a regional level, there are very few active breeding sites along the central coast of California and none remain between ODSVRA and San Francisco Bay. Within San Luis Obispo and Santa Barbara counties, there are four least tern colony sites, all with management providing protective measures. These are ODSVRA, the only site in San Luis Obispo County; and Rancho Guadalupe Dunes County Park, Vandenberg Air Force Base, and Coal Oil Point Reserve in Santa Barbara County (approximately 7, 22, and 85 miles south of the ODSVRA colony, respectively). For this regional population, ODSVRA has become an important source of productivity. During the period 2004-09, ODSVRA produced a minimum of 250 juvenile terns while Rancho Guadalupe Dunes County Park, Vandenberg Air Force Base, and Coal Oil Point Reserve combined produced 84 juveniles (Tables 6 and 7).

Table 6. California least tern reproductive success at four colonies in San Luis Obispo and Santa Barbara counties from 2004-09. ODSVRA=Oceano Dunes SVRA, RGDCP=Rancho Guadalupe Dunes County Park, VAFB=Vandenberg Air Force Base, COPR=Coal Oil Point Reserve. Note: Chicks are not banded at VAFB, COPR, or RGDCP. Sources: Rancho Guadalupe Dunes County Park (pers. comm. J. King), Vandenberg Air Force Base (pers. comm. D. Robinette), Coal Oil Point Reserve (pers. comm. C. Sandoval).

Year	Site	No. pairs	No. nests	No. nests hatching	No. chicks	No. juveniles	No. juveniles per nest	No. juveniles per pair
2004	ODSVRA	47	63	44	69	min. 25	0.4	0.53
	RGDCP	8	8	3	7	0	-	-
	VAFB[1]	1	1	0	-	-	-	-
	COPR	6	6	0	-	-	-	-
2005	ODSVRA	47	59	39	66	min. 20	0.34	0.43
	RGDCP	4	4	0	-	-	-	-
	VAFB	44	44	18	32	1	0.02	0.02
	COPR	0	-	-	-	-	-	-
2006	ODSVRA	31	38	28	45	min. 36	0.95	1.16
	RGDCP	0	-	-	-	0	-	-
	VAFB[1]	2	2	0	-	-	-	-
	COPR	5	5	4	7	7	1.4	1.4
2007	ODSVRA	54	66	51	90	min. 70	1.06	1.3
	RGDCP	1	1	1	1	1	1	1
	VAFB	18	18	13	20	16	0.89	0.89
	COPR	min. 4	6	2	4[2]	0	-	-
2008	ODSVRA	55	56	50	99	min. 70	1.25	1.27
	RGDCP	0	-	-	-	-	-	-
	VAFB	18	18	17	32-33	19	1.06	1.06
	COPR	1	1	0	-	-	-	-
2009	ODSVRA	25	26	23	43	29-33	1.12-1.27	1.16-1.32
	RGDCP	2-3	3	2	3	3	1	1.00-1.50
	VAFB	30	31	28	56	37	1.19	1.23
	COPR	0	-	-	-	-	-	-

[1]Minimum counts of adult terns at the VAFB colony site were 60 and 40 in 2004 and 2006, respectively, but nesting was limited.

[2]Two chicks depredated at nest. Fate of other two chicks unknown.

Table 7. Number of breeding least tern pairs and juveniles produced at ODSVRA and the combined sites of Rancho Guadalupe Dunes County Park (RGDCP), Vandenberg Air Force Base (VAFB), and Coal Oil Point Reserve (COPR) from 2004-09. Note: Number of juveniles produced at RGDCP, VAFB, and COPR are estimates as these sites do not band chicks.

Year	ODSVRA		RGDCP, VAFB, and COPR combined	
	No. breeding pairs	No. juveniles	No. breeding pairs	No. juveniles
2004	47	25	15	0
2005	47	20	48	1
2006	31	36	7	7
2007	54	70	23	17
2008	55	70	19	19
2009	25	29-33	32-33	40
Total juveniles produced		250-254		84

WESTERN SNOWY PLOVER

Banded snowy plover adults provide the most accurate means to identify breeding population size but currently at ODSVRA too few adults are banded. From 2002 to 2008 we identified number of breeding adults by examining the number of concurrently active nests and broods. A minimum number of breeding females was derived from the maximum number of nests active on the same day plus any additional nests active one day before or after this date. As males typically raise chicks the combined number of nests and broods known to be simultaneously active provide an indication of the minimum number of breeding individuals (males with broods three weeks of age or older are not included if they may be associated with a new nest). In 2009, we additionally looked at all color-banded adults confirmed breeding. Any number of this group that could not be accounted for on the same day high count, including nests or broods with unknown males, was added to the same day high count. This resulted in two additional birds added to the minimum number of breeding males, but did not increase the minimum number of breeding females. (Applying this revised method to 2008 did not result in any change in the minimum number of breeding males and females.) In 2009 there were at least 48 breeding females (high counts on 6 and 25 June) and 66 males (high counts on 23 and 26 June). The estimated minimum number of breeding adults is 114. This is an increase of 20% from the estimated minimum number of 95 breeding adults (41 females, 54 males) in 2008. There were 32, 84, 121, 116, 107, and 79 breeding adults for 2002-07, respectively (Table 8) (George 2002, 2003; CDPR 2004, 2005, 2006, 2007, 2008). The number of breeding adults in 2009 indicates continuing recovery from 2007 when the number of breeding adults was 26-35% lower than the previous three years. The lower number in 2007 was likely due in part to poor productivity at ODSVRA in 2006 with subsequent reduced recruitment of one-year old birds (snowy plovers breed at one year of age) (CDPR 2007). In addition, snowy plovers over a larger coastal region may have experienced higher than typical mortality during the 2006-07 winter, again resulting in a reduction of available birds (USFWS 2008).

Table 8. Number of snowy plover chicks fledging per breeding male for the eight-year period, 2002-09. From 2002-08, the minimum number of breeding males was calculated from the highest same day count of active nests and broods (males with broods three weeks of age or older were not included if they could be associated with a new nest). In 2009, in addition to this adjusted same day high count, we also examined all color-banded males documented to breed at ODSVRA. Breeding banded males that could not have been part of the adjusted single day high count were added to the total to derive a minimum number of known breeding males. In 2009, this revised method increased the total of known breeding males by two (66 compared to 64).

Year	Min. no. breeding adults	Min. no. breeding males	No. fledglings	No. fledglings per breeding male
2002	32	18	35	1.94
2003	84	52	108	2.08
2004	121	67	66	0.99
2005	116	65	82	1.26
2006	107	58	17	0.29
2007	79	47	66	1.40
2008	95	54	72	1.33
2009	114	66	81	1.23
Average for eight-year period 2002-09	**94**	**53**	**66**	**1.32**
Average for five-year period 2005-09	**102**	**58**	**64**	**1.10**

There were 150 known nesting attempts, one known only by detection of brood and two with fate (hatch or fail) unknown. Of the 149 nests from known locations, 84% were in the Southern Exclosure, 15% in Oso Flaco and 1% north of Grand Ave. More specifically, 29% were in 6 exclosure, 23% in 7 exclosure, 26% in 8 exclosure and 5% in Boneyard exclosure. In Oso Flaco, 5% were in North Oso Flaco and 11% in South Oso Flaco (Appendix D). Both the nest hatching rate (69% compared to 36%) and chick fledging rate (36% compared to 9%) were higher in the Southern Exclosure than Oso Flaco. The overall fledge rate for ODSVRA in 2009 was 33.1% (81/245) with 1.23 chicks fledging per male, enough to promote population growth as 1.0 fledglings per male is believed necessary to prevent population decline and 1.2 allows for moderate population growth (assuming approximately 75% annual adult survival and 50% juvenile survival) (Table 9) (USFWS 2007). During the period 2002-09, the number of fledglings per male has exceeded 1.2 in six of the eight years (Table 8). (Note that if the number of breeding males is underestimated, this will result in an overestimate of the number of chicks fledged per male.)

Table 9. Nesting success of snowy plovers at ODSVRA in 2009. Percentage of chicks fledging calculated by using number of chicks with known fate (245). Percentage of nests hatching and number of fledglings per nest calculated using number of nests with known fate and known location (147) (two with unknown fate and one with unknown location). The numbers in parenthesis are the number of nests whose fate (hatch or fail) was determined.

Area	No. nests	No. eggs laid	No. nests hatching	% nests hatching	No. chicks	No. chicks fledging	% chicks fledging	No. fledglings per nest
Southern Exclosure								
6 exclosure	43 (43)	121	37	86.0%	97	31	32.0%	0.72
7 exclosure	35 (35)	100	28	80.0%	76	33	43.4%	0.94
8 exclosure	39 (38)	109	18	47.4%	40	14	35.0%	0.37
Boneyard exclosure	8 (8)	23	3	37.5%	8	1	12.5%	0.13
TOTAL SOUTHERN EXCLOSURE	125 (124)	353	86	69.4%	221	79	35.7%	0.64
Oso Flaco								
North Oso Flaco	7 (7)	17	2	28.6%	4	0	0.0%	0.00
South Oso Flaco	16 (15)	43	6	40.0%	18	2	11.1%	0.13
TOTAL OSO FLACO	23 (22)	60	8	36.4%	22	2	9.1%	0.09
TOTAL UNKNOWN LOCATION	1 (1)	min. 2	1	-	min. 2	0	0.0%	-
TOTAL PISMO LAGOON	1 (1)	3	0	0.0%	0	0	0.0%	0.00
GRAND TOTAL	150 (148)	418	95	63.9%	245	81	33.1%	0.55

Direct observation or physical evidence found of snowy plover mortality included: one chick depredated by gull; 2 juvenile or adult sized plovers depredated by peregrine falcon; three intact chicks found on the shoreline (two in 8 exclosure and one in North Oso Flaco); partial remains of one chick found on 8 exclosure shoreline; one juvenile found on 6 exclosure shoreline; one intact juvenile found in a vehicle tire track between Grand and Pier avenues; and an adult found one foot east of the Southern Exclosure fence (see Notes Section, Appendix G, and necropsy Attachment).

Clutch hatching rate

There were 150 identified nesting attempts, initiated between 18 March – 22 July, with an average of 2.85 eggs per clutch calculated from completed clutches with known locations (n=144) (Appendix B). Excluding three nests with unknown fate or detected by brood only, the clutch hatching rate was 64% (94/147) (Tables 9 and 10, Figures 8 and 9). This compares to 68% in 2008 and an average of 74% from 2002-07 (Table 10) (George 2002, 2003; CDPR 2004, 2005, 2006, 2007, 2008). Fifty-three nests were known to fail with losses attributed to abandonment pre-term (13), nonviable eggs (3), unknown cause (3), overwashed by tide (2), unidentified predator (10), unidentified avian predator (17), gull (2), northern harrier (1) crow (1), and skunk (1) (Table 11). The fate (hatch or fail) of two nests was not determined. Five nests were observed with one or more eggs with a small to large patch of brown discoloration on the shell. Several of these eggs were collected and submitted for analysis of possible contaminants. These eggs were found to be nonviable and analysis of contaminants was inconclusive (See Notes Section).

For the eight-year period 2002-09, 233 of 830 nests in the Southern Exclosure or Oso Flaco were identified as failed. Abandonment accounted for 45% (106/233) of all nest loss during this period with the majority (77%, 82/106) identified as abandoned pre-term (nest abandoned prior to the expected hatch date) (Table 12) (George 2002, 2003; CDPR 2004, 2005, 2006, 2007, 2008). Potential factors that can cause abandonment pre-term include eggs buried by sand movement during high winds, disturbance near nesting birds (directly causing abandonment or allowing burial of eggs while the bird is kept from nest during high winds), or death of nesting adult(s). In the absence of disturbance plovers are very attentive to nests with complete clutches and sit tightly during high winds and blowing sand. During three periods of sustained high winds (40 mph on 14 April and over 30 mph on 6 and 14 May) at ODSVRA in 2009 there was a combined total of 59 different nests that were active during one to three of these periods. During these high wind events five nests were abandoned pre-term (two with eggs buried). Three of these were newly initiated and with incomplete clutches. An additional six nests each lost one egg, but remaining eggs in clutch continued to be active.

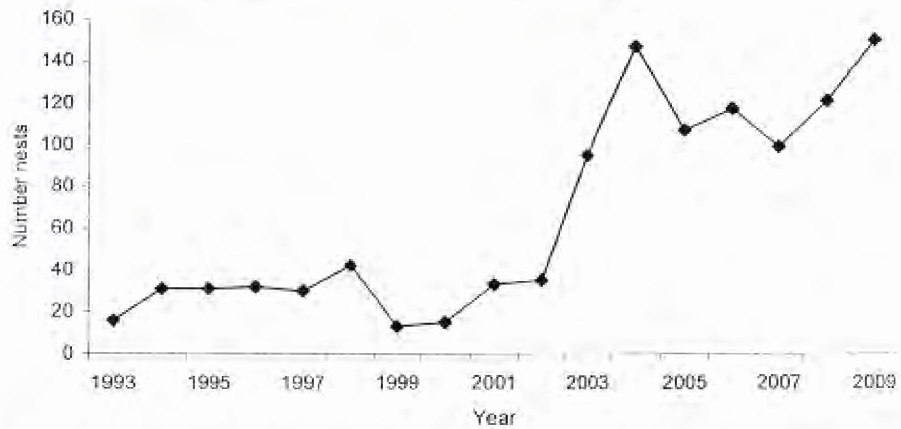


Figure 7. Number of snowy plover nests at ODSVRA, 1993-2009.

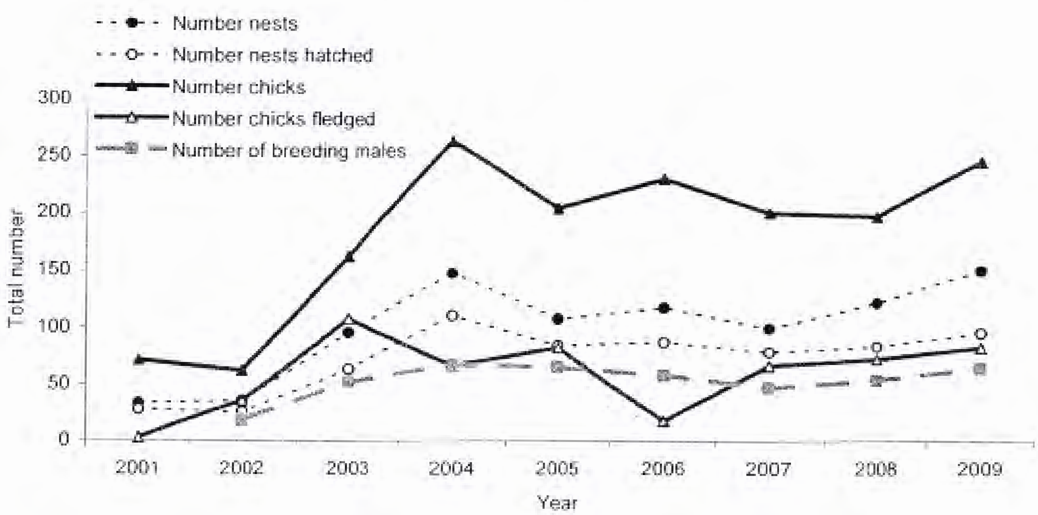


Figure 8. Number of snowy plover nests, hatched nests, chicks, fledged chicks, and breeding males at ODSVRA, 2001-09. Prior to 2001, monitoring at Oso Flaco and Dune Preserve was intermittent and fledging information was not obtained. Banding of chicks was initiated in 2001, allowing for tracking of chicks and determination of fledging success.

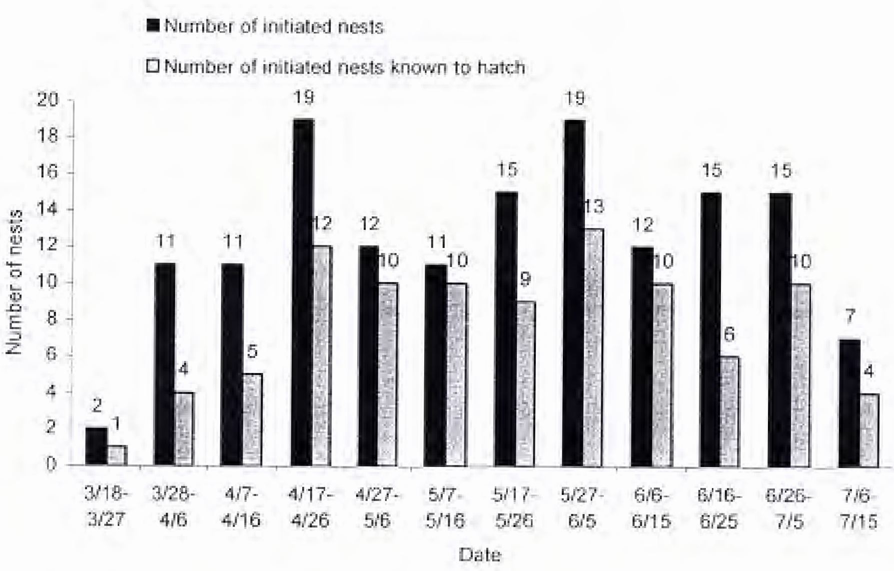


Figure 9. Number of known location snowy plover nests initiated per ten-day period and the number subsequently known to hatch at ODSVRA in 2009.

Table 10. Nesting success of snowy plovers at ODSVRA, 2001-2009. Beginning in 2001, a monitoring goal has been to band all chicks, allowing for documentation of fledging rate. Number of nests with known fate are nests whose fate (hatch or fail) was determined. Nests with unknown fate, or detected only by presence of a brood, are not used in calculating nest hatching rate. Beginning in 2006 an additional 0.4 mile of shoreline at the southern end of park has been monitored by ODSVRA (a survey conducted by the Guadalupe-Nipomo Dunes National Wildlife Refuge in 2005 determined this area was part of ODSVRA and not the refuge, as was previously thought). From 2001 to 2004, the amount of seasonally protected nesting habitat in the riding area has periodically increased in size. Subsequent to 2004 there has been no increase in size of this protected area. Broods from nests with unknown location were detected inside the seasonally protected habitat in Southern Exclosure or Oso Flaco. Refer to Appendix H for corrections/clarifications made to this table from previous reports.

Year	Area	No. nests	No.nests with known fate	No. nests hatching	% nests hatching	No. chicks	No. banded or known fate chicks	No. banded or known fate chicks fledged	% chicks known fledged
2001	Arroyo Grande Creek	3	3	3	100	8	7	0	0
	Riding Area	26	25	21	84	56	56	1	2
	Oso Flaco	4	4	2	50	6	6	1	17
	Total	33	32	26	81	70	69	3	4
2002	Riding Area	33	33	25	76	62	62	35	56
	Oso Flaco	2	2	0	0	0	0	0	0
	Total	35	35	25	71	62	62	35	56
2003	Dune Preserve	1	1	1	100	3	3	0	0
	Pipeline Revegetation	3	3	2	67	4	4	2	50
	Riding Area	75	74	54	73	139	138	95	69
	East of Boneyard	2	2	1	50	3	3	2	67
	Oso Flaco	13	13	5	38	11	11	7	64
	Unknown location	1	1	1	-	2	2	2	100
	Total	95	94	64	68	162	161	108	67
2004	Pipeline Revegetation	1	1	1	100	3	3	0	0
	Riding Area	114	112	87	78	208	205	59	29
	Oso Flaco	27	27	17	63	40	39	7	18
	Unknown location	5	5	5	-	12	12	0	0
	Total	147	145	110	75	263	259	66	25
2005	Riding Area	79	79	60	76	142	142	57	40
	East of Boneyard	2	2	2	100	6	6	2	33
	Oso Flaco	22	22	18	82	49	49	23	47
	Unknown location	4	4	4	-	7	7	0	0
	Total	107	107	84	78	204	204	82	40
2006	Riding Area	88	85	65	76	173	173	8	5
	Oso Flaco	29	29	22	76	57	57	9	16
	Total	117	114	87	76	230	230	17	7
2007	Riding Area	76	76	61	80	159	157	58	37
	Oso Flaco	15	15	9	60	20	20	4	20
	Unknown location	8	8	8	-	21	21	4	19
	Total	99	99	78	77	200	198	66	33
2008	Riding Area	100	100	73	73	172	172	64	37
	Oso Flaco	19	19	8	42	19	19	5	26
	Unknown location	2	2	2	-	6	6	3	50
	Total	121	121	83	68	197	197	72	37
2009	Pismo Lagoon	1	1	0	0	0	0	0	0
	Riding Area	125	124	86	69	221	221	79	36
	Oso Flaco	23	22	8	36	22	22	2	9
	Unknown location	1	1	1	-	2	2	0	0
	Total	150	148	95	64	245	245	81	33

Table 11. Causes of snowy plover nest loss at specific locations at ODSVRA in 2009. Nests abandoned pre-term were abandoned prior to the expected hatch date and may include failure due to wind, adult mortality, or disturbance. Nests failed with unknown cause disappeared well before expected hatch date and with cause of failure undetermined.

Area	Abandoned pre-term	Failed, eggs removed by staff	Failed, nonviable eggs, abandoned viable egg added[1]	Failed, cause unknown	Unidentified predator	Avian predator	Gull	Northern harrier	Crow	Skunk	Flooded
Southern Exclosure											
6 exclosure	1	0	1	1	1	0	2	0	0	0	0
7 exclosure	4	0	0	0	0	2	0	0	0	0	1
8 exclosure	4	2	0	0	6	7	0	1	0	0	0
Boneyard exclosure	0	0	0	0	1	4	0	0	0	0	0
TOTAL SOUTHERN EXCLOSURE	9	2	1	1	8	13	2	1	0	0	1
Oso Flaco											
North Oso Flaco	2	0	0	1	0	1	0	0	0	1	0
South Oso Flaco	2	0	0	1	2	3	0	0	0	0	1
TOTAL OSO FLACO	4	0	0	2	2	4	0	0	0	1	1
Pismo Lagoon	0	0	0	0	0	0	0	0	1	0	0
ODSVRA TOTAL	13	2	1	3	10	17	2	1	1	1	2

[1] Nonviable eggs were incubated past expected hatch date. An abandoned viable egg from another nest added and subsequently hatched.

Table 12. Causes of snowy plover nest loss at Southern Exclosure and Oso Flaco at ODSVRA, 2002-09. The percentage of total loss represented by individual causes is shown in 2002-09 for Southern Exclosure and Oso Flaco separately and combined. Nests abandoned pre-term were abandoned prior to the expected hatch date; these may include failure due to wind, adult mortality, and disturbance. Nests abandoned post-term were abandoned subsequent to expected hatch date; these may include failure due to nonviable eggs. Nests failed with unknown cause disappeared well before expected hatch date and with cause of failure undetermined. So. Excl. = Southern Exclosure.

Year	Area	Abandoned pre-term	Abandoned post-term	Abandoned unknown pre- or post-term	Failed, nonviable eggs removed by staff	Failed, nonviable eggs, abandoned viable egg added[1]	Failed, cause unknown	Unidentified predator	Avian predator	Gull	Raven	Northern harrier	Coyote	Skunk	Flooded
2002	So. Excl.			6			1						1		
2002	Oso Flaco			2											
2003	So. Excl.	16	2					2			1				
2003	Oso Flaco	2[2]					1	1			4				
2004	So. Excl.	12					7	2			2		1		
2004	Oso Flaco	4[3]					2	3							1
2005	So. Excl.	9	3				7								
2005	Oso Flaco	2	1					1							
2006	So. Excl.	5	4				2	1		3			4		
2006	Oso Flaco			1				1		3					2
2007	So. Excl.	4	1				9				1				
2007	Oso Flaco	2					2				1		1		
2008	So. Excl.	10		3			7	4		1		1			1
2008	Oso Flaco	3		1				5							2
2009	So. Excl.	9	0	0	2	1	1	8	13	2		1		0	1
2009	Oso Flaco	4	0	0	0	0	2	2	4	0		0		1	1
2002-09 Total Failed nests	So. Excl.	65 / 38.2%	10 / 5.8%	9 / 5.2%	2 / 1.2%	1 / 0.6%	34 / 19.7%	17 / 9.9%	13 / 7.5%	6 / 3.5%	4 / 2.3%	2 / 1.2%	6 / 3.5%	0 / 0.0%	2 / 1.2%
2002-09 Total Failed nests	Oso Flaco	17 / 27.4%	1 / 1.6%	4 / 6.5%	0 / 0.0%	0 / 0.0%	7 / 11.3%	13 / 21.0%	4 / 6.5%	3 / 4.8%	5 / 8.1%	0 / 0.0%	1 / 1.6%	1 / 1.6%	6 / 9.7%
2002-09 Grand Total So. Excl and Oso Flaco		82 / 35.2%	11 / 4.7%	13 / 5.5%	2 / 0.9%	1 / 0.4%	41 / 17.4%	30 / 12.9%	17 / 7.2%	9 / 3.8%	9 / 3.8%	2 / 0.9%	7 / 3.0%	1 / 0.4%	8 / 3.4%

[1] Nonviable eggs were incubated past expected hatch date. An abandoned viable egg from another nest added and subsequently hatched.

[2] Both nests abandoned due to death of adult(s)

[3] One nest abandoned due to death of adult(s)

Chick fledging rate

Of the 245 snowy plover chicks known hatched, 234 were banded and the fate of eleven unbanded chicks is known (none fledged) (Appendix B) (Tables 9 and 11, Figure 8). The eleven chicks were not banded due to one of the following circumstances: no chicks present or adult broody behavior (behavior suggesting presence of chicks) observed immediately following hatch; one or two chicks disappeared prior to banding remaining chick(s) in brood, very young chick seen with banded siblings but unbanded chick soon disappeared, or chick not banded after brood moved and remained near a large gull roost. Thirty-three percent (81/245) of the chicks are known to have fledged. This compares to 37% (72/197) in 2008 and an average rate of 38% (range=7-67%) for the six-year period 2002-07 (Table 10). For chicks hatching in the 6, 7, 8, and Boneyard exclosures the fledging rate was 32%, 43%, 35%, and 12%, respectively. The fledging rate for Oso Flaco was 9% (0% for North Oso Flaco and 11% for South Oso Flaco) compared to 26% in 2008 (20% for North Oso Flaco and 29% for South Oso Flaco) (Table 9). During the latter portion of the season there was a noticeable drop in productivity. The fledging rate for chicks hatched during the 69-day period 20 April – 28 June was 50% (66/132) compared to 13% (15/113) for chicks hatched during the 60-day period 29 June – 27 August. Beginning in 2003 and continuing through 2009, the number of chicks produced each season has exceeded 150. During this period, chick survival has also often been lower during late season compared to early season in the six of the seven years. The mean number of hatched chicks for this period is 98 for early season and 114 for late season. The average fledge rate for chicks hatched in early season was 47% compared to 24% for late season (Figure 10).

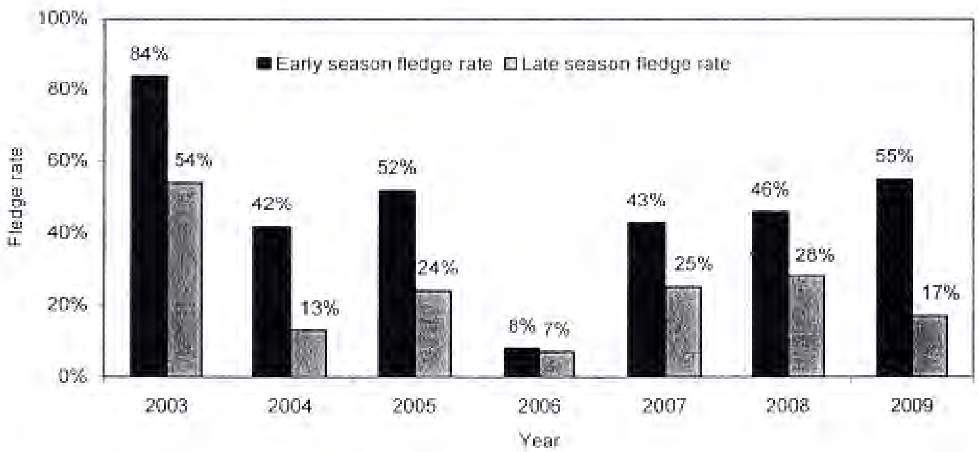


Figure 10. Variation of fledge rate of snowy plover chicks hatching in early season versus late season at ODSVRA in 2003-09. Dates separating early season from late season ranged from 17 June – 22 June. The mean number of hatching chicks is 98 for early season and 114 for late season.

At ODSVRA, most snowy plover broods are initially led from the nest by the parent(s) to the nearest shore for foraging opportunities. The majority (75%) of broods were not known to move beyond the beach section (6, 7, and 8 exclosures, North Oso Flaco, and South Oso Flaco) nearest where they hatched. Of the 81 fledglings produced in 2009, 69 were from broods remaining in the general area where hatched (Table 13). Close availability of quality shoreline habitat for raising chicks can benefit productivity as mortality rates are typically highest for young chicks.

In 2009, 38% (63/164) of chicks not fledging were last seen at four days old or younger (Figure 11). For 111 chicks reaching 16 days of age the fledge rate was 73%. This is lower than the results from a six-year (1977-1982) study at Monterey Bay in Monterey County, California, that found at least 93% of the 124 chicks reaching 16 days of age fledged (Warriner et al. 1986).

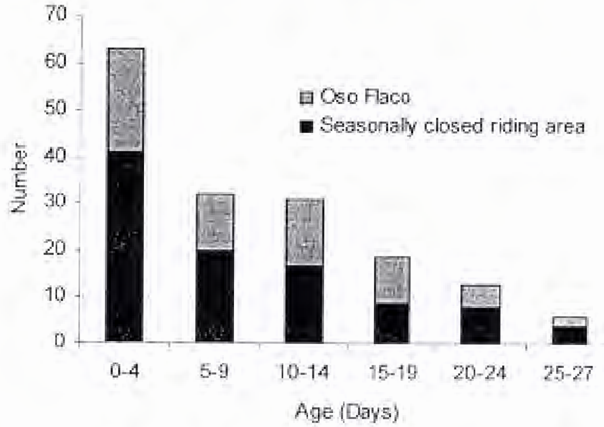


Figure 11. Loss of snowy plover chicks by age and location last seen in the Southern Exclosure and Oso Flaco at ODSVRA in 2009. Of the 245 chicks whose fate was tracked, 164 were lost and are represented in this graph. One brood was monitored unattended for several hours at the nest and subsequently removed for captive rearing. These chicks are considered lost on the day they were removed.

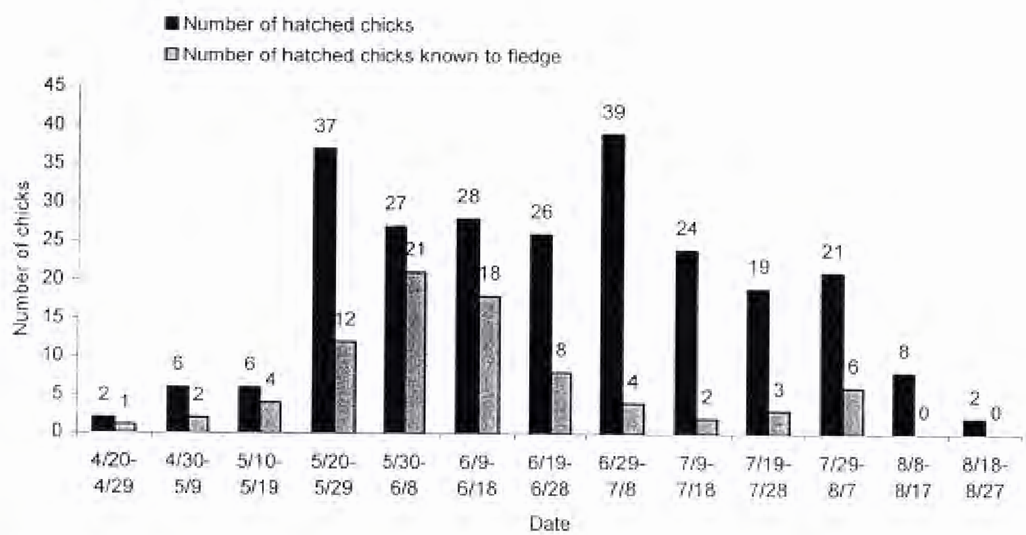


Figure 12. Number of snowy plover chicks hatching per ten-day period and the number of those subsequently fledging at ODSVRA in 2009. For the single brood originating from an unknown nest an estimated age was based on chick size.

Table 13. Snowy plover brood movement at ODSVRA in 2009. All areas have a shoreline component to the habitat, except Boneyard exclosure. The three broods that hatched from Boneyard exclosure are included in North Oso Flaco (Boneyard exclosure is located directly east of North Oso Flaco and broods are typically first moved to North Oso Flaco shore). One brood hatched from unknown location is included in the area where first seen (6 exclosure). Chicks from unknown location were estimated to be one day old or younger when first seen. Several broods were known to cross back-and-forth over arbitrary borders between areas.

Area	Shoreline length	Total no. hatching nests in area	No. broods remaining in area hatched	No. broods remaining in area hatched that fledged at least one chick	No. chicks remaining in area hatched that fledged	No. broods leaving area hatched	No. broods leaving area hatched that fledged at least one chick	No. chicks leaving area hatched that fledged
Southern Exclosure								
6 exclosure	0.52 mile	38	26	14	28	12	3	3
7 exclosure	0.42 mile	28	22	16	29	6	2	4
8 exclosure	0.45 mile	18	11	7	9	6	3	5
Oso Flaco								
North Oso Flaco	0.54 mile	5	5	1	1	0	--	--
South Oso Flaco	1.16 miles	6	6	2	2	0	--	--

Banded birds breeding at ODSVRA in 2009

Fifty-one banded snowy plovers (33 males, 18 females) were known to breed at ODSVRA in 2009 and 21 of these also bred at ODSVRA in 2008 (Appendix B and E). These birds were banded as chicks at the following sites: ODSVRA (20 from 2008, 12 from 2007, seven from 2005, two from 2004, three from 2003, and one from unknown year as it was missing a right band); Guadalupe-Nipomo Dunes National Wildlife Refuge (one from 2002); Vandenberg Air Force Base (one each 2008 and 2004); and Monterey Bay area (one from Pajaro Spit 2003, one from Fort Ord Dunes State Park 2007, and one from Salinas State Beach 2006). Of the 51 banded plovers known to breed at ODSVRA in 2009, 88% hatched and were banded as chicks at ODSVRA.

FACTORS INFLUENCING LEAST TERN AND SNOWY PLOVER REPRODUCTIVE SUCCESS

The following is a discussion of some of the factors that influence reproductive success of terns and plovers at ODSVRA. The adequacy of any single factor alone is not sufficient to achieve and sustain recovery goals.

Size of protected habitat
Maintaining an adequate size of protected habitat at ODSVRA has been important in providing sufficient area for terns and plovers to roost, nest, and raise young. Protected breeding habitat of sufficient size allows nests and chicks to be dispersed which can reduce exposure and vulnerability to predators, as well as reduce adverse disturbance from human recreational activities. For plovers, it also improves opportunities for chicks to have access to adequate invertebrate food resources.

Quality of protected habitat
During the March through September least tern and snowy plover nesting season, habitat within the seasonal Southern Exclosure is protected and closed to public entry. Following the nesting season, and for the five-month period October through February, the area is open to public use, including camping, street-legal vehicles, and off-highway vehicles. This recreational use results in large areas of flattened terrain and barren sand with very limited scattered natural debris and vegetation. Snowy plovers have been observed to nest in areas of available limited patchy cover (e.g., scattered debris from campfires and gravel). To offer more areas of disruptive cover (to provide shelter from wind and blowing sand, reduce exposure to predators, and augment potential nesting substrate) the park staff places material in the 6, 7, and 8 exclosures. Materials added include surf-cast kelp (wrack), branches, driftwood, and woodchips. In addition, seeds of beach strand plants and a limited number of small container plants are put out in an effort to encourage development of some scattered plants and vegetated hummocks during the nesting season.

In 2009, woodchips, resulting from maintenance activities at Pismo State Beach campground, were spread in the 6, 7, and 8 exclosures for the fourth consecutive year in patches less than a quarter-acre in size. The woodchips were placed in areas of barren sand and over some thinning woodchip patches remaining from the previous year(s). Wind and shifting sand altered the amount and composition of surface substrates over the course of the season, exposing and covering debris and woodchip patches from this and earlier years. The type of substrate in which nests were located was recorded in the field by monitors when the nest was first found or checked. A few nests could not be walked up to until after the nest was no longer active to avoid disturbing nearby chicks present on the shore or near roosting gull flocks. In both 2006 and 2008, the amount of woodchip coverage was calculated when the material was put out at the beginning of the season. This was provided as a percentage of an area less than the total size of the 6, 7, and 8 exclosures, with the area below the upper high tide line and within 100 feet of the north and east fence excluded. These areas were excluded because: 1) they have never received woodchip patches, and 2) the likelihood of nesting is reduced below the upper high tide line as well as in close proximity to the boundary with the open riding area. In 2009, 115 of 118 plover nests found in the 6, 7, and 8 exclosures were above the upper high tide line and greater than 100 feet from the open riding area. Of these 115 nests, 44% were found in assorted debris (debris, both natural and human litter, other than material brought in as enhancement), 37% in woodchip patches, 11% in bare sand, and 7% in vegetation (Figure 13 and Appendix I). In 2006 and 2008, 31% and 49% of nests were found in woodchip substrate that covered approximately five percent and 10%, of the 6, 7, and 8 exclosures. In all years when woodchips were added, bare sand substrate has been extensive throughout the 6, 7 and 8 exclosures during the breeding season.

Of the 43 snowy plover nests in woodchip debris in 2009, 67% hatched (Figure 14), 19% were depredated, 7% were abandoned, 2% failed with cause unknown, and 5% had nonviable eggs. Of the 13 plover nests in bare sand substrate 77% hatched, 15% were abandoned, and 8% had an unknown fate. In 2008, 77% of nests in woodchip substrate and 60% of nests in bare sand hatched. While the woodchip patches and assorted debris provide nesting substrate attractive to plovers, it is important to note they do not provide chicks with the cover and shelter that is available with larger material (such as driftwood and wrack) or plants and vegetated hummocks.

Least terns also made use of the woodchip patches for nesting. Of the 23 nests with known substrate type located in the woodchip addition area, 11 were in woodchips, 8 in bare sand, and 4 in assorted debris. For those least tern nests in woodchip debris, 9 hatched (82%), 1 was abandoned pre-term (9%), and was abandoned post-term (9%) (Figures 15 and 16).

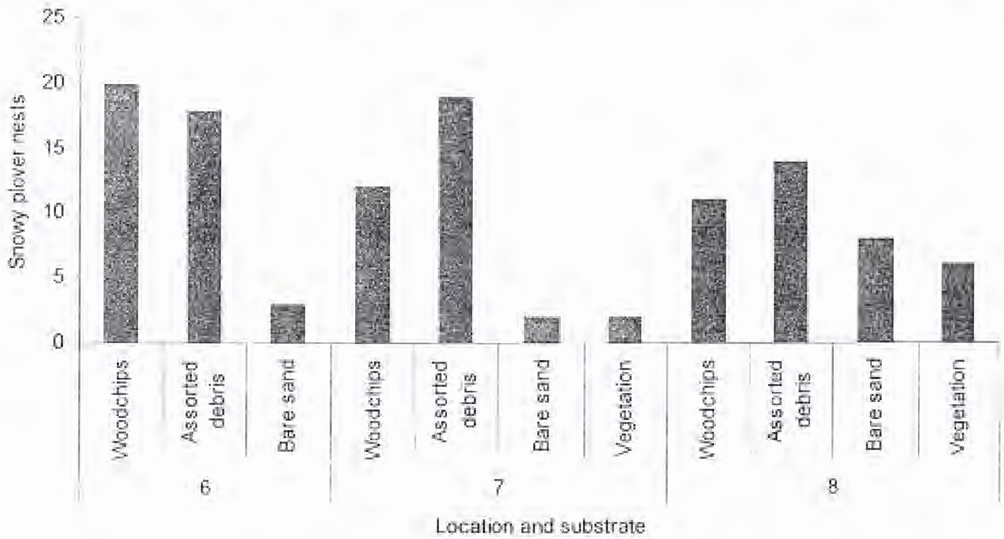


Figure 13. Total number of snowy plover nests established in each substrate (woodchips, assorted debris, bare sand, and vegetation) in 6, 7, and 8 exclosures at ODSVRA in 2009.

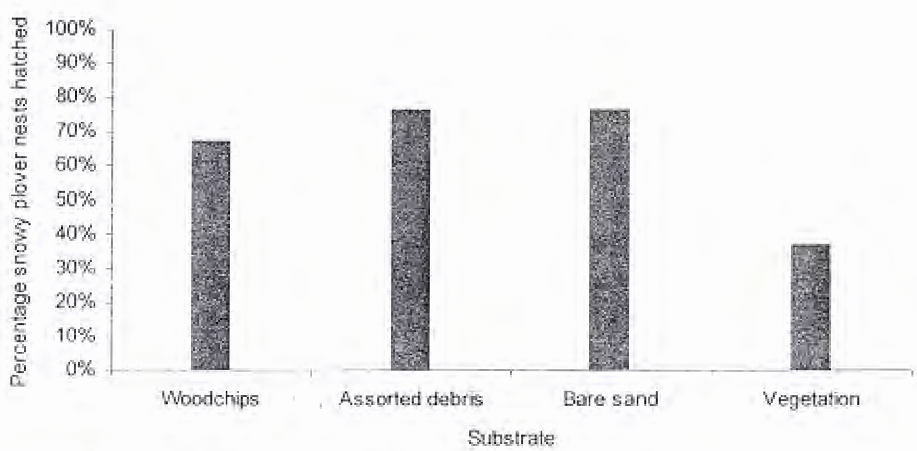


Figure 14. Percentage of snowy plover nests hatching per the total in each substrate (assorted debris, bare sand, vegetation, and woodchips) where woodchips were distributed in 6, 7, and 8 exclosures at ODSVRA in 2009.

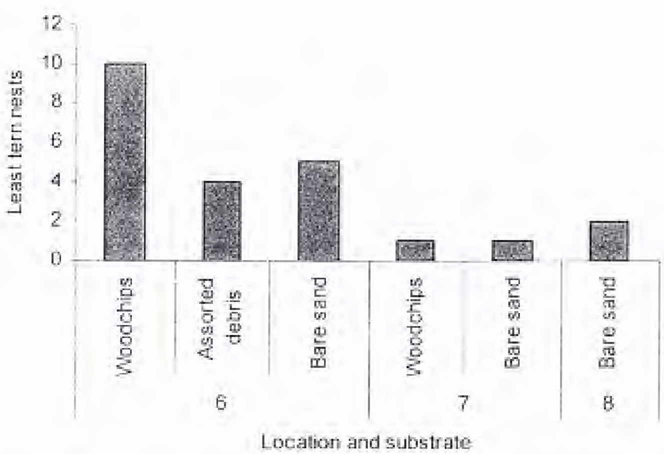


Figure 15. Total number of least tern nests established in each substrate (assorted debris, bare sand, and woodchips) in 6, 7, and 8 exclosures at ODSVRA in 2009. None nested in vegetation.

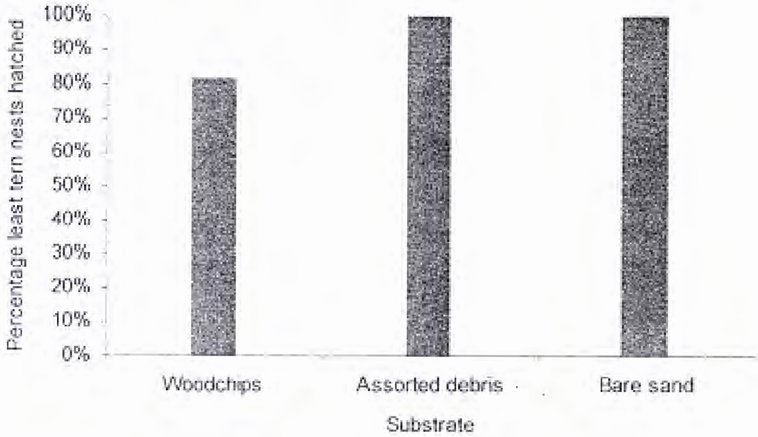


Figure 16. Percentage of least tern nests hatching per the total in each substrate (assorted debris, bare sand, and woodchips) where woodchips were distributed in 6, 7, and 8 exclosures at ODSVRA in 2009.

Predators and Predator Management

Predators and predation can be an important factor limiting least tern and snowy plover reproductive success (Page et al. 1995; Thompson et al. 1997). Impacts can include predation on eggs, chicks, fledglings, and adults as well as predators causing disturbance and keeping adults from eggs or chicks. Disturbance can also increase time spent in vigilance and avoidance behavior and reduce time spent brooding and foraging. If adult terns or plovers are depredated, this may result in the abandonment of eggs or the loss of dependent chicks.

ODSVRA has a predator management plan that includes: 1) large fenced exclosures (Southern Exclosure and North Oso Flaco), 2) large single nest exclosures (for nests outside of the larger fenced exclosure), 3) option to use smaller 10 foot by 10 foot nest exclosures (with or without net top) 4) removal of marine mammal and seabird carcasses deposited on the shoreline in breeding habitat (to reduce attracting scavengers that may prey on terns and plovers), 5) placement of limited amounts of available driftwood and beach-cast wrack in 6, 7, and 8 exclosures to provide some cover for chicks, 6) placement of beach-cast wrack on 6, 7, and 8 exclosure shorelines to support re-establishment of beach invertebrates (a prey source for plovers) 7) use of tern chick shelters, and 8) option of live-trapping and relocation or selective lethal removal of individual predators posing serious threats. Information on predator presence was collected by ODSVRA resource staff and contractors (The Bird Group, USDA Wildlife Services, and PRBO). The detected presence of mammal and avian species known to be predators of least terns and/or snowy plovers ranged from limited to common (Table 14). In 2009, five coyotes (*Canis latrans*) and one California gull (*Larus californicus*) were lethally removed. Additionally, five American kestrels (*Falco sparverius*), two great-horned owls (*Bubo virginianus*), two peregrine falcons (*Falco peregrinus*) and six loggerhead shrikes (*Lanius ludovicianus*) were live-trapped and relocated (Table 15). Live-trapping and relocation of selected avian predators was carried out by The Bird Group and selective lethal removal by USDA Wildlife Services.

In 2009, 32 of 149 (21%) plover nests with known location were identified as lost to predation with 21 (66%) of these attributed to avian predators. Pismo Lagoon had a single nest that was depredated. All other plover nests were in the Southern Exclosure and Oso Flaco with predation rates ranging from 5.7% and 7.0% in 7 exclosure and 6 exclosure, respectively, to 35.9% and 62.5% in 8 exclosure and Boneyard, respectively (Table 16). One snowy plover chick was observed being eaten by a gull on the 6 exclosure shoreline. Two juvenile or adult size snowy plovers were depredated by peregrine falcon on separate occasions (Appendix G). There were no known depredated least tern nests.

Table 14. Summary of predators detected in Southern Exclosure and Oso Flaco at ODSVRA in 2009. Observations from 1 March – 10 September (a 194-day period). Observer presence in field by park staff and especially contracted predator management specialists reduced after mid-August.
Max no. individ. = maximum number of different individuals identified during one day. This number was not determined for mammals or owls as these species were primarily nocturnal with occurrence detected by tracks.

Species	First date observed	Last date observed	No. days detected	Max no. individ.	Notes
Mammals					
Coyote	2 Mar	10 Sep	147	-	Widespread on shoreline, 19 occurrences (on 19 days) documented inside the predator fencing of Southern Exclosure and North Oso Flaco.
Domestic dog	4 May	2 Sept	28	-	Majority of occurrences at north end of 6 exclosure shoreline. Two occurrences documented in South Oso Flaco.
Opossum	21 Mar	4 Sep	10	-	
Raccoon	2 Mar	10 Sep	141	-	Tracks concentrated in northern portion of 6 exclosure, 7.5 revegetation area, west of the Pipeline revegetation area, southwest portion of 8 exclosure, northern portion of North Oso Flaco, just north of the boardwalk south to Oso Flaco Creek, and near the southern boundary.
Skunk	8 Mar	10 Sep	48	-	Majority of occurrences in 8 exclosure west of the Pipeline revegetation area, south portion of North Oso Flaco foredunes, between the boardwalk and Oso Flaco Creek and the south portion of South Oso Flaco foredunes.
Birds					
American kestrel	10 Mar	4 Sep	11	1	Observed in flight over 6 and 7 exclosures. Sightings in 8 exclosure all from west portion of Pipeline revegetation area or perched on east fence. Majority of Boneyard sightings in eastern portion. Multiple sightings over North Oso Flaco foredunes. All sightings in South Oso Flaco in southern portion. Not commonly seen on shoreline of Southern Exclosure or Oso Flaco.
Merlin	18 Apr	26 Aug	2	1	
Peregrine falcon	9 Mar	26 Aug	36	2	Minimum of six individuals observed during season based on age, sex, and alphanumeric band combinations. Observed actively pursuing and feeding on avian prey in protected area.
Cooper's hawk	10 Apr	6 Aug	3	1	
Northern harrier	3 Mar	9 Sep	52	2	Minimum of six individuals observed during season based on age, sex, and plumage differences. Observed actively hunting in protected area.
Red-tailed hawk	8 Mar	7 Aug	16	1	Three active nests immediately east of the park boundary throughout 2009 season.
Owl spp.	11 May	4 Sep	38	-	Great-horned owls were seen in North Oso Flaco foredunes, 8 exclosure and Pipeline revegetation area in addition to observed owl tracks.
American crow	23 Mar	7 Aug	8	4	All occurrences in South Oso Flaco with the exception of one occurrence over Boneyard exclosure. Majority of sightings were bird(s) in direct flight over South Oso Flaco or perched at Oso Flaco Creek. Crows are present on a daily basis in the northern portion of Oceano Dunes SVRA (3-5 miles north of protected area).
Common raven	27 May	27 May	1	2	Two ravens observed in direct flight east of South Oso Flaco foredunes on 27 May.
Gull spp.	Present daily throughout season				Includes birds in flight, foraging on shoreline, and roosting.

Table 15. Mammalian and avian predators removed under predator management actions for least terns and snowy plovers at ODSVRA in 2009. Five coyotes and one California gull were lethally removed. All other animals were live-trapped and relocated. All animals were at ODSVRA with the exception of five American kestrels and one loggerhead shrike trapped on adjoining private property with the permission of landowner. Note: One raccoon from the Oso Flaco area was lethally removed on 10 September because it was a nuisance animal; it is not listed on this table as it was not removed for the management least terns or snowy plovers.

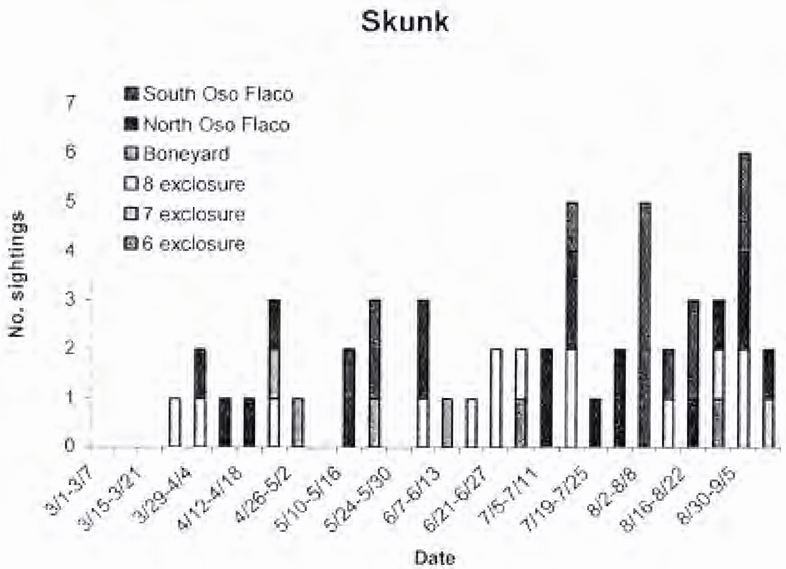
Date	Species	No.	Location	Notes
Mammals				
16 Jun	coyote	1	Maidenform revegetation area	adult (lethally removed)
16 Jun	coyote	1	Maidenform revegetation area	juvenile (lethally removed)
17 Jun	coyote	1	Maidenform revegetation area	juvenile (lethally removed)
4 Aug	coyote	1	east of Oso Flaco creek	juvenile (lethally removed)
18 Aug	coyote	1	South Oso Flaco, east side of foredunes	adult (lethally removed)
Birds				
25 Feb	American kestrel	1	adjoining property	adult male
26 Feb	American kestrel	1	adjoining property	adult female
26 Feb	American kestrel	1	adjoining property	adult female
12 Mar	American kestrel	1	adjoining property	adult female
13 Mar	American kestrel	1	adjoining property	adult male
14 May	great-horned owl	1	Pipeline revegetation area	adult male
15 Jun	great-horned owl	1	Pipeline revegetation area	adult male
21 Jun	loggerhead shrike	1	North Oso Flaco, southeast portion of foredunes	juvenile
24 Jun	loggerhead shrike	1	North Oso Flaco, southeast portion of foredunes	juvenile
26 Jun	loggerhead shrike	1	adjoining property	juvenile
13 Jul	loggerhead shrike	1	North Oso Flaco, southeast portion of foredunes	juvenile
23 Jul	California gull	1	6 exclosure shoreline	sub-adult (lethally removed)
5 Aug	peregrine falcon	1	6 exclosure shoreline	juvenile female
12 Aug	loggerhead shrike	1	Pipeline revegetation area	juvenile
14 Aug	loggerhead shrike	1	North Oso Flaco, southeast portion of foredunes	juvenile
19 Aug	peregrine falcon	1	6 exclosure shoreline	sub-adult male

Table 16. Predation rates by area of known location snowy plover nests at ODSVRA in 2009. The one nest from an unknown location (known only from detection of brood) is not included in table.

	6 exclosure	7 exclosure	8 exclosure	Boneyard exclosure	North Oso Flaco	South Oso Flaco	Pismo Lagoon	Park total
Depredated nests	3	2	14	5	2	5	1	32
Total known location nests	43	35	39	8	7	16	1	149
Percent depredated	7.0%	5.7%	35.9%	62.5%	28.6%	31.3%	100.0%	21.5%

Opossum (*Didelphis virginiana*) tracks were infrequently noted in the Southern Exclosure and Oso Flaco. Striped skunk (*Mephitis mephitis*) tracks were recorded on 48 days in 2009 compared to two days in 2008 (Table 14). One plover nest depredation in the North Oso Flaco foredunes was attributed to skunk. The majority of tracks were seen in 8 exclosure, North Oso Flaco foredunes, between the boardwalk and Oso Flaco Creek, and in the south portion of the South Oso Flaco foredunes (Figure 17). There were only seven noted occurrences of skunk tracks on the beach west of the foredunes. Fresh raccoon (*Procyon lotor*) tracks were noted on 141 days in 2009 compared to 68 days in 2008 (Table 14). Tracks in the Southern Exclosure were concentrated in the northern portion of 6 exclosure, in and around the 7.5 revegetation area, west of the Pipeline revegetation area, and in the southwest portion of 8 exclosure. In Oso Flaco raccoon tracks were concentrated in the northern portion of North Oso Flaco, just north of the boardwalk in the southern portion of North Oso Flaco south to Oso Flaco Creek, and in the southern portion of South Oso Flaco near the southern boundary (Figure 17). Tracks and scat indicated raccoons commonly traveled directly from the dunes to the shoreline and foraged in the intertidal zone on sand crabs (*Emerita analoga*). Tracks were rarely seen meandering through the protected area of the Southern Exclosure or the Oso Flaco shoreline. There were no known nests lost due to raccoon.

Coyote tracks were noted inside the predator fenced portion of the Southern Exclosure and North Oso Flaco on 19 occasions (on 19 different days), typically passing through a limited area inside the exclosure. This compares to 15 intrusions in 2008 and 25 in 2007. Coyotes entered and exited the exclosure by digging under, climbing, or jumping over the fence. Fourteen of the 19 coyote intrusions were between 3 May and 20 June. As has been the case for at least the past eight years, coyote presence was frequently detected along the shoreline throughout the season (Figure 18). Coyote tracks were recorded on 147 days in 2009 compared to 114 and 126 days in 2008 and 2007, respectively (Table 14). Coyotes have only rarely been observed during daytime hours inside the exclosures or along the shore. The lack of diurnal sightings, as well as timing of observed fresh tracks relative to wind and tide, indicate coyote activity is primarily nocturnal in these areas. There was no documented nest lost to coyote. As part of monitoring at ODSVRA, coyote scat encountered opportunistically was checked in the field for plastic and aluminum bands used in banding least terns and snowy plovers. No bands were found in 2009 or 2008, nine plastic bands were found in 2007. There continues to be concerns about possible plover chick loss to coyote along the shoreline outside of the predator fencing.



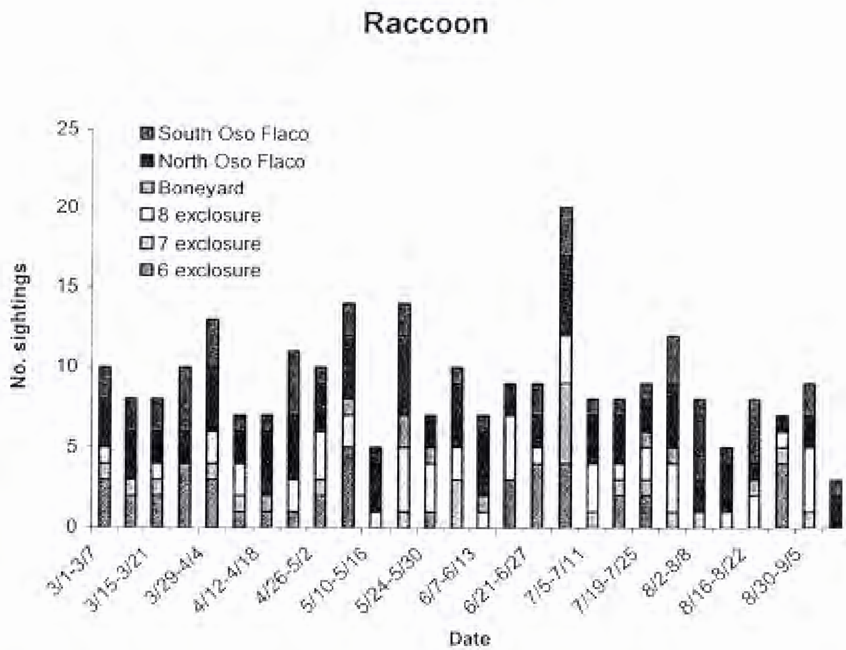


Figure 17. Skunk and raccoon presence documented in the Southern Exclosure and Oso Flaco at ODSVRA in 2009. To better assess the extent of predator activity in the protected area, skunk and raccoon presence is documented by occurrences in different areas in the above graphs. Predator presence in each of the geographic areas of Southern Exclosure (6, 7, 8 and Boneyard), North Oso Flaco and South Oso Flaco were recorded as separate sightings. Thus, the presence of a single skunk or raccoon on one day would frequently be recorded as a separate occurrence at multiple locations. Skunk and raccoon presence was detected only by tracks; no attempt was made to determine additional sightings due to multiple individuals present or multiple occurrences in a day.

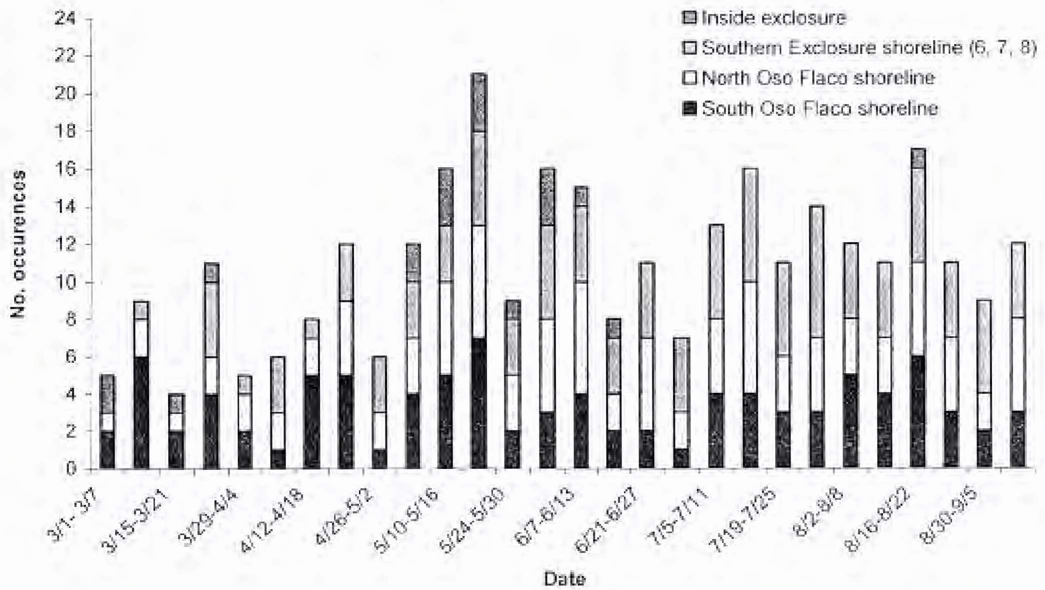
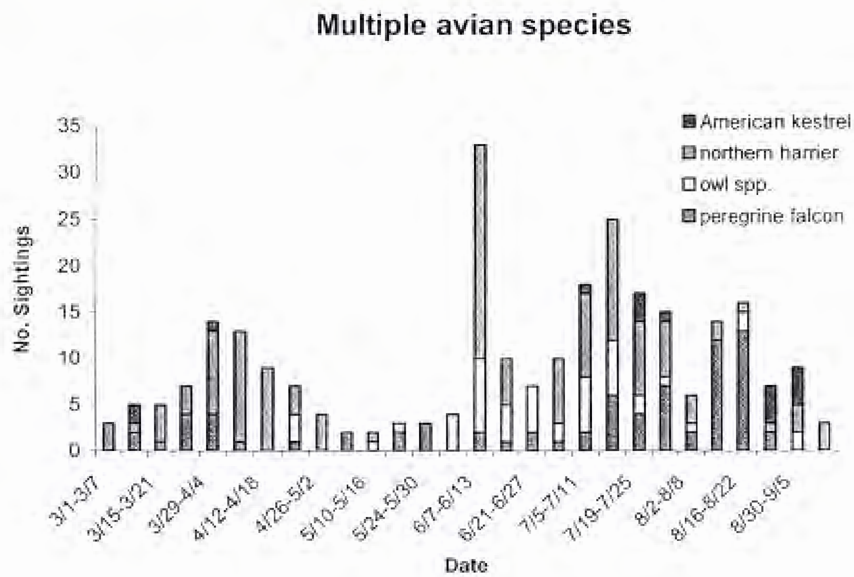


Figure 18. Coyote presence documented in the Southern Exclosure and Oso Flaco at ODSVRA in 2009. To better assess the extent of predator activity in the protected area, coyote presence is documented by occurrences in different areas in the above graph. Predator presence in each of the areas of Southern Exclosure shoreline, North Oso Flaco shoreline, South Oso Flaco shoreline, and inside the perimeter of predator fenced area were recorded as separate sightings. Thus, the presence of a single coyote on one day would frequently be recorded as a separate occurrence at multiple locations. Coyote presence was detected almost exclusively by tracks; no attempt was made to determine additional sightings due to multiple individuals present or multiple occurrences in a day.

Documented occurrence of Cooper's hawk (*Accipiter cooperii*), red-tailed hawk (*Buteo jamaicensis*), merlin (*Falco columbarius*), American kestrel, American crow (*Corvus brachyrhynchos*) and common raven (*Corvus corax*) in the Southern Exclosure and Oso Flaco was limited (seen on one to seventeen days). Northern harrier (*Circus cyaneus*), peregrine falcon, and owl spp. (owl presence identified by tracks) occurred more frequently (Table 14, Figure 19).

Figure 19. Selected avian predator sightings documented in the Southern Exclosure and Oso Flaco at ODSVRA in 2009. To better assess the extent of predator activity in the protected area, avian predator presence is documented by "sightings" in weekly intervals in the above graphs. If more than one individual was seen, each was described as a separate sighting. Presence of the same species at least one hour apart were counted as separate sightings. Lastly, predator presence in each of the geographic areas of Southern Exclosure (6, 7, 8, and Boneyard), North Oso Flaco and South Oso Flaco were recorded as separate sightings. Owl spp. presence was detected almost exclusively by tracks; no attempt was made to determine additional sightings due to multiple individuals present or occurrence one or more hours apart.



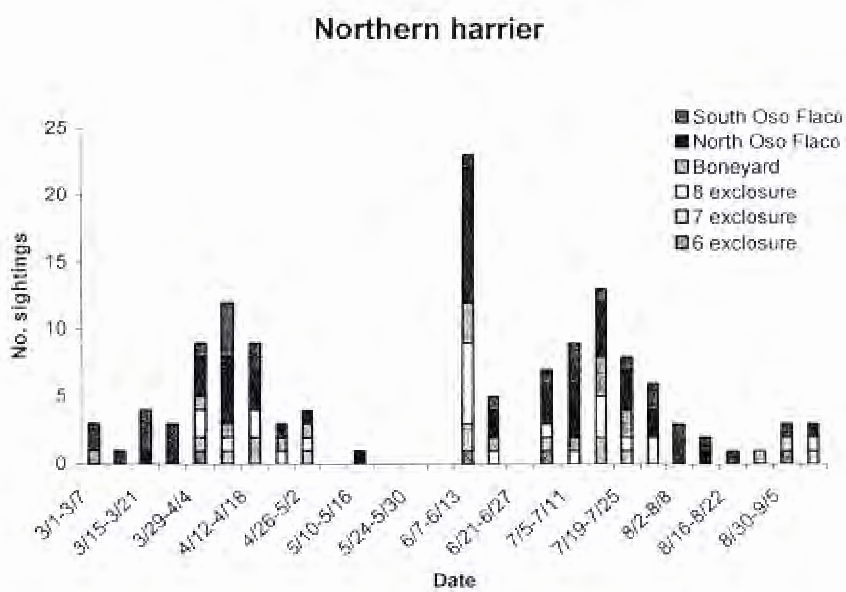
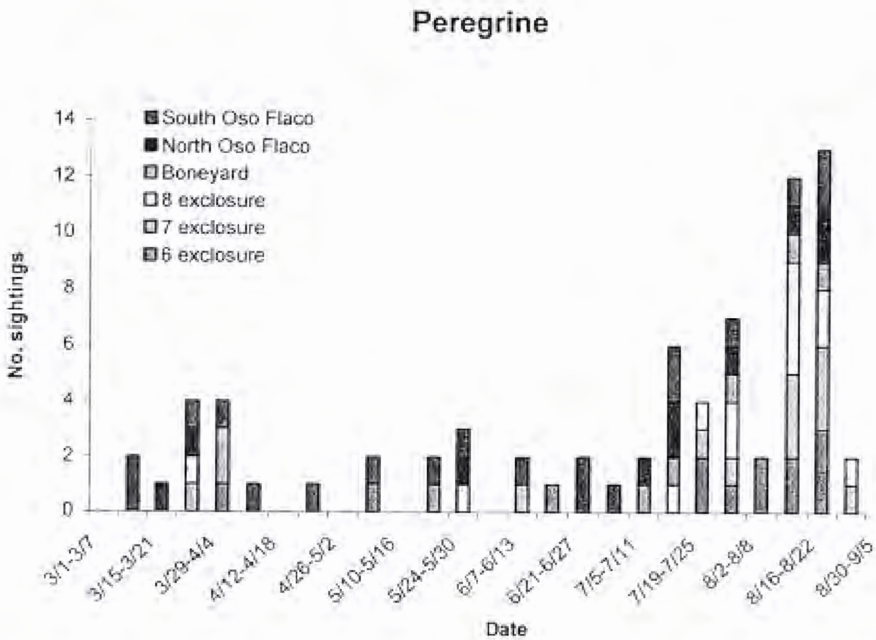


Figure 19, continued. Selected avian predator sightings documented in the Southern Exclosure and Oso Flaco at ODSVRA in 2009.



As has been the case in the past, gulls (including Heermann's (*Larus heermanni*), California, western (*Larus occidentalis*) and ring-billed (*Larus delawarensis*)) were regularly seen in flight, roosting, and foraging in the Southern Exclosure and Oso Flaco, especially on the shore. Gulls roosting on the shore were typically in flocks (ranging from a few to several hundred individuals) and unevenly distributed. A gull flock also formed inside the fenced area of northern 6 exclosure (high count of 700 on 24 July). It is likely that the number of gulls inside the protected tern and plover habitat was supplemented by birds displaced from the adjacent open riding area by high human and vehicle disturbance. Gull numbers were surveyed once daily at multiple locations in the open riding area, on the 6 exclosure shoreline and within the fenced area in the north portion of 6 exclosure. A weekly survey included counts in the perimeter fenced areas of 6, 7, and 8 exclosures, the Southern Exclosure shoreline, and Oso Flaco shoreline. Surveys were primarily carried out in the morning hours. Gull flock numbers on the 6 exclosure shoreline increased on daily surveys from a mean of 21 from 1 March to 31 May to a mean of 246 from 1 June to 10 September. Two plover nests were depredated by gulls in the fenced area of northern 6 exclosure. Two additional nests thought to be at high risk from gull flocks in the area were protected with 10 foot by 10 foot single nest exclosures and both hatched. On 23 July a sub-adult California gull on the 6 exclosure shoreline was seen with a plover chick in its bill and quickly swallowing it whole (chick believed to be from SP78 brood and 27 days old). On 24 July a sub-adult California gull, similar in appearance to the gull observed on 23 July, was observed exhibiting aggressive behavior toward plovers. The gull was lethally removed (stomach contents examined by parks staff and no snowy plover or least tern remains noted) (Appendix G). After the observed chick predation by a gull both predator management specialists spent several days watching plover broods on the shoreline. No incidents were observed between plover chicks and gulls during this period. Rate of chick loss was not substantially different prior to or after the removal of the gull.

Both State Park environmental scientists and contracted predator management specialists identified northern harriers as a threat to tern and plover reproductive success at ODSVRA in 2009. Plover and tern eggs and chicks are vulnerable to northern harrier predation. Live-trapping of selected northern harriers that posed a threat was the preferred predator management option but such efforts were unsuccessful this season. A minimum of six individual northern harriers were seen in the Southern Exclosure and North Oso Flaco during the 2009 breeding season: one adult male, two adult females, one sub-adult female, and two juveniles. Between 1 March to 10 September there were 133 sightings on 52 days of northern harriers in the protected area, including sightings of perched birds and birds in low flight actively hunting (Tables 14 and 17). On 10 June an adult male northern harrier was seen eating a white plover size bird in the northern portion of 8 exclosure (prey remains not located). The northern harrier then flew approximately 1000 feet directly to a snowy plover nest in the southern portion of 8 exclosure and was observed eating the eggs. The Chevron property site, also located in the Guadalupe-Nipomo Dunes complex, reported multiple snowy plover nests lost to northern harrier in 2009 (pers. comm. C. E. Holmes).

Peregrine falcons were observed actively hunting in the Southern Exclosure and Oso Flaco, including the shoreline, during the season. Between 1 March – 10 September there were 74 peregrine sightings on 36 days in the tern and plover protected area. Peregrines were observed perched, actively hunting in flight, and on the ground consuming prey (Tables 14 and 17). On six different occasions a peregrine consuming avian prey was observed in the Southern Exclosure (four inside the perimeter fenced area and twice on the shoreline). At least two of these predation events were of juveniles or adult size snowy plovers, one was identified visually by an ODSVRA environmental scientist and the second was both seen and confirmed by feather and bill remains. One peregrine associated with depredation of a plover and another seen repeatedly hunting the Southern Exclosure were live-trapped along the Southern Exclosure shoreline on 5 August and 19 August.

Fresh owl tracks in the protected area were noted on 38 days, even though our ability to detect owls is very limited. Evidence was collected suggesting owl depredation of recently hatched snowy plover chicks from Boneyard exclosure. The nest was checked on 10 July and all three eggs showed cracks consistent with approaching hatch. When the nest was next checked 12 July it had hatched and the tracks of the parent bird(s) with the chicks were followed down an open sand sheet leading toward the shore. At two separate locations tracks showed that an owl had landed at a brooding scrape where the chicks had assembled. This brood, with a known banded male, was subsequently seen on the shore with only one chick.

Table 17. Total number of sightings of selected avian predators in specific areas in the Southern Exclosure and North Oso Flaco at ODSVRA in 2009. To better assess the extent of predator activity in the protected area, avian predator presence is documented by "sightings" in the following table. If more than one individual was seen, each was described as a separate sighting. Presence of the same species at least one hour apart were counted as separate sightings. Lastly, predator presence in each of the geographic areas of Southern Exclosure (6, 7, 8, and Boneyard), North Oso Flaco and South Oso Flaco were recorded as separate sightings. Owl spp. presence was detected almost exclusively by tracks; no attempt was made to determine additional sightings due to multiple individuals present or occurrence one or more hours apart.

Location	American kestrel	Northern harrier	Owl spp.	Peregrine falcon	Total
6 exclosure	1	4	1	13	19
7 exclosure	3	14	1	13	31
8 exclosure	4	23	25	13	65
Boneyard exclosure	2	15	10	6	33
North Oso Flaco	3	45	9	9	66
South Oso Flaco	3	32	2	20	57
Total	16	133	48	74	271

It should be noted that there are many hours each day (including almost all night hours) when resource staff or predator management specialists are either not present or not in a position to observe predation. In addition, predation can occur quickly, often leaving little or no evidence behind (this may especially be the case with chick predation). It is likely that only a small percentage of predation events of chicks, fledglings, or adults are witnessed or documented during a breeding season. There are also limitations in the ability of monitors to detect predators. Diurnal avian predators can move quickly into and out of the large site and be missed. Nocturnal owl presence in the protected area was almost exclusively noted by tracks left where an owl landed and walked short distances. Such tracks can be quickly erased by windblown sand before they are detected. In addition, the 6, 7, and 8 exclosures are frequently monitored with binoculars and spotting scopes from the perimeter with less frequent monitoring on foot, thus reducing opportunities to detect areas where an owl landed. (Monitoring is done in a manner to carefully manage disturbance to nesting birds and broods and to avoid entering the exclosures during unfavorable weather conditions.)

RECOMMENDATIONS

Continue posting Arroyo Grande Creek

Beginning in 2006, ODSVRA installed a series of posts and signs that clearly delineated a closed area around the Arroyo Grande Creek and lagoon. Posts at regular intervals were placed from just south of the last Strand Way home to immediately south of the lagoon. Signage and ropes were installed to deter vehicle, pedestrian, and equestrian trespass. This clearly posted area has been effective in keeping vehicles out of the estuary and surrounding habitat. This closed area also provides shorebirds and gulls a protected area from vehicle traffic, which may take pressure off the protected shoreline of the Southern Exclosure and Oso Flaco where gulls congregate, at times conflicting with tern and plover management efforts.

Oso Flaco

Continue the current level of monitoring and management conducted at Oso Flaco. This includes nonnative plant control, protection of nests in single nest exclosures if located outside of predator fenced areas, predator fencing enclosing the dunes and seasonal closure to public use in North Oso Flaco (including shoreline), seasonal closure of upper beach and dunes with symbolic fencing in South Oso Flaco (pedestrian use permitted on lower beach), and active predator management.

Maintain size and location of Southern Exclosure

In 2010, maintain the size of the Southern Exclosure that was present during the 2009 breeding season. The size, location, and configuration has been approximately the same since 2004.

Continue use of increased fence height (initiated in 2006) and use of aprons to improve the effectiveness of the perimeter fence protecting terns and plovers breeding in the Southern Exclosure and North Oso Flaco

The exclosure fencing is important in discouraging coyotes from entering nesting and chick rearing habitat. In 2010, ODSVRA will continue use of the perimeter fence with the goal of maintaining the fence at six feet above the surface (using two layers of fencing) and buried 1.5 feet.

High winds at ODSVRA can cause gaps or blowouts at the bottom of the fence. To deter coyote entry into the exclosure in 2007-2009 an additional "apron" on the fence in areas where high winds cause gaps or blowouts was used. An apron is a section of fencing that is bent in an L-shape and attached to the bottom of the exclosure fence. Sand is pushed to cover the bottom of the apron and the lower part of the fencing. It is recommended to continue the use of the aprons in 2010.

Continue placing the west fence of Southern Exclosure and North Oso Flaco as low as possible on shoreline to increase protected habitat

The western fence of the Southern Exclosure is installed in late February before the beach has reached a summer profile. By the time plover broods are active, the western fence may be many yards inland of the wrack line. To increase protected plover chick rearing habitat on the shoreline, particularly from coyotes, the western fence of the exclosures should be placed as close as possible to the upper high tide zone, while still minimizing the possibility of the fence washing out due to storms or high tides. Install the fence along the shoreline last (after all other fencing is installed) and as close to 1 March as possible. In 2009, the western fence was installed an average of 26 feet further west than the 2008 fence, resulting in an additional 4.8 acres of protected shoreline compared to 2008. This western extension protected chick rearing habitat from coyote foraging disturbance occurring on the shoreline. In addition, the extension exclosed two nests in 2009 that would have received single nest exclosures if the fence line was at the 2008 location. Shoreline conditions will vary from year to year and it may not be possible to continue to enclose the shoreline at the 2009 level.

Continue management actions to minimize trespass along the Southern Exclosure and North Oso Flaco shorelines

Trespass into the nest exclosure can occur during both day and night and includes pedestrians, joggers, dogs, and motor vehicles. Such disturbances pose a threat of crushing nests and chicks, separating chicks from adults, and inadvertently pushing broods from the exclosure into the open riding area. On this shallow gradient shore, a wide portion of the lower beach can be exposed during low tides. In 2008 and 2009, additional tall posts with large stop signs were installed extending into the intertidal area at marker post 6 (northern boundary of the Southern Exclosure). In 2008, the similar action was taken at Oso Flaco boardwalk (south boundary of North Oso Flaco), helping reduce trespass into North Oso Flaco. Rope and additional signage were added between the shoreline posts. The posts and roped area in the intertidal zone at marker post 6 was effective at reducing the level of shoreline trespass observed in the 2009 season. For 2010, continue to install posts and rope at marker post 6 and Oso Flaco boardwalk on 1 March. Extend posts and rope into the intertidal zone as needed as the beach widens during the breeding season.

As possible, reduce disturbance to the protected nesting habitat by aircraft flying very low over the Southern Exclosure and Oso Flaco

Low-flying aircraft (often well under 500 feet of the ground) can cause direct and indirect disturbances to snowy plovers and least terns by being perceived as potential predators, causing excessive noise, and flushing gull flocks that could potentially land near nests or chicks resulting in possible disturbance or depredation (USFWS 2007). In 2008, attempts were made to place seasonal height restrictions for aircrafts over the nesting areas; however, the FAA will only authorize a voluntary height restriction over federal lands and will not apply the restriction to state lands. There was a considerable reduction in aircraft activity over the seasonal exclosure with a total of 97 observations of low flying aircrafts documented in 2008 and 20 observations in 2009. Staff will continue to document the impact of low-flying aircraft over the nesting exclosure.

Monitoring

Monitoring is critical for effective protection of nesting terns and plovers. As problems and threats arise for adult birds, nests, and chicks, timely information from monitoring can help guide appropriate management actions and evaluate their effectiveness. Monitoring efforts at ODSVRA should have adequate funding, resources, and flexibility to address anticipated problems (e.g., nesting failure, causes of chick loss, predator pressure) as well as unanticipated problems. Specific recommendations for monitoring are the following:

Retain skilled monitors. Maintain a core of trained and competent monitors with growing experience and knowledge of least tern and snowy plover biology and site-specific field experience at ODSVRA. This is important for maintaining a consistent quality of monitoring and the availability of qualified personnel to train new monitors. This is especially important at ODSVRA due to the presence of breeding populations of both least terns and snowy plovers sharing the same area. To retain a core group of skilled monitors, three Permanent Intermittent Environmental Scientist positions were filled in 2007. One hurdle to retaining seasonal monitors is the relatively low pay of the Senior Park Aid and Environmental Services Intern classifications. ODSVRA should pursue available means to increase the pay of skilled seasonal monitors including options to increase the pay rates for these classifications, options to start employees at higher pay ranges, or use of alternative classifications.

Continue banding least tern and snowy plover chicks. Continue banding least tern and snowy plover chicks to better understand chick behavior and factors promoting or threatening survival of chicks (e.g., feeding rates for tern chicks, foraging activity and movements of plover chicks, age and location of disappearance of different cohorts of chicks). Banding also provides a means to document fledging success. Without this information, the seasonal productivity of terns and plovers at ODSVRA would be unknown and management effectiveness could not be assessed. Additionally, bands provide an opportunity to gain insight into predator impacts on chicks and fledglings. Over time, banding of tern and plover chicks will also provide information on natal site fidelity of terns and plovers fledged at ODSVRA.

Continue banding least tern chicks to individual. Beginning in 2006, least tern chicks were banded to allow individual chicks to be identified. This was done by placing one or two different colors of tape on the federal band, creating a unique combination for each chick. Banding to individual provides the opportunity to gain additional information that otherwise may not be obtainable, including: 1) providing the most accurate means to count the number of juveniles produced, 2) identifying if there are pronounced differences in chicks surviving to fledge age between early and late periods of the breeding season in some years, 3) identifying if different areas within the colony are having different fledging success during a season, 4) identifying if broods hatching more than one chick are fledging more than one chick, 5) tracking movement of individual chicks and juveniles within the colony at ODSVRA, and 6) providing information on the length of stay of individual juveniles at the colony site after fledging. The additional information provided by banding to individual benefits developing and assessing site management actions directed toward the recovery of the least tern.

Option to band adult snowy plovers. The occurrence of abandoned plover nests can raise concern about possible mortality of adult plovers. If elevated adult mortality rates occur or are suspected, it could prove beneficial to band various adults. This would allow monitors to verify if mortality was taking place and possibly identify the causes.

Continue monitoring least tern juveniles, night roost, and foraging activity. At the ODSVRA colony site, juvenile terns can be widely dispersed over a large area and a monitoring effort directed specifically for terns is needed to estimate the number of juveniles produced as well as identify threats to survival. Knowing the locations of least tern night roosts is important in order to protect the sites as well as obtaining a better understanding of the number of adults and fledglings at the colony. Bodies of fresh water can provide a source of fish in addition to the near-shore ocean. Continue to identify and monitor nearby fresh water lakes where terns are foraging to better understand their importance in supplying chicks and juveniles with adequate numbers of fish and of appropriate size (chicks require fish small enough that they can be swallowed whole).

Continue gull surveys. Gulls are a known predator of snowy plover and least tern eggs and chicks and the behavior of gulls is recorded as part of our general predator monitoring. More focused and regular surveys of gull distribution and numbers within the park began at ODSVRA in 2006 to look for long-term trends. This information may prove useful in understanding potential or occurring impacts to plovers and terns and to assist in making management decisions.

Importance of sharing information among sites in the Guadalupe-Nipomo dunes complex. ODSVRA recognizes the importance of sharing information among managers in the dune complex and should continue to provide updates throughout the season and encourage the other site managers to do the same.

Use of night vision equipment. A Generation 3 night vision unit and infrared spotlight was tested and used by ODSVRA in 2009 during several monitoring surveys. There were occasions when it proved useful in monitoring the least tern night roost area after dusk. During the 2010 season, it is recommended to schedule monitors (if staff levels allow) for additional late evening and night shifts as needed to take advantage of night vision capabilities in collecting tern night roost information. Additionally, if staff and funding levels allow, ODSVRA should assess the ability to collect information on tern, plover, and predator activity on the shoreline at night with this equipment.

Use of video camera equipment to monitor activity on the shoreline. Direct observations of nocturnal coyote and snowy plover brood activity is limited because of the increased risks to broods from driving on the shoreline after dark and the difficulty of coordinating limited staff resources for nighttime monitoring. In the latter part of the 2009 season, ODSVRA obtained an infrared video system for monitoring such activity. During the winter of 2009 and 2010, the system should continue to be tested and adjusted to the needs of the ODSVRA beach. During the 2010 season, it is recommended to place the video equipment in locations on the shoreline for best viewing of brood and nocturnal predator activity. This equipment also provides daytime monitoring capabilities.

Enhance habitat in the Southern Exclosure by distributing natural materials with the help of maintenance staff and heavy equipment.

Natural materials such as driftwood, woodchips, shell, and kelp should be distributed in large amounts within the exclosures (including the shoreline area) prior to the breeding season to enhance habitat features. Monitors have observed terns and plovers using such material types for roosting, nesting, foraging, and wind shelter. The practical limitation of available time and materials for this action needs to be recognized.

Greater efficiencies can be achieved in two main areas of ongoing habitat enhancement efforts, woodchips and wrack distribution. Since 2008, OSDVRA resource staff has received assistance with increased availability of heavy equipment in loading woodchips to be distributed into the exclosure. The assistance from heavy equipment has allowed the placement of approximately 310 and 275 cubic yards of woodchips in 2008 and 2009, compared to approximately 175 and 200 cubic yards in 2006 and 2007 when heavy equipment wasn't always available. The effort to enhance the breeding area with surf-cast wrack can be greatly assisted with the use of heavy equipment. Since 2002, surf-cast wrack has been gathered by hand and placed in the exclosure. In 2010, it is recommended that heavy equipment be available throughout the season to assist in loading wrack to be distributed into the seasonal exclosure by permitted staff. This would allow larger amounts of kelp to be dispersed on the shoreline, helping to maintain larger populations of invertebrate prey over a larger area for snowy plover chicks, fledglings, and adults. Broader distribution of wrack also provides shelter from wind and cover from predators. The use of heavy equipment needs to be balanced with other operational needs in the park.

The addition of quick-growing annual dune vegetation should continue to be evaluated as habitat enhancement. Planting in early spring, with sufficient late rains, may allow enough time for plant growth to provide topographic features that could benefit plovers and terns. The effort takes very little labor and overall cost is low. Seed of sea rocket and beach-bur were dispersed in multiple areas of 6 and 7 exclosures in February and March of 2009. Also in March, 110 four inch container plants of sea rocket and beach-bur were dispersed in areas of 6, 7, and 8 exclosures. Approximately 10% of the container stock appeared alive in September 2009 and most of the plants were still small in size and with very little root system. This may be due to a lack of rain after planting and/or the advanced age of the container stock. Also noted were seed sprouts of sea rocket and some beach-bur, and although not providing significant plant cover, a few sea rocket plants had grown to greater than one-foot-wide and were forming small hummocks. Plant survival overall appeared greater in the woodchip patches compared to areas without woodchips.

Seeding of the Southern Exclosure with sea rocket and beach-bur is recommended in 2010. Continue limited test planting in areas of added materials (e.g., woodchips) of sea rocket or other appropriate available containers stock should also be evaluated in 2010. The seeding and planting would occur around the time the fence is installed on 1 March. Seeding or planting may be attempted prior to the fence installation in order to take advantage of rain events and moist sand. The goal of this planting is to provide areas of scattered vegetation for cover and to encourage the development of small hummocks.

For the past 4 years, ODSVRA has been using woodchips to enhance habitat in the breeding exclosure. These woodchips have a short life and are prone to deteriorating and blowing away. ODSVRA should investigate the use of shells to provide for longer lasting debris patches in the exclosure. Shells have been used at multiple sites in Washington, Oregon, and California with positive results. Shells have not been used at ODSVRA up to this point due to an unstable supply source. In addition, there are issues that need to be worked out related to archaeology to accurately record shell introductions and ensure that modern shell introductions do not encroach or otherwise impact the integrity of existing known archaeological sites. In 2010, ODSVRA should explore the use of shell as a habitat enhancement and address archaeological and supply issues.

Continue to study the benefits of wrack addition to the Southern Exclosure shoreline and inoculation with wrack-associated invertebrates as a possible means to restore invertebrate species and biomass (these invertebrates are part of the prey base for snowy plover chicks, juveniles, and adults)

In 2007-2009, Drs. Jenifer Dugan and Mark Page, researchers from the Marine Science Institute at the University of California Santa Barbara, examined the responses of invertebrate numbers and diversity in areas where wrack (surf-cast kelp) was added to the shoreline throughout the breeding season. In 2007, a controlled experiment examined natural colonization of wrack-associated invertebrates on the Southern Exclosure shoreline during the seasonal closure period. Selected areas received wrack additions throughout the period to ensure consistent availability of fresh wrack (wrack was collected from the open riding area). Results suggested that the seven month seasonal closure (March through September) was not a sufficient period of time for invertebrates to effectively recover species diversity and abundance on the Southern Exclosure shoreline. In response to these findings, the experimental design was repeated during the 2008 breeding season with the addition of collecting approximately 15,000 wrack-associated invertebrates from outside of the vehicle use area (north of Grand Avenue) and inoculating wrack with these invertebrates in wrack addition areas of the Southern Exclosure. Results suggest that the translocated invertebrates survived and reproduced but did not disperse widely (pers. comm. J. Dugan). Based on this outcome, the experimental design was altered in 2009 to inoculate a longer stretch of shoreline within the exclosure with a larger number of invertebrates early in the season. Preliminary analysis of the results suggest that addition of wrack combined with early season inoculation of invertebrates over a broader area may allow more rapid reestablishment and spread of invertebrates on the Southern Exclosure shore (pers. comm. J. Dugan). This, in turn, would benefit snowy plover chicks, juveniles, and adults by providing additional available prey. If funding levels allow, experimental examination of wrack and invertebrate manipulation on the Southern Exclosure shore should continue in the 2010 season with the goal of identifying potential means to enhance the diversity and abundance of invertebrate species that are natural prey for plovers.

Continue use of tern chick shelters

Tern chick shelters of various types are used at the majority of managed least tern sites in California (Marschalek 2009). Tern chick shelters were placed in the 6 and 7 exclosures in 2008 and 2009 to provide chicks with some available cover for protection from predators and harsh weather conditions. The tern chick shelters were simple plywood constructions in A-shape, L-shape, or T-shape designs. In 2009, tern chicks were observed crouching under or next to tern chick shelters on numerous occasions. Examples of observed use of the shelters included: chick use recorded almost daily between 21 July – 4 August (13 of 14 days) with chicks seen crouching under or emerging from the shelters; and up to six chicks observed on the same day using shelters. The use of tern chick shelters of the design types used in 2008 and 2009 should be continued in 2010 for further evaluation.

Continue use of 10 foot by 10 foot single nest exclosures with net top

Exclosures with net tops are not without risks to incubating adults and their use requires careful evaluation and close monitoring. They are best considered a temporary protective measure during periods of high risk from avian egg predators while more sustainable predator management options to protect eggs are pursued. The 10 foot by 10 foot exclosure with a net top has been used in the past in an effort to protect plover nests from avian predators. They are not a management option for tern nests as the incubating adult approaches and leave the nest in flight and the net top would be a barrier. Snowy plovers can approach and leave their nests on foot and pass through the openings of the exclosure fence.

Use tern chick fencing to prevent chicks from moving into the open riding area

Least tern chicks are frequently left unattended while their parents forage for fish away from the colony. The mobile chicks can naturally wander, as well as move rapidly over long distances in response to disturbance or predators. To prevent chicks from moving out of protected areas, many sites in southern California use tern chick fencing. This fencing is a low plastic fence with very small mesh size, typically attached to the bottom of a larger and sturdy existing fence. In past seasons there has been documentation of tern chick movement toward or past the eastern fence of the Southern Exclosure. In 2008 and 2009 there were four occasions (three in 2008 and one in 2009 involving four chicks) when chicks were observed moving through the fence and into the open riding area and were directed back into the exclosure by park monitors. During the past several seasons, when monitors checked the exclosure east fence in the morning, tern chick tracks moving into the open riding area a short distance and returning to the exclosure have been noted on limited occasions. On one occasion, a live half-grown chick was still in the open riding area (picked up and returned to the exclosure by the permitted contractor).

In 2008, tern chick fencing was experimentally placed on the eastern side of Boneyard exclosure. In 2009, tern chick fencing was experimentally placed in two sections (approximately lengths of 130 feet and 170 feet) along the 6 and 7 exclosure east fence in areas of different topography and wind conditions. The installation of the two portions occurred on 20 May and 3 June, before the initiation of the first tern nest, and after regular sightings of terns at ODSVRA. The fencing was monitored regularly and was maintained for the entire season. This experiment on the eastern exclosure fence demonstrated that the tern chick fencing can be successfully used with the field conditions encountered at ODSVRA.

In 2010, ODSVRA should work with the USFWS to secure approval to install tern chick fencing on the north and east fence of the 6 exclosure and a portion of the east 7 exclosure. The installation should occur prior to the arrival of terns, possibly with the installation of the seasonal fence. No least tern chick fencing would be placed on the west side where it would prevent snowy plover chick movement to the shoreline. Monitoring of the fence will occur daily and any problems addressed immediately. It is recommended for 2010 to bury the bottom portion of the tern fencing during installation to reduce the amount of blowouts and to have heavy equipment move any sand build-up occurring east of the fence throughout the season. The tern chick fencing will be removed prior to tern nests hatching if it is determined that the fencing can not be maintained or other concerns arise. ODSVRA will continue to work in consultation with managers and least tern and snowy plover biologists at sites experienced with the use of chick fencing and consult with USFWS as to the methods used.

Continue predator management

In 2010, continue the predator management actions that have been in place since 2003 and 2004, including the option for selective live-trapping and relocation and selective removal of predators posing a threat to tern and plover reproductive success. Monitoring efforts in 2010 should continue to carefully monitor gulls, including numbers, behavior, and distribution in tern and plover habitat. Continue to monitor coyote tracks along the shore to monitor presence and activity. In the 2010 season it is recommended to better establish coyote numbers and behavior on the shoreline using video equipment previously noted in monitoring recommendations. It is also recommended to continue to provide all other land owners/managers within the Guadalupe-Nipomo Dunes complex with information from ODSVRA on predators and known or suspected impacts to least terns and snowy plovers and to encourage better sharing of such information from the other sites as this will benefit recovery efforts throughout the dune complex.

Continue to submit least tern and snowy plover carcasses for necropsy examination when appropriate

Examination of least tern and snowy plover carcasses by a veterinarian pathologist is not only useful to potentially determine cause of death, but also to help monitor for exposure to contaminants or diseases that may impact terns or plovers. This could provide an early warning to what might become larger problems. For 2010, continue to submit plover and tern carcasses in good condition with an unknown cause of death.

Maintain option to salvage and rescue eggs, chicks, juveniles, and adults under very limited circumstances

In some circumstances the abandonment of least tern or snowy plover eggs and chicks can be directly attributed to human disturbance. The option to salvage such eggs and chicks to be raised in captivity by an approved facility and released in the wild is useful. Beginning in 2003, a limited number of abandoned but likely viable snowy plover eggs or chicks from ODSVRA were brought into captivity. Chicks were raised in a manner that they did not imprint on humans and were released into the wild when fledged. Captive care should only be used selectively and not as a substitute for responding to the primary causes of elevated egg or chick abandonment rates.

NOTES

Least tern injury and mortality

On 9 August 2009, LT8 fledgling banded W/G:W/B (25 days old) was seen in the exclosure dragging the right wing and not flying (previously seen to fly well). It continued to be fed by the parent(s) but did not improve. On 11 August it was captured and taken to an approved rehabilitation facility in San Diego County and found to have a compound fracture in the wing. This bird received care but did not survive.

On 2 June 2009, the desiccated carcass of a least tern banded G/Y:B/Y was found in the southwest portion of 8 exclosure. The right wing of the carcass measured 108 mm. This bird hatched from LT33 in the 2008 breeding season at ODSVRA and was last seen on the day of banding near the nest site. The sibling chick of this brood did not survive and was found dead on site 28 August 2008. It is likely the G/Y:B/Y bird died during the 2008 breeding season.

Abandonment of least tern nest located close to the east exclosure fence

One abandoned nest in 2009 was inside 6 exclosure approximately 75 feet from the east fence. The incubating adult was observed flushed from the nest on more than one occasion by vehicle activity alongside the fence. The internal protocol at ODSVRA for nests that are close to the fence separating the open riding area and the Southern Exclosure is to add temporary fence in the open riding area to provide at minimum of a 75 foot radius buffer from the nest. Two snowy plover nests were protected in this manner in 2009 and both hatched. Nests close to the fence, but 75 feet or greater distance from the open riding area are monitored for disturbance with the option of installing additional fencing to the east side of the exclosure as necessary. The procedures involving this protocol are being reevaluated and reviewed.

Snowy plover eggs with discolored brown patch on shell

Eight eggs from five early season nests had a small to large discolored brown patch on the outer surface of egg. Each nest had a complete clutch of three eggs. Three nests had one discolored egg, one nest had two discolored eggs, and one nest had all three eggs discolored. All of the affected eggs felt abnormally weighted, with one end too light and all the weight concentrated at the other end. Seven of the discolored eggs were collected (in some cases well past expected hatch date). Five eggs were sent to UC Davis Animal Health and Food Safety Laboratory, Fresno, California, where they were opened and found to be nonviable and without any embryo development. The brown patch, described as an accumulation of black granular material on the surface, was tested for bacterial or fungal activity with negative results. No other tests were performed (Refer to attached Inspection Report). Two eggs, with smaller brown patches, were sent to the USFWS Environmental Contaminants Division, Biomonitoring and Investigations Branch. At the time of this report preparation, no information has been received regarding these two eggs. In clutches with a discolored egg there were several unaffected eggs that did hatch and some of the chicks fledged. Collection of the eggs was done in consultation with USFWS. Snowy plover eggs with similar appearing brown patches have infrequently been recorded at other sites in California, including in 2009.

Two abandoned viable eggs placed in nests with nonviable eggs

On two occasions a single viable abandoned egg (from SP31 and 141) was placed in an active nest (SP6 and 136) that had nonviable eggs (both nests were incubated for 47 days). In each case the egg was accepted, hatched, and chick received normal parental care (neither chick known to fledge). This was done as a permitted activity under our USFWS permit and in consultation with the Ventura USFWS Office.

Snowy plover nest north of open riding area

On 11 May 2009, a three-egg snowy plover nest (SP54), incubated by an unbanded female, was found on the beach adjacent to Pismo Lagoon. This was the first plover nest found north of Grand Ave. since 2000. This area is closed to vehicles, but pedestrian and dog use is high. A single nest exclosure 25 feet in radius and a symbolic fence 75 feet in radius were built around the nest on the day it was found. The next day the symbolic fence was expanded to 100 feet in radius. The nest was checked from a distance several times each day to confirm the presence of an incubating adult. On 16 May, five days after the nest was found, it was depredated by a crow.

Abandoned snowy plover egg and chicks raised in captivity

On 27 July 2009, a nest (SP138) in 7 exclosure was observed with two chicks, but no attending adult (nest observed from open riding area with spotting scope). The nest was watched continuously for several hours with no adult activity in the area. After consulting USFWS, the two chicks and one egg were taken to a captive rearing facility at Coal Oil Point Reserve, Santa Barbara County, where the egg hatched and all chicks subsequently fledged. Prior to their release near a snowy plover flock at Coal Oil Point Reserve the fledglings were banded (PG:LY, VV:OB, and VV:OR).

Rehabilitation of snowy plover adult

On 31 August 2009, an unbanded snowy plover was observed near Pismo Lagoon with violent convulsions, head twisting back and forth quickly, and beating wings rapidly. The bird was picked up by hand and taken to the VCA Animal Hospital in Arroyo Grande, California, where the veterinarian reported the plover was in good body condition with tremors, torticolis (head moving back and forth), leg paresis (impaired movement), and increased respiratory rate. The veterinarian indicated symptoms could be caused by infection, trauma (no signs of trauma), or toxicity. The bird was then transported to the Monterey Bay Aquarium in Monterey County, where the aviculturist reported the bird was standing and slightly lethargic upon arrival. Within a few hours, it was observed to be more alert, and resumed eating and defecating. On the next day (1 September), the bird exhibited no ataxia (inability to coordinate voluntary muscle movements; unsteady movements and staggering gait), good flight, droppings within normal limits, and no seizure activity. No testing was performed on the bird. The bird was banded AP:YP and released at Del Monte Beach in Monterey County on 1 September.

Necropsy results of one snowy plover chick, one juvenile, and one adult

In 2009, the carcasses of one chick, one juvenile, and one adult snowy plover were sent for necropsy (see Appendix G and Attachment).

On 5 August 2009, one dead chick (SP132) was found on the 8 exclosure shoreline. On 29 September 2009, a banded juvenile (fledged from ODSVRA [SP80] and 93 days old) was found dead in a tire track midway between Pier and Grand Avenues. Finally, On 26 February 2009, an unbanded adult snowy plover was found dead on the ground approximately one foot east of the Southern Exclosure fence. All birds were submitted for necropsy (attached).

LITERATURE CITED

Bailey, J.P. and F.A. Servello. 2008. Chicks survival, fledging residency and evaluation of methods for estimating fledging success in least terns. Waterbirds 31(4):571-579.

CDPR. 2008. Nesting season of the California and Snowy Plover at Oceano Dunes State Vehicular Recreation Area, San Luis Obispo County, California 2008 Season. Unpublished Report, CDPR, Off-Highway Motor Vehicular Recreation Division.

CDPR. 2007. Nesting season of the California and Snowy Plover at Oceano Dunes State Vehicular Recreation Area, San Luis Obispo County, California 2007 Season. Unpublished Report, CDPR, Off-Highway Motor Vehicular Recreation Division.

CDPR. 2006. Nesting season of the California and Snowy Plover at Oceano Dunes State Vehicular Recreation Area, San Luis Obispo County, California 2006 Season. Unpublished Report, CDPR, Off-Highway Motor Vehicular Recreation Division.

CDPR. 2005. Nesting season of the California and Snowy Plover at Oceano Dunes State Vehicular Recreation Area, San Luis Obispo County, California 2005 Season. Unpublished Report, CDPR, Off-Highway Motor Vehicular Recreation Division.

CDPR. 2004. Nesting season of the California and Snowy Plover at Oceano Dunes State Vehicular Recreation Area, San Luis Obispo County, California 2004 Season. Unpublished Report, CDPR, Off-Highway Motor Vehicular Recreation Division.

George, D.E. 2003. Nesting of the California Least Tern and Snowy Plover at Oceano Dunes State Vehicular Recreation Area, San Luis Obispo County, California, 2003 Season. Unpublished Report, PRBO, Stinson Beach, CA.

George, D.E. 2002. Nesting of the California Least Tern and Snowy Plover at Oceano Dunes State Vehicular Recreation Area, San Luis Obispo County, California in 2002. Unpublished Report, PRBO, Stinson Beach, CA.

Marschalek, D.A. 2009. California least tern breeding survey, 2008 season. California Department of Fish and Game. Sacramento, CA.

Marschalek, D.A. 2008. California least tern breeding survey, 2007 season. California Department of Fish and Game. Sacramento, CA.

Marschalek, D.A. 2007. California least tern breeding survey, 2006 season. California Department of Fish and Game. Sacramento, CA.

Marschalek, D.A. 2006. California least tern breeding survey, 2005 season. California Department of Fish and Game. Sacramento, CA.

Page, G.A., J.S. and J.C. Warriner, and P.W.C. Paton. 1995. Snowy Plover (Charadrius alexandrinus). In The Birds of North America, No. 154, (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, PA, and The American Ornithologists' Union, Washington DC.

Thompson, B.C., J.A. Jackson, J. Burger, L.A. Hill, E.M. Kiroch, and J.L.Atwood. 1997. Least Tern (Sterna antillarum). In A. Poole and F. Gill, eds. The Birds of North America, No. 290. The Academy of Natural Sciences, Philadelphia, PA, and The American Ornithologists' Union, Washington, D.C.

USFWS. 2008. 2007 – 08 California Winter Snowy Plover Survey Results. Unpublished Report. USFWS, Arcata, CA.

USFWS. 2007. Recovery Plan for the Pacific Coast Population of the western Snowy Plover (*Charadrius alexandrinus nivosus*). In two volumes. Sacramento, CA. xiv+751pp.

USFWS. 2006. Five-Year Review Summary and Evaluation for the California Least Tern (*Sterna antillarum browni*). USFWS, Carlsbad, CA. September 2006.

USFWS. 1985. Recovery Plan for the California Least Tern (*Sterna antillarum browni*). USFWS, Portland, OR. 112 pp.

Warriner, J.S., J.C. Warriner, G.W. Page and L.E. Stenzel. 1986. Mating system and reproductive success of a small population of polygamous snowy plovers. Wilson Bulletin 98(1):15-37.

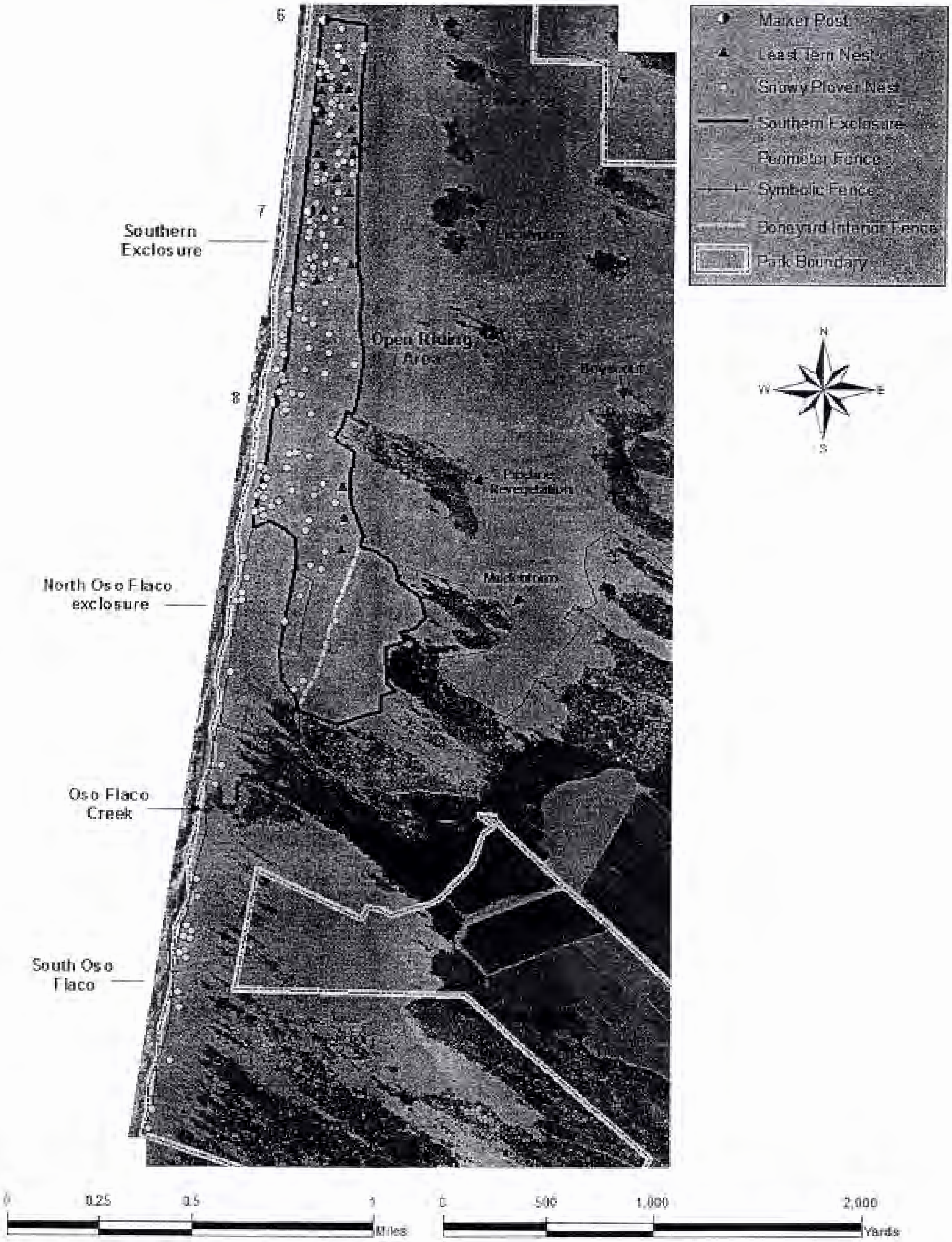


Figure 20. California least tern and snowy plover nests at ODSVRA in 2009. One snowy plover nest located near Pismo Lagoon is located in Appendix D.

Appendix A. California least tern nests at ODSVRA in 2009.

Hatching nest defined as nest with at least one egg hatching. All least tern chicks were banded with white over blue vinyl tape on a white band on the right leg and an aluminum federal band on the left. Color tape was placed on federal band to create combinations unique to individual. Chicks were weighed when banded, typically one to three days old. Some chicks not banded until older and have higher weights.

Abandoned pre-term = nest abandoned prior to expected hatch date.

Abandoned post-term = nest abandoned at or after expected hatch date.

Abandoned unknown pre- or post-term = nest abandoned prior to, at, or after expected hatch date.

Location: 6 = 6 exclosure 7 = 7 exclosure 8 = 8 exclosure BY = Boneyard exclosure

Nest	Location	Date found	Nest fate	Estimated fate date	No. eggs	No. chicks (No. fledge)	Chick band combination (chick weight in grams when banded)	Confirmed fledged	Notes
1	BY	11-Jun	Hatch	27-Jun	2	2 (1)	W:W/B (5.5) Y:W/B (6.7)	W:W/B	At least one adult associated with this nest was unbanded. Y:W/B chick last seen 7 July at 10 days old.
2	8	15-Jun	Hatch	9-Jul	2	2 (0)	G:W/B (6.0) O:W/B (6.3)		Both chicks last seen 11 July at 2 days old.
3	6	20-Jun	Hatch	11-Jul	2	2 (2)	B:W/B (7.8) R:W/B (6.7)	B:W/B R:W/B	One adult associated with this nest was banded with a federal band (no tape) on the right leg.
4	6	23-Jun	Hatch	15-Jul	2	2 (2)	R/O:W/B (11.6) R/W:W/B (11.7)	R/O:W/B R/W:W/B	One adult associated with this nest was banded with a federal band (no tape) on the right leg. The other adult associated with this nest was unbanded.
5	6	23-Jun	Hatch	15-Jul	2	2 (0)	Y/B:W/B (6.4) Y/G:W/B (6.0)		Y/B:W/B last seen with a second chick (bands not identified) 29 July at 14 days old.
6	6	23-Jun	Abandoned post-term	17-Jul	2	0			Nest abandoned, post-term, incubated for a minimum of 24 days.
7	7	23-Jun	Hatch	13-Jul	2	2 (2)	W/O:W/B (7.6) W/Y:W/B (6.3)	W/O:W/B W/Y:W/B	At least one adult associated with this nest was unbanded.
8	6	23-Jun	Hatch	15-Jul	2	2 (2)	B/W:W/B (10.3) W/G:W/B (5.6)	B/W:W/B W/G:W/B	One adult associated with this nest was banded with a federal band (no tape) on the right leg. The other adult associated with this nest was unbanded. W/G:W/B (previously seen flying) had an injured right wing at 25 days old and was transported to a facility for rehabilitation on 11 August at 27 days old. Its elbow joint was not fully functional with an obvious break in the right radius or ulna. Due to the extent of the wing injury, this bird will likely not be flight capable in the future and is considered not to have survived to leave the natal colony. This bird died on 30 September.
9	6	23-Jun	Hatch	15-Jul	2	1 (1)	O/R:W/B (13.3)	O/R:W/B	Nonhatching egg abandoned post-term
10	6	26-Jun	Hatch	17-Jul	2	2 (2)	G/W:W/B (6.8) Y/O:W/B (8.1)	G/W:W/B Y/O:W/B	Both adults associated with this nest were unbanded.
11	7	29-Jun	Hatch	18-Jul	2	2 (1)	O/B:W/B (7.8) O/Y:W/B (5.9)	O/B:W/B	At least one adult associated with this nest was unbanded. O/Y:W/B last seen 5 August at 18 days old.
12	8	30-Jun	Hatch	14-Jul	1	1 (0)	R/Y:W/B (9.2)		At least one adult associated with this nest was unbanded. R/Y:W/B last seen 25 July at 11 days old.
13	6	27-Jun	Hatch	17-Jul	2	2 (2)	B/O:W/B (7.3) B/Y:W/B (7.8)	B/O:W/B B/Y:W/B	One adult associated with this nest was banded with a federal band covered with white tape on the right leg. The other adult associated with this nest was unbanded.

Appendix A. California least tern nests at ODSVRA in 2009 (continued).

Nest	Location	Date found	Nest fate	Estimated fate date	No. eggs	No. chicks (No. fledge)	Chick band combination (chick weight in grams when banded)	Confirmed fledged	Notes
14	7	4-Jul	Hatch	20-Jul	2	2 (2)	B/R:W/B (5.5) O/A:W/B (6.2)	B/R:W/B O/A:W/B	At least one adult associated with this nest was unbanded.
15	6	3-Jul	Abandoned unknown pre- or post-term	18-Jul	2	0			Nest abandoned, unknown pre- or post-term, incubated for a minimum of 14 days. It was incubated continuously for nine days then inconsistently for seven days prior to abandonment. Nest was 74 feet west of east fence. Disturbance to incubating adult from vehicles was observed.
16	6	12-Jul	Hatch	22-Jul	2	2 (2)	A/Y:W/B (9.3) R/B:W/B (8.2)	A/Y:W/B R/B:W/B	One adult associated with this nest was most likely banded aqua over green on the right leg. This adult was observed feeding a chick, but the band was not confirmed. The other adult associated with this nest was unbanded.
17	6	13-Jul	Hatch	13-Jul	2	2 (2)	P:W/B (5.6) V:W/B (5.3)	P:W/B V:W/B	
18	6	23-Jun	Hatch	13-Jul	2	2 (2)	O/W:W/B (9.0) Y/W:W/B (9.5)	O/W:W/B Y/W:W/B	At least one adult associated with this nest was unbanded.
19	6	26-Jun	Hatch	17-Jul	2	2 (*)	unbanded unbanded		Two chicks hatched, but not banded due to their close proximity to young plover broods that in turn were near gull flocks on the shoreline.
20	6	23-Jun	Hatch	13-Jul	2	2 (2)	A:W/B (7.6) L:W/B (7.3)	A:W/B L:W/B	
21	6	24-Jun	Hatch	13-Jul	2	2 (2)	W/B:W/B (11.3) Y/R:W/B (10.8)	W/B:W/B Y/R:W/B	One adult associated with this nest was banded with a USFWS band (no tape) on the right leg. The other adult associated with this nest was unbanded.
22	6	18-Jul	Abandoned pre-term	2-Aug	2	0			Nest abandoned, pre-term, incubated for a minimum of 14 days.
23	6	22-Jul	Hatch	12-Aug	2	1 (1)	R/A:W/B (7.4)	R/A:W/B	Both adults associated with this nest were unbanded. Nonhatching egg abandoned post-term.
24	6	10-Aug	Hatch	10-Aug	2	2 (1)	A/R:W/B (6.4) B/A:W/B (5.5)	A/R:W/B	One adult associated with this nest was banded red over white on the right leg. The other adult associated with this nest was unbanded. B/A:W/B last seen 19 August at 9 days old. Seen in the same position the next day not moving and likely dead, and was not seen again subsequent to this sighting.
25	6	2-Jul	Hatch	14-Jul	2	2 (*)	unbanded unbanded		Two chicks hatched, but not banded due to their close proximity to young plover broods that in turn were near gull flocks on the shoreline.
26	6	4-Jul	Hatch	14-Jul	2	2 (*)	unbanded unbanded		Two chicks hatched, but not banded due to their close proximity to young plover broods that in turn were near gull flocks on the shoreline.

Appendix B. Snowy Plover nests at ODSVRA in 2009.

Hatching nest defined as nest with at least one egg hatching. Where there are two fate dates, this indicates a split hatch (chicks hatching on more than one day). All plover chicks were banded to brood.

Location: 6=6 exclosure, 7=7 exclosure, 8=8 exclosure, BY=Boneyard, NOF=North Oso Flaco, SOF=South Oso Flaco

Adult pair: M=male, F=female, U=unbanded

ULT = Federal aluminum band on left leg with color tape applied leaving upper one-third exposed metal in 2002, 2003, and 2004.

URT = Federal aluminum band on right leg with color tape applied leaving upper one-third exposed metal in 2002, 2003, and 2004.

LLT = Federal aluminum band on left leg with color tape applied leaving lower one-third exposed metal in 2002, 2003, and 2004.

Abandoned pre-term = nest abandoned prior to the expected hat date

Abandoned post-term = nest abandoned at or after the expected hatch date

Failed, cause unknown = nest not hatching, cause of failure unknown

Unknown = unknown if failed or hatched.

Nest	Location	Adult Pair	Est. Initiation Date	Nest Fate	Fate Date (estimated)	No. Eggs	No. Chicks	No. Chicks Banded and Combination	No. Chicks Fledged	Protection Type	Notes
1	7	F=GA:AW M=U	18 Mar	Hatch	20 Apr	3	2	2 VV:RR	1	Seasonal exclosure fence	One egg abandoned post-term.
2	NOF	F=U M=PV:AY	19 Mar	Depredated avian	2 Apr	3	0			Seasonal exclosure fence	Two eggs depredated by avian predator. Remaining egg abandoned pre-term.
3	6	F=U M=U	2 Apr	Hatch	4 and 5 May	3	2	2 VV:OR		Seasonal exclosure fence	One egg abandoned post-term without cracks.
4	8		6 Apr	Depredated avian	21 Apr	3	0			Seasonal exclosure fence	
5	8		6 Apr	Depredated	(15 Apr)	2	0			Seasonal exclosure fence	
6	8	F=U M=U	6 Apr	Failed. Eggs removed by staff	24 May	3	0			Seasonal exclosure fence	Nest incubating for 47 days. Three eggs each with brown spot on shell collected for analysis. Eggs determined to be nonviable. Abandoned egg from SP31 placed in nest, incubated, and hatched.
7	7	F=U M=U	4 Apr	Hatch	8 and 9 May	3	2	2 BB:BG	2	Seasonal exclosure fence	One egg with brown spot on shell collected for analysis. Egg determined to be nonviable.
8	6	F=U M=U	6 Apr	Hatch	13 May	3	1	1 BB:OY		Seasonal exclosure fence	One egg with brown spot on shell collected for analysis and determined to be nonviable. One egg abandoned post-term.
9	8	M=AW:WO	1 Apr	Hatch	3 May	3	2	2 PV:PB		Seasonal exclosure fence	One egg missing pre-term

Appendix B. Snowy Plover nests at ODSVRA in 2008 (continued).

Nest	Location	Adult Pair	Est. Initiation Date	Nest Fate	Fate Date (estimated)	No. Eggs	No. Chicks	No. Chicks Banded and Combination	No. Chicks Fledged	Protection Type	Notes
10	8	F=UM=U?	4 Apr	Failed. Eggs removed by staff	12 May	3	0			Seasonal exclosure fence	One egg missing pre-term. Initiation date calculated from egg float measurement. Nest active for 39 days. Two eggs with brown spot on shell collected for analysis. Eggs determined to be nonviable.
11	8	F=U	4 Apr	Abandoned pre-term	7 May	3	0			Seasonal exclosure fence	Nest abandoned pre-term; all eggs with cracks, one with audible peeps. Wind was recorded over 30 mph prior to abandonment, but eggs were well exposed on the surface and not buried.
12	SOF	F=U	4 Apr	Depredated avian	17 Apr	3	0			Single nest exclosure and symbolic fence.	Two eggs depredated. Remaining egg abandoned pre-term.
13	SOF	F=U M=U	10 Apr	Unknown	(15 May)	3	0			Single nest exclosure and symbolic fence.	One egg with brown spot on shell collected for analysis. Egg determined to be nonviable. Winds were 20-30 mph prior to failure of this nest.
14	NOF	F=U	6 Apr	Abandoned pre-term	15 Apr	3	0			Seasonal exclosure fence	All eggs found buried.
15	7	F=U M=PV:GB	12 Apr	Abandoned pre-term	(14 Apr)	1	0			Seasonal exclosure fence	Likely failed due to wind. This was a newly initiated nest during a period when winds over 40 mph were recorded.
16	7	F=U	13 Apr	Abandoned pre-term	7 May	3	0			Seasonal exclosure fence	Nest abandoned pre-term; two eggs on surface and one egg 40% buried
17	6	F=PV:WW M=GG:VY	13 Apr	Hatch	18 May	2	1	1 VV:OB		Seasonal exclosure fence. Nest 36 feet from fence separating exclosure and open riding area. Temporary fencing added (soon after nest was found) in open riding area to provide a 75 foot radius buffer from nest.	One egg abandoned post-term.
18	8		16 Apr	Abandoned pre-term	17 Apr	1	0			Seasonal exclosure fence	This was a newly initiated nest after a windy period when wind speeds over 40 mph were recorded.
19	7	F=U M=PV:GB	16 Apr	Hatch	21 May	3	3	3 VV:OW		Seasonal exclosure fence	

Appendix B. Snowy Plover nests at ODSVRA in 2008 (continued).

Nest	Location	Adult Pair	Est. Initiation Date	Nest Fate	Fate Date (estimated)	No. Eggs	No. Chicks	No. Chicks Banded and Combination	No. Chicks Fledged	Protection Type	Notes
20	NOF		17 Apr	Abandoned pre-term	18 Apr	1	0			Seasonal exclosure fence	Possibly failed due to wind: this was a newly initiated nest after a windy period when wind speeds over 40 mph were recorded.
21	SOF	F=UM=U	16 Apr	Depredated avian	(12 May)	2	0			Single nest exclosure and symbolic fence.	Eggs depredated by unknown avian predator.
22	7		18 Apr	Abandoned pre-term	(26 Apr)	3	0			Seasonal exclosure fence	
23	7	F=U M=WN:WB	18 Apr	Hatch	21 May	3	3	3 BB:GW	3	Seasonal exclosure fence	
24	6	M=BB:GG	17 Apr	Hatch	20 May	3	3	3 VV:RB	2	Seasonal exclosure fence	
25	7	F=U M=GG:AB	16 Apr	Hatch	16 May	3	1	1 RR:VW	1	Seasonal exclosure fence	One egg missing pre-term. One egg abandoned post-term.
26	8	M=PV:GY	13 Apr	Hatch	15 May	3	2	2 PV:YY	2	Seasonal exclosure fence	One egg abandoned post-term.
27	6	F=GG:BB M=U	15 Apr	Hatch	16 May	3	1	1 BB:VB	1	Seasonal exclosure fence	Two eggs abandoned post-term.
28	6	F=PG:VB M=U	23 Apr	Depredated	30 Apr	3	0			Seasonal exclosure fence	Suspected avian depredation.
29	6	F=U	13 Apr	Abandoned pre-term	10 May	2	0			Seasonal exclosure fence	Two eggs abandoned pre-term; one buried 30%, second buried 80%.
30	6	M=GG:BY	23 Apr	Hatch	25 May	3	3	3 VV:WY		Seasonal exclosure fence	
31	6	F=U M=RR:VB	21 Apr	Hatch	24 May	3	2	2 BB:VR		Seasonal exclosure fence	One egg abandoned post-term.
32	8	F=U M=U	24 Apr	Abandoned pre-term	8 May	3	0			Single nest exclosure	Three eggs abandoned pre-term; all eggs found buried.
33	NOF	F=NW:AW M=PG:WG	24 Apr	Hatch	26 May	3	1	1 VV:AR		Single nest exclosure	One egg missing pre-term.
34	SOF	F=U	24 Apr	Depredated	9 May	2	0			Single nest exclosure and symbolic fence.	Suspected avian depredation.
35	SOF	F=U M=U	23 Apr	Hatch	25 May	3	3	3 VV:WB	1	Single nest exclosure and symbolic fence.	
36	SOF	F=U M=PV:BR	23 Apr	Hatch	24 May	3	3	3 RR:VR		Single nest exclosure and symbolic fence.	
37	7	F=VV:VW M=GA:VB	26 Apr	Hatch	28 May	3	3	3 VV:VG	2	Single nest exclosure	
38	6	F=RR:VG	23 Apr	Failed, cause unknown	(16 May)	3	0			Seasonal exclosure fence	Two eggs missing pre-term. Remaining egg abandoned pre-term.

Appendix B. Snowy Plover nests at ODSVRA in 2008 (continued).

Nest	Location	Adult Pair	Est. Initiation Date	Nest Fate	Fate Date (estimated)	No. Eggs	No. Chicks	No. Chicks Banded and Combination	No. Chicks Fledged	Protection Type	Notes
39	6	F=U M=U	29 Apr	Hatch	1 Jun	3	3	3 PV:VB	2	Seasonal exclosure fence. A 10 foot by 10 foot exclosure provided due to proximity of large gull roost.	
40	7	F=U? M=RR:BR (LLT)	27 Apr	Hatch	31 May	3	3	3 PV:OR	3	Seasonal exclosure fence	
41	8	F=GG:BR M=U	27 Apr	Hatch	28 May	3	1	1 RW:GR		Seasonal exclosure fence	Two eggs abandoned post-term.
42	8		27 Apr	Depredated avian	(16 May)	3	0			Seasonal exclosure fence	Three eggs depredated by unknown avian predator.
43	7	F=U M=U	25 Apr	Hatch	26 May	3	2	2 RR:PG	2	Seasonal exclosure fence	One egg missing pre-term.
44	8		19 Apr	Abandoned pre-term	7 May	3	0			Single nest exclosure	Eggs abandoned pre-term; all eggs found buried.
45	7	F=PV:(W?)B M=U	25 Apr	Hatch	26 May	3	2	2 VV:AO	1	Seasonal exclosure fence	One egg abandoned post-term.
46	6	F=U M=PV:AY	24 Apr	Hatch	25 and 26 May	3	3	3 VV:YW		Seasonal exclosure fence	
47	8	F=U M=U	1 May	Hatch	3 Jun	3	1	1 PG:OG	1	Seasonal exclosure fence	One egg abandoned post-term with cracks and audible taps. Same bicolored with small brown spot on shell.
48	7	F=U M=U	27 Apr	Hatch	28 May	3	3	2 VV:OO 1 unbanded	1	Seasonal exclosure fence	Unbanded chick not seen subsequent to hatch.
49	8	F=U M=U	9 May	Hatch	9 Jun	3	3	2 GG:WR 1 unbanded	1	Seasonal exclosure fence	Third egg likely hatched but never seen (and not banded).
50	7	F=PV:AB M=U	5 May	Hatch	5 Jun	3	3	3 VV:GB	3	Seasonal exclosure fence	
51	6	F=U M=U	6 May	Hatch	6 Jun	3	3	3 PV:BA	1	Seasonal exclosure fence	
52	6	F=PG:VB M=U	8 May	Hatch	8 Jun	3	3	3 GG:OW	2	Seasonal exclosure fence	
53	6	F=U M=U	8 May	Hatch	8 Jun	3	3	3 GG:RB	2	Seasonal exclosure fence	
54	Pismo Lagoon	F=U	30 Apr	Depredated Crow	16 May	3	0			Single nest exclosure and symbolic fence.	Eggs depredated by crow.
55	6	M=GA:R	12 May	Hatch	12 Jun	3	3	3 VV:GW	3	Seasonal exclosure fence	
56	7	M=PG:WW	29 Apr	Hatch	(30 May)	2	2	2 PV:YG	2	Seasonal exclosure fence	

Appendix B. Snowy Plover nests at ODSVRA in 2008 (continued).

Nest	Location	Adult Pair	Est. Initiation Date	Nest Fate	Fate Date (estimated)	No. Eggs	No. Chicks	No. Chicks Banded and Combination	No. Chicks Fledged	Protection Type	Notes
57	8		13 May	Depredated avian	28 May	3	0			Seasonal exclosure fence	Eggs depredated by unknown avian predator.
58	7	F=U M=BB:RG	11 May	Hatch	11 Jun	3	3	3 GG:VR	3	Seasonal exclosure fence	
59	6	F=U M=U	14 May	Hatch	14 Jun	3	3	3 VV:BG	3	Seasonal exclosure fence	
60	BY	F=NY:OG M=U	17 May	Hatch	17 Jun	3	3	3 VG:GY	1	Seasonal exclosure fence	On 17 July, one chick found dead at south end of NOF. Last seen alive at 27 days old. Carcass intact and decomposing.
61	SOF	F=U	18 May	Failed, cause unknown	8 Jun	3	0			Single nest exclosure and symbolic fence.	
62	8	F=UM=U	1 May	Hatch	1 Jun	3	3	3 PG:YB	2	Seasonal exclosure fence	On 28 June, three 27 day old chicks were seen and one of these chicks was limping. Likely this same chick was found dead 30 June. Legs and feet of carcass had no breaks, swelling or discoloration.
63	6	F=U M=U	13 May	Hatch	13 Jun	3	3	3 GG:RR	1	Seasonal exclosure fence	
64	BY	F=U M=RR:OW (ULT)	25 Apr	Hatch	26 May	2	2	2 VV:BW		Seasonal exclosure fence	
65	6	F=U M=BB:--	3 May	Hatch	3 Jun	3	3	3 PV:VY	3	Seasonal exclosure fence	
66	6	F=U M=BB:BY	14 May	Hatch	16 Jun	3	2	2 VG:OB	2	Seasonal exclosure fence	One egg abandoned post-term.
67	8	F=U M=U	14 May	Hatch	14 Jun	3	3	3 VG:VR	2	Single nest exclosure	
68	8	F=U M=U	22 May	Hatch	24 Jun	3	1	1 GA:YY		Seasonal exclosure fence	Two eggs abandoned post-term.
69	8	F=U? M=U	18 May	Hatch	18 Jun	3	2	2 VV:GG	2	Seasonal exclosure fence	One egg abandoned post-term.
70	7	F=U M=PY:GO	23 May	Hatch	23 Jun	3	2	2 VG:PY	2	Seasonal exclosure fence	One egg abandoned post-term.
71	6		20 May	Depredated gull	30 May	3	0			Seasonal exclosure fence	Two eggs depredated by gull prior to gull being flushed from nest. Remaining egg abandoned pre-term (and not seen incubated after egg depredation at nest by gull).

Appendix B. Snowy Plover nests at ODSVRA in 2008 (continued).

Nest	Location	Adult Pair	Est. Initiation Date	Nest Fate	Fate Date (estimated)	No. Eggs	No. Chicks	No. Chicks Banded and Combination	No. Chicks Fledged	Protection Type	Notes
72	BY	F=U	24 May	Depredated avian	9 Jun	3	0			Seasonal exclosure fence	Two eggs depredated by unknown avian predator. Remaining egg abandoned pre-term.
73	6	F=RR:VG M=U	20 May	Hatch	20 Jun	3	3	3 VV:OG	2	Seasonal exclosure fence	
74	7	F=U M=U	19 May	Hatch	19 Jun	3	3	3 GG:PG	1	Single nest exclosure	
75	7		27 May	Depredated avian	12 Jun	3	0			Seasonal exclosure fence	Two eggs depredated by unknown predator. Remaining egg abandoned post-term.
76	BY		25 May	Depredated avian	(15 Jun)	3	0			Seasonal exclosure fence	Eggs depredated by unknown avian predator.
77	BY		25 May	Depredated	(2 Jun)	3	0			Seasonal exclosure fence	Two eggs depredated by unknown predator. Remaining egg abandoned pre-term and found 50% buried.
78	6	F=GG:BBM=VG:VB	26 May	Hatch	26 Jun	3	3	2 GA GB1 unbanded		Single nest exclosure	Late hatching chick not banded. Unbanded chick and a banded chick seen on a daily basis. Likely banded chick of this brood seen eaten by California gull on 23 July when 27 days old. Banded attending adult subsequently observed carefully, but there was no evidence of a banded chick.
79	NOF	F=U M=U	31 May	Hatch	2 Jul	3	3	3 VG:PR		Single nest exclosure	A barrier of surf-cast kelp and burlap put on west side of single nest exclosure successfully kept nest from being overwashed. In absence of barrier, nest would have failed due to high tides.
80	8	F=BB:RG M=GG:WG	28 May	Hatch	28 Jun	3	3	3 GA:RW	1	Seasonal exclosure fence	On 29 September, juvenile observed alive at 10:15 a.m. and found dead at 10:55 a.m. partially flattened in fresh tire tracks. Necropsy results noted comminuted fractures of the skull and breast plate, hemorrhage of associated tissues and hearniation of abdominal viscera. These conditions are consistent with vehicle strike.

Appendix B. Snowy Plover nests at ODSVRA in 2008 (continued).

Nest	Location	Adult Pair	Est. Initiation Date	Nest Fate	Fate Date (estimated)	No. Eggs	No. Chicks	No. Chicks Banded and Combination	No. Chicks Fledged	Protection Type	Notes
81	8	F=U M=AW:WO	31 May	Hatch	2 Jul	3	3	3 GA:VR	1	Seasonal exclosure fence	
82	7		29 May	Abandoned pre-term	(31 May)	2	0			Seasonal exclosure fence	Eggs abandoned pre-term and found buried.
83	7	F=RR:BY (ULT) M=U	26 May	Hatch	26 Jun	3	3	3 GG:YB	2	Seasonal exclosure fence	
84	8		2 Jun	Depredated northern harrier	10 Jun	2	0			Seasonal exclosure fence	Eggs depredated by northern harrier.
85	SOF	F=U M=PV:WG	1 Jun	Hatch	2 Jul	3	3	3 PV:BG		Single nest exclosure and symbolic fence. A 10 foot by 10 foot exclosure with a net top provided due to increased depredations in SOF.	
86	SOF	F=U M=U	9 May	Hatch	9 Jun	3	3	3 GG:WB		Symbolic fence	
87	7	F=U M=U	28 May	Hatch	28 Jun	3	3	3 PG:GG		Seasonal exclosure fence	
88	6	F=U M=GG:VY	31 May	Hatch	1 Jul	3	3	3 PG:VW		Seasonal exclosure fence	
89	6	F=U M=U	24 May	Hatch	24 and 25 Jun	3	3	3 VG:PB		Seasonal exclosure fence	
90	SOF	F=RR:VYM=U	5 Jun	Depredated	(27 Jun)	2	0			Single nest exclosure and symbolic fence.	Eggs depredated by unknown predator.
91	6	F=U M=U	2 Jun	Hatch	3 Jul	3	3	3 GA:OG		Seasonal exclosure fence	
92	7	F=U M=U	1 Jun	Hatch	2 Jul	3	3	3 GA:PB		Seasonal exclosure fence	
93	7	F=U M=VV:VR	29 May	Hatch	29 and 30 Jun	3	3	3 VG:VY	2	Seasonal exclosure fence	
94	8		25 May	Depredated avian	15 Jun	3	0			Seasonal exclosure fence	Eggs depredated by unknown avian predator.
95	7	F=U M=U	9 Jun	Hatch	10 Jul	3	3	3 PV:OG		Seasonal exclosure fence	
96	7	F=U M=U	7 Jun	Hatch	8 Jul	3	3	3 GG:YW		Seasonal exclosure fence	
97	7	F=U M=PV:BB	4 Jun	Hatch	5 Jul	3	3	3 GA:VY		Seasonal exclosure fence	
98	8	F=U M=PV:PR	28 May	Hatch	28 Jun	3	2	2 VV:RY		Seasonal exclosure fence	One egg abandoned post-term.

Appendix B. Snowy Plover nests at ODSVRA in 2008 (continued).

Nest	Location	Adult Pair	Est. Initiation Date	Nest Fate	Fate Date (estimated)	No. Eggs	No. Chicks	No. Chicks Banded and Combination	No. Chicks Fledged	Protection Type	Notes
99	8		7 Jun	Depredated avian	3 Jul	3	0			Seasonal exclosure fence	Eggs depredated by unknown avian predator.
100	8	F=RR:GB M=PG:WG	7 Jun	Hatch	8 Jul	3	2	2 GA:PG		Seasonal exclosure fence	One egg abandoned post-term.
101	BY		30 May	Depredated avian	24 Jun	3	0			Seasonal exclosure fence	Three eggs depredated by unknown avian predator.
102	BY	F=Banded M=PV:BR	11 Jun	Hatch	12 Jul	3	3	1 GA:PY 2 unbanded		Single nest exclosure	On 10 July, all eggs with cracks. On 12 July, evidence of hatch found at nest. Tracks indicate adult led chicks west across open sand sheet toward shoreline. A set of owl tracks found at two different sites with clusters of brood scrapes. One chick seen subsequent and banded.
103	8	F=GA:G M=U	6 Jun	Hatch	7 Jul	3	2	2 GG:BG	1	Single nest exclosure. A 10 foot by 10 foot exclosure with a net top provided due to increased depredations in 8 exclosure.	One egg abandoned post-term.
104	6	F=U M=U	6 Jun	Hatch	7 Jul	3	3	3 GG:YR		Seasonal exclosure fence. Nest 10 feet from fence separating exclosure and open riding area. Temporary fencing added (soon after nest was found) in open riding area to provide a 75 foot radius buffer from nest.	
105	8	F=U M=U	12 Jun	Hatch	13 Jul	3	3	3 VV:OR		Seasonal exclosure fence	
106	SOF	F=U	13 Jun	Overwash by tide	22 Jun	2	0			Single nest exclosure and symbolic fence.	Eggs overwashed by tide.
107	8	F=VV:VW M=PV:AY	4 Jun	Hatch	4 and 5 Jul	2	2	2 PV:PG		Seasonal exclosure fence	
108	8	F=U M=U	13 Jun	Hatch	14 Jul	3	3	3 VV:RG	1	Seasonal exclosure fence. A 10 foot by 10 foot exclosure provided due proximity of large gull roost.	
109	SOF	F=PV:WB M=VV:OY	3 Jun	Hatch	6 Jul	3	3	2 PG:GB 1 unbanded		Single nest exclosure and symbolic fence. A 10 foot by 10 foot exclosure with a net top provided due to increased depredations in SOF.	Unbanded chick from third egg known to hatch but never seen.

Appendix B. Snowy Plover nests at ODSVRA in 2008 (continued).

Nest	Location	Adult Pair	Est. Initiation Date	Nest Fate	Fate Date (estimated)	No. Eggs	No. Chicks	No. Chicks Banded and Combination	No. Chicks Fledged	Protection Type	Notes
110	SOF	F=U M=PV:BR	12 Jun	Hatch	13 Jul	3	3	3 BB:OY	1	Single nest exclosure and symbolic fence. A 10 foot by 10 foot exclosure with a net top provided due to increased depredations in SOF.	
111	SOF	F=U	18 Jun	Depredated avian	28 Jun	3	0			Single nest exclosure and symbolic fence.	Eggs depredated by unknown avian predator.
112	7	F=PV:WW? M=PG:VY	18 Jun	Overwash by tide	21 Jun	2	0			None	Nest overwashed by tide.
113	8		4 Jun	Depredated avian	28 Jun	3	0			Seasonal exclosure fence	Eggs depredated by unknown avian predator.
114	7	F=PV:AB M=U	14 Jun	Hatch	15 Jul	3	3	3 PV:PB		Seasonal exclosure fence	
115	8	F=U	17 Jun	Depredated avian	(2 Jul)	3	0			Single nest exclosure	Eggs depredated by unknown avian predator.
116	8	F=U M=U	21 Jun	Hatch	22 Jul	3	3	3 BB:VR		Seasonal exclosure fence. A 10 foot by 10 foot exclosure with a net top provided due to increased depredations in 8 exclosure.	
117	6	F=U M=GG:AB	17 Jun	Hatch	18 and 19 Jul	3	3	3 PG:AG		Seasonal exclosure fence	One 19 July, three chicks banded at one time and appeared normal. Female later attempts to lead one chick from the nest down to the shoreline where male is attending the other two chicks. Third chick attempts to follow but can only move in tight circles.
118	8	F=Banded	22 Jun	Depredated	(1 Jul)	2	0			Seasonal exclosure fence	Eggs depredated; suspected avian depredation.
119	8	F=U	24 Jun	Depredated	1 Jul	2	0			Seasonal exclosure fence	Eggs depredated by avian predator.
120	NOF	F=NW:AW	20 Jun	Depredated skunk	6 Jul	3	0			Seasonal exclosure fence	Eggs depredated by skunk.
121	7	F=UM=WS:WB	22 Jun	Hatch	23 and 25 Jul	3	3	3 VV:AR	1	Seasonal exclosure fence	
122	BY		23 Jun	Depredated avian	20 Jul	3	0			Seasonal exclosure fence	Eggs depredated by avian predator.

Appendix B. Snowy Plover nests at ODSVRA in 2008 (continued).

Nest	Location	Adult Pair	Est. Initiation Date	Nest Fate	Fate Date (estimated)	No. Eggs	No. Chicks	No. Chicks Banded and Combination	No. Chicks Fledged	Protection Type	Notes
123	7	M=PG:VY	26 Jun	Hatch	25 and 26 Jul	3	3	3 VV:WY		Single nest exclosure. A 10 foot by 10 foot exclosure with a net top provided due to increased depredations near 7.5 revegetation area.	
124	8	F=U M=U	24 Jun	Depredated	(14 Jul)	3	0			Seasonal exclosure fence	Eggs depredated; suspected avian depredation.
125	8	F=U M=(PG:??)?	28 Jun	Depredated	(15 Jul)	2	0			Seasonal exclosure fence	Eggs depredated; suspected avian depredation.
126	NOF	M=RR:OW	30 Jun	Failed, cause unknown	1 Jul	1	0			Seasonal exclosure fence	
127	8	F=BB:VW M=PV:GY	2 Jul	Hatch	2 Aug	2	2	2 PG:WY		Single nest exclosure. A 10 foot by 10 foot exclosure with a net top provided due to increased depredations in 8 exclosure.	
128	6	F=U M=BB:--	30 Jun	Hatch	31 Jul	3	3	3 GA:GB		Seasonal exclosure fence	
129	7	F=U M=RR:BR (LLT)	1 Jul	Hatch	1 Aug	3	3	3 GA:YY	1	Seasonal exclosure fence	
130	8		6 Jul	Depredated	14 Jul	3	0			Seasonal exclosure fence	Eggs depredated; suspected avian depredation.
131	7	F=U M=U	9 Jul	Hatch	9 Aug	3	3	2 VV:LY 1 unbanded		Single nest exclosure. A 10 foot by 10 foot exclosure with a net top provided due to increased depredations near 7.5 revegetation area.	Unbanded chick from third egg known to hatch but never seen.
132	8	F=U M=PV:AG	26 Jun	Hatch	27 Jul	3	2	2 VV:OW	1	Seasonal exclosure fence. A 10 foot by 10 foot exclosure with a net top provided due to increased depredations in 8 exclosure.	On 5 August, two chicks brooded by adult, one dead and one alive foraging actively. Both chicks seen alive 3 August at 7 days old. Chick collected for necropsy. Cause of death undetermined.
133	SOF	F=U	5 Jul	Abandoned pre-term	(15 Jul)	2	0			Single nest exclosure and symbolic fence. A 10 foot by 10 foot exclosure with a net top provided due to increased depredations in SOF.	Eggs abandoned pre-term and found on surface.
134	7		4 Jul	Depredated avian	(15 Jul)	3	0			Seasonal exclosure fence	

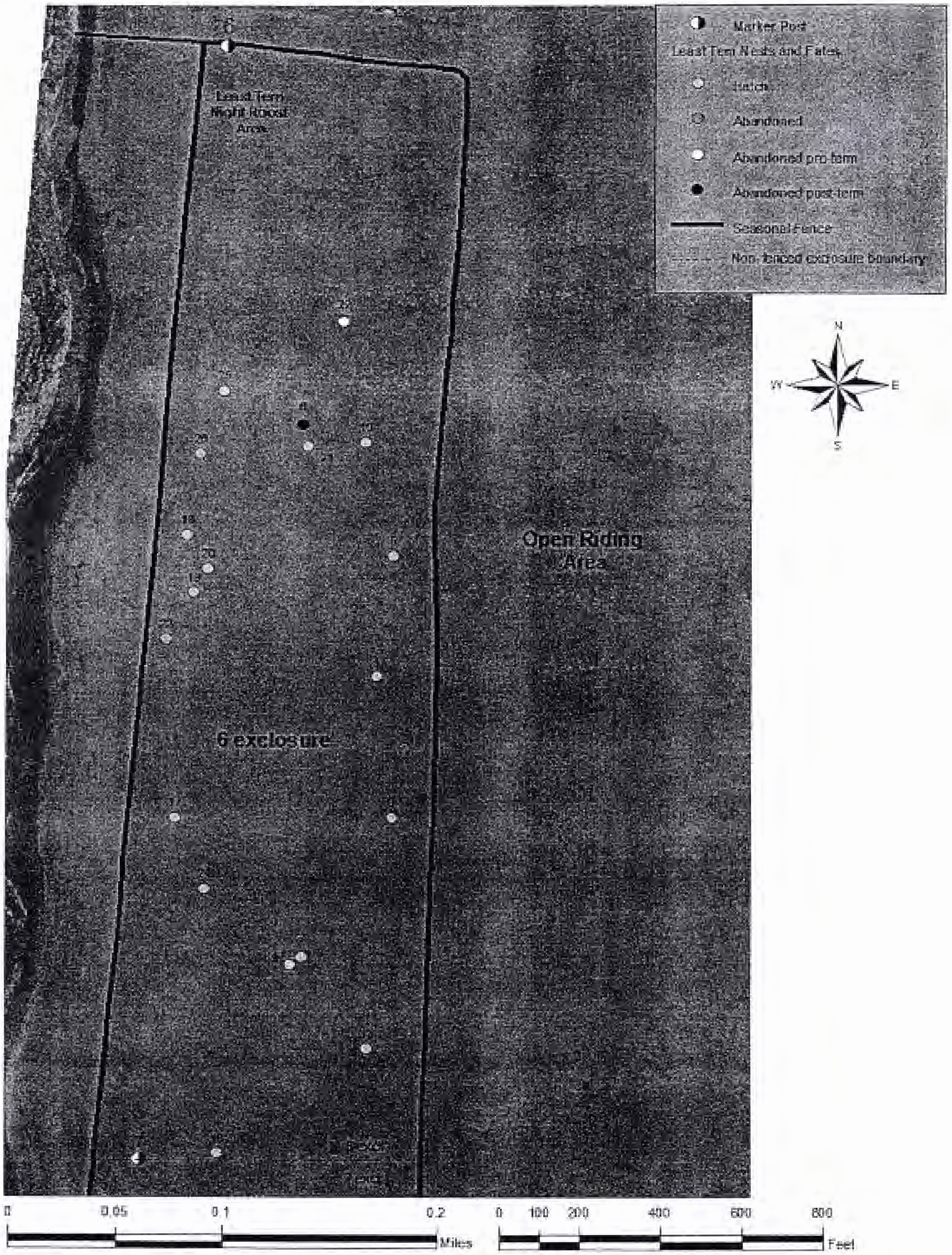
Appendix B. Snowy Plover nests at ODSVRA in 2008 (continued).

Nest	Location	Adult Pair	Est. Initiation Date	Nest Fate	Fate Date (estimated)	No. Eggs	No. Chicks	No. Chicks Banded and Combination	No. Chicks Fledged	Protection Type	Notes
135	6	M=U	28 Jun	Hatch	29 Jul	3	3	3 PG:BG	2	Seasonal exclosure fence	
136	6	F=U M=PG:WW	26 Jun	Failed, nonviable eggs, abandoned viable egg added (see Notes)	11 Aug	2	0			Seasonal exclosure fence	Initiation date calculated from egg float measurement. Nest active for 47 days. Eggs determined to be nonviable. Abandoned egg from SP140 placed in nest and is incubated and hatches.
137	6	F=U M=U	23 Jun	Hatch	24 Jul	3	3	3 RR:VR	1	Seasonal exclosure fence	
138	7	F=U	26 Jun	Hatch	27 Jul	3	3	1 PG:LY 1 VV:OB 1 VV:OR		Seasonal exclosure fence	On 27 July, nest observed for several hours with no adult activity in the area. Two chicks and one egg were removed to Coal Oil Point Reserve. The remaining egg hatched. All chicks fledged and were released at Coil Oil Point Reserve.
139	6	M=U	29 Jun	Hatch	30 and 31 Jul	3	3	3 VV:BW	2	Seasonal exclosure fence	
140	6	F=U M=U	10 Jul	Hatch	10 and 11 Aug	3	2	2 RR:LY		Seasonal exclosure fence	One egg abandoned post-term.
141	8	F=U	10 Jul	Unknown	9 Aug	3	0			Seasonal exclosure fence. A 10 foot by 10 foot exclosure with a net top provided due to increased depredations in 8 exclosure.	Tracks seen near nest, but no evidence of chicks.
142	6	F=U M=U	2 Jul	Hatch	2 Aug	2	2	2 VG:PR		Seasonal exclosure fence	
143	6	F=U M=BB:GG	21 Jun	Hatch	22 Jul	3	2	2 unbanded		Seasonal exclosure fence	Two chicks not seen subsequent to hatch.
144	SOF	F=U	6 Jul	Abandoned pre-term	23 Jul	3	0			Single nest exclosure and symbolic fence. A 10 foot by 10 foot exclosure with a net top provided due to increased depredations in SOF.	Three eggs abandoned pre-term; eggs found 60% buried.
145	6	F=U M=U	3 Jul	Hatch	3 and 4 Aug	3	3	3 BB:LY	1	Seasonal exclosure fence	On 20 September, juvenile found dead. Maggots present in carcass. No visible wounds on carcass. One juvenile last observed on 3 September at 31 days old.
146	6	F=U M=PV:GB	16 Jun	Hatch	16 Jul	3	3	3 PV:VR		Seasonal exclosure fence	

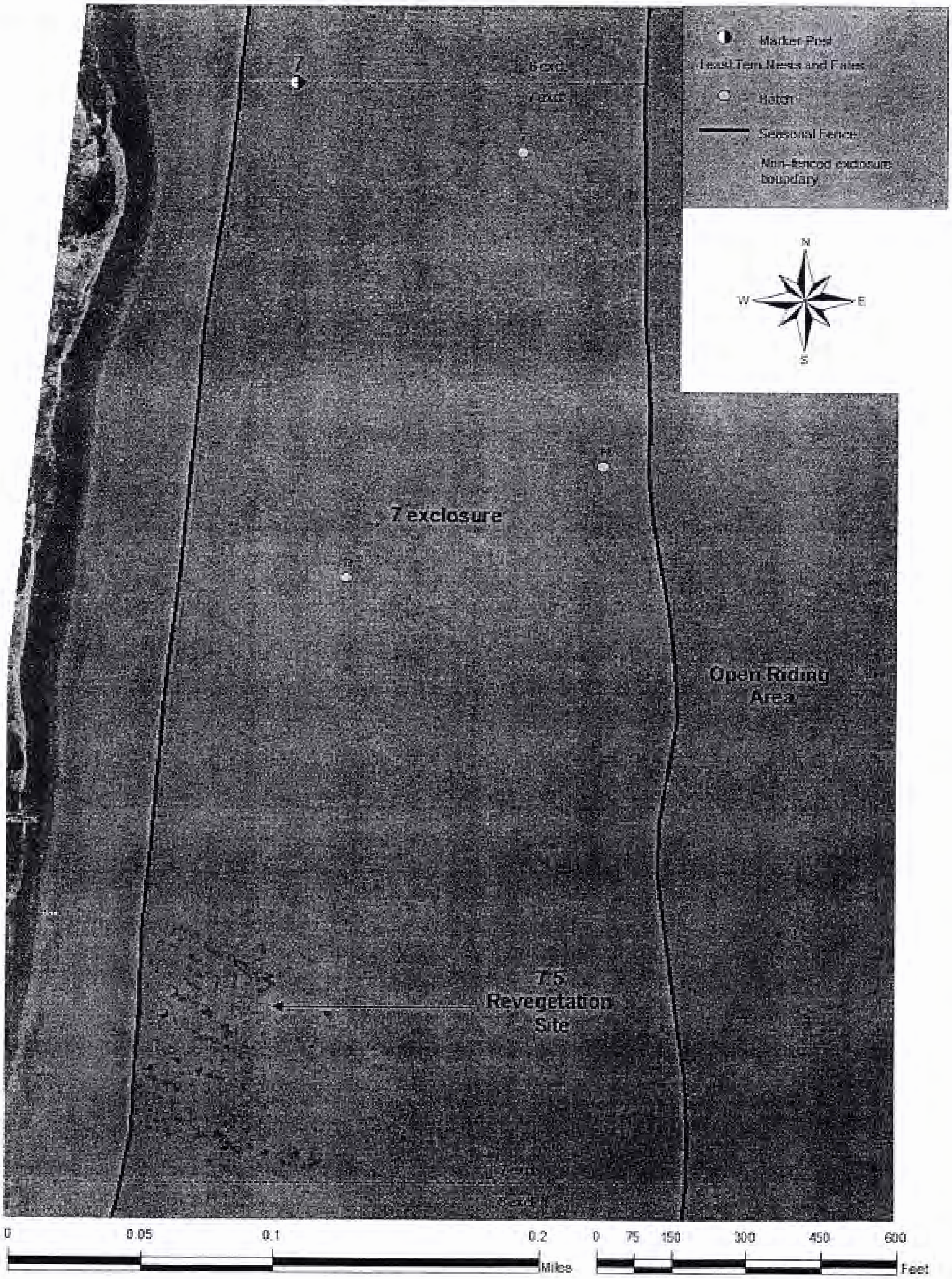
Appendix B. Snowy Plover nests at ODSVRA in 2008 (continued).

Nest	Location	Adult Pair	Est. Initiation Date	Nest Fate	Fate Date (estimated)	No. Eggs	No. Chicks	No. Chicks Banded and Combination	No. Chicks Fledged	Protection Type	Notes
147	6	F=U	24 Jun	Depredated gull	11 Jul	1	0			Seasonal exclosure fence	Minimum of 1 egg in clutch. Nest depredated by gull.
148	6	M=RP:WR	13 Jul	Hatch	13 and 14 Aug	3	3	3 PV:LY		Seasonal exclosure fence	
149	6	M=GA:YB (URT)	7 Jul	Hatch	7 Aug	2	2	2 VG:LY		Seasonal exclosure fence	Minimum of 2 eggs in clutch.
150	Unknown	M=BB:RW	22 Jul	Hatch	(22 Aug)	2	2	2 GG:LY		Unknown	Minimum of 2 eggs in clutch. First seen on 6 exclosure shoreline at 1 day old or younger.

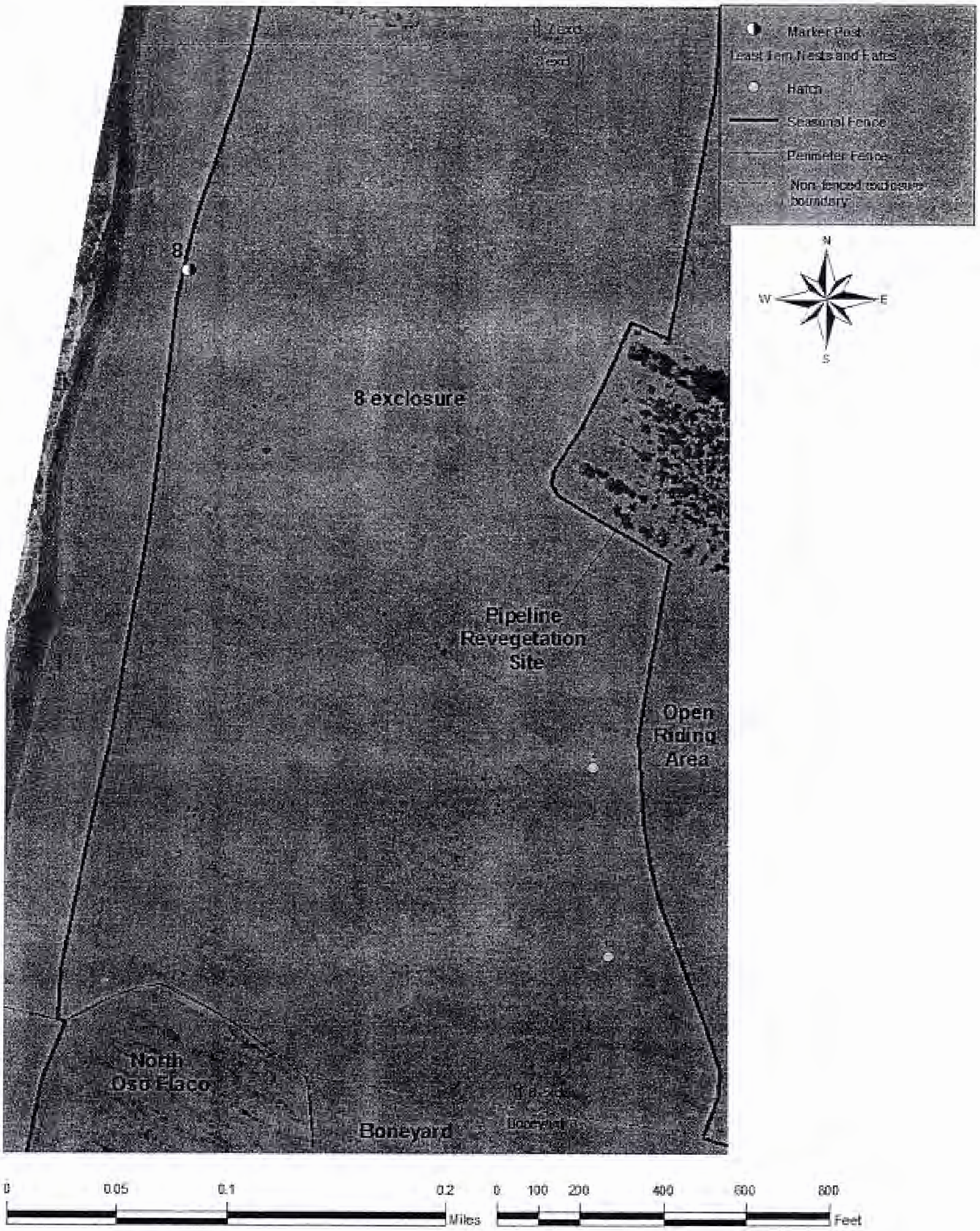
Appendix C. California least tern nest locations at ODSVRA in 2009 (6 exclosure).



Appendix C. California least tern nest locations at ODSVRA in 2009 (7 exclosure).

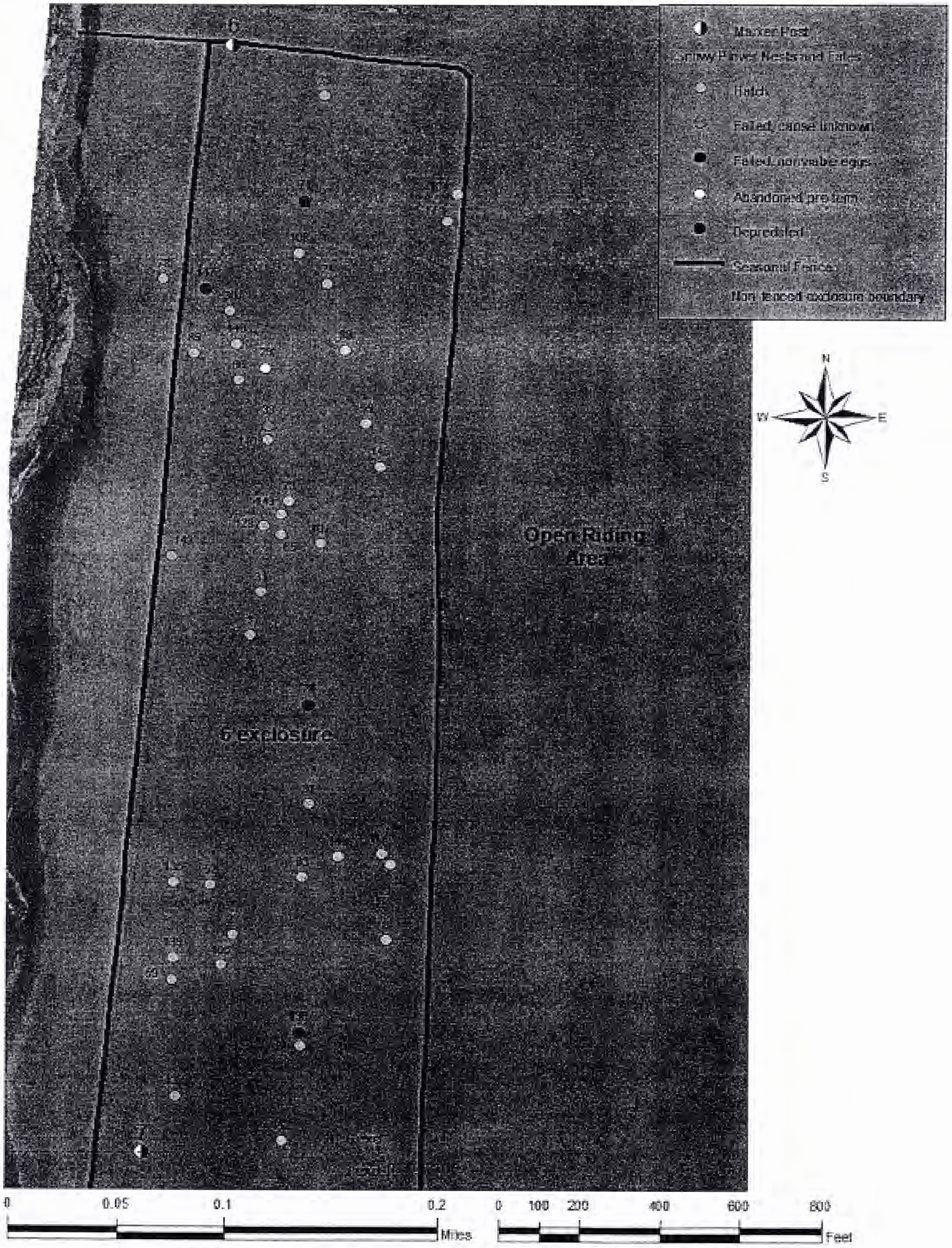


Appendix C. California least tern nest locations at ODSVRA in 2009 (8 exclosure).

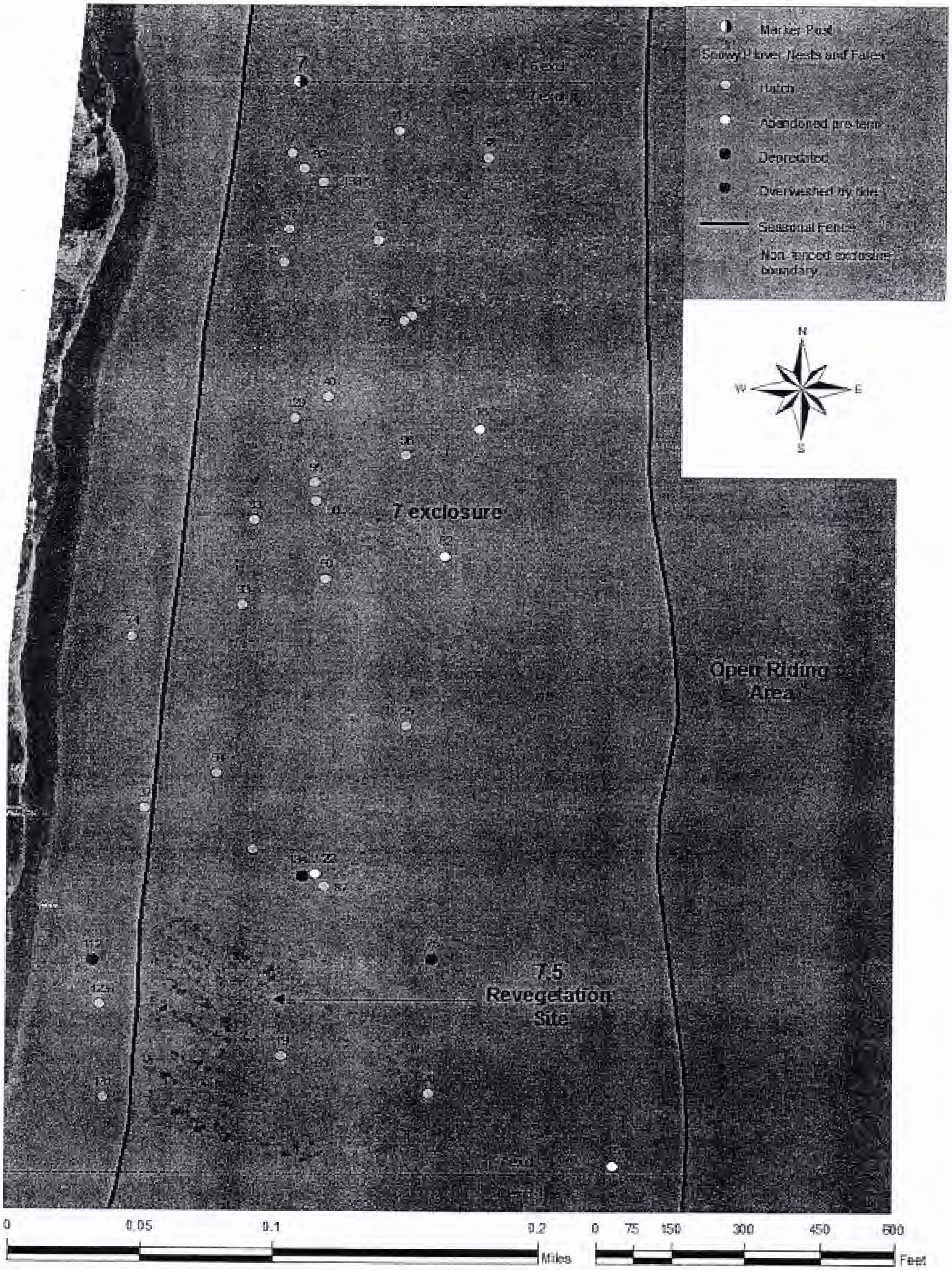


Appendix C. California least tern nest locations at ODSVRA in 2009 (Boneyard exclosure).

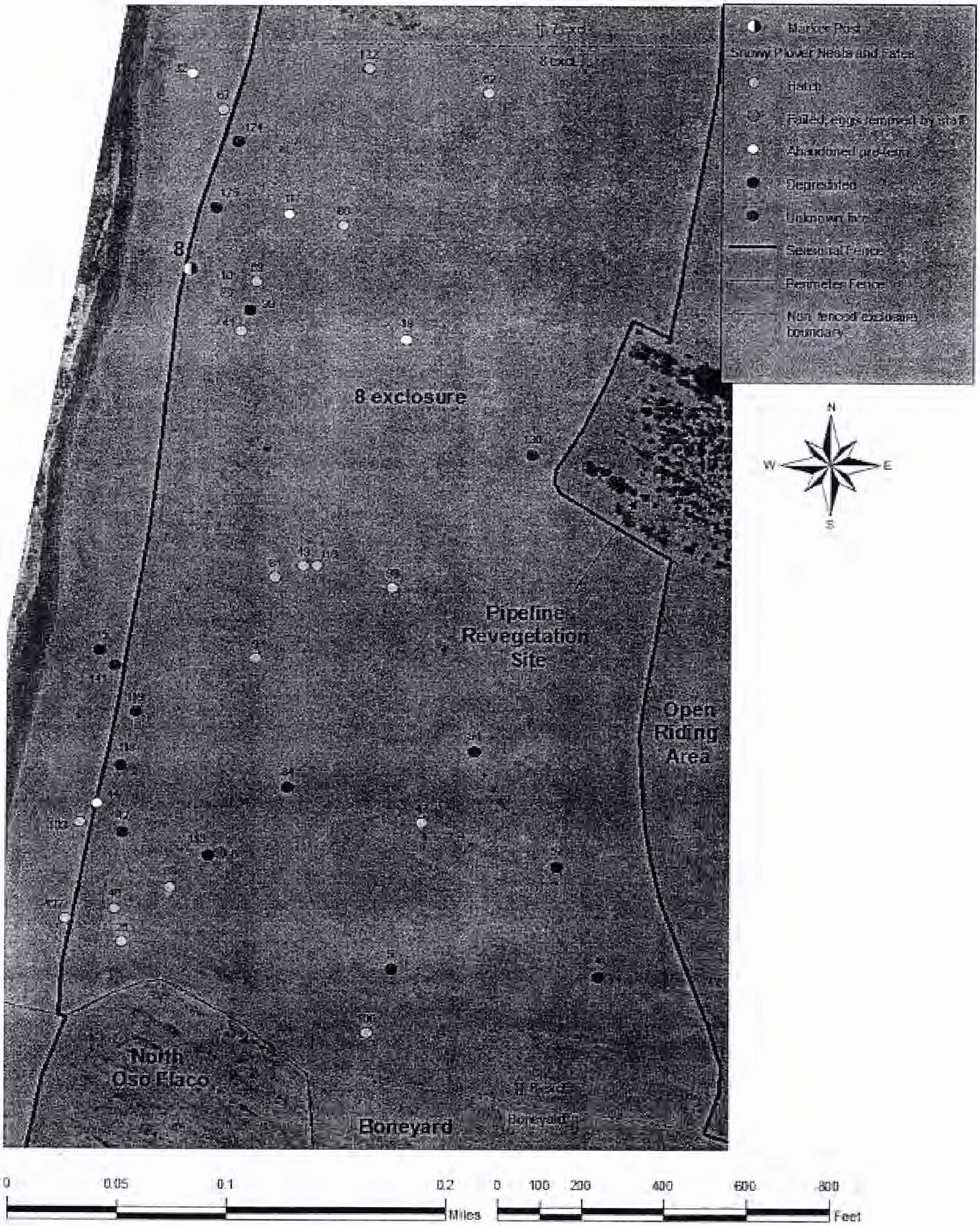
Appendix D. Snowy plover nest locations at ODSVRA in 2009 (6 exclosure).



Appendix D. Snowy plover nest locations at ODSVRA in 2009 (7 exclosure).

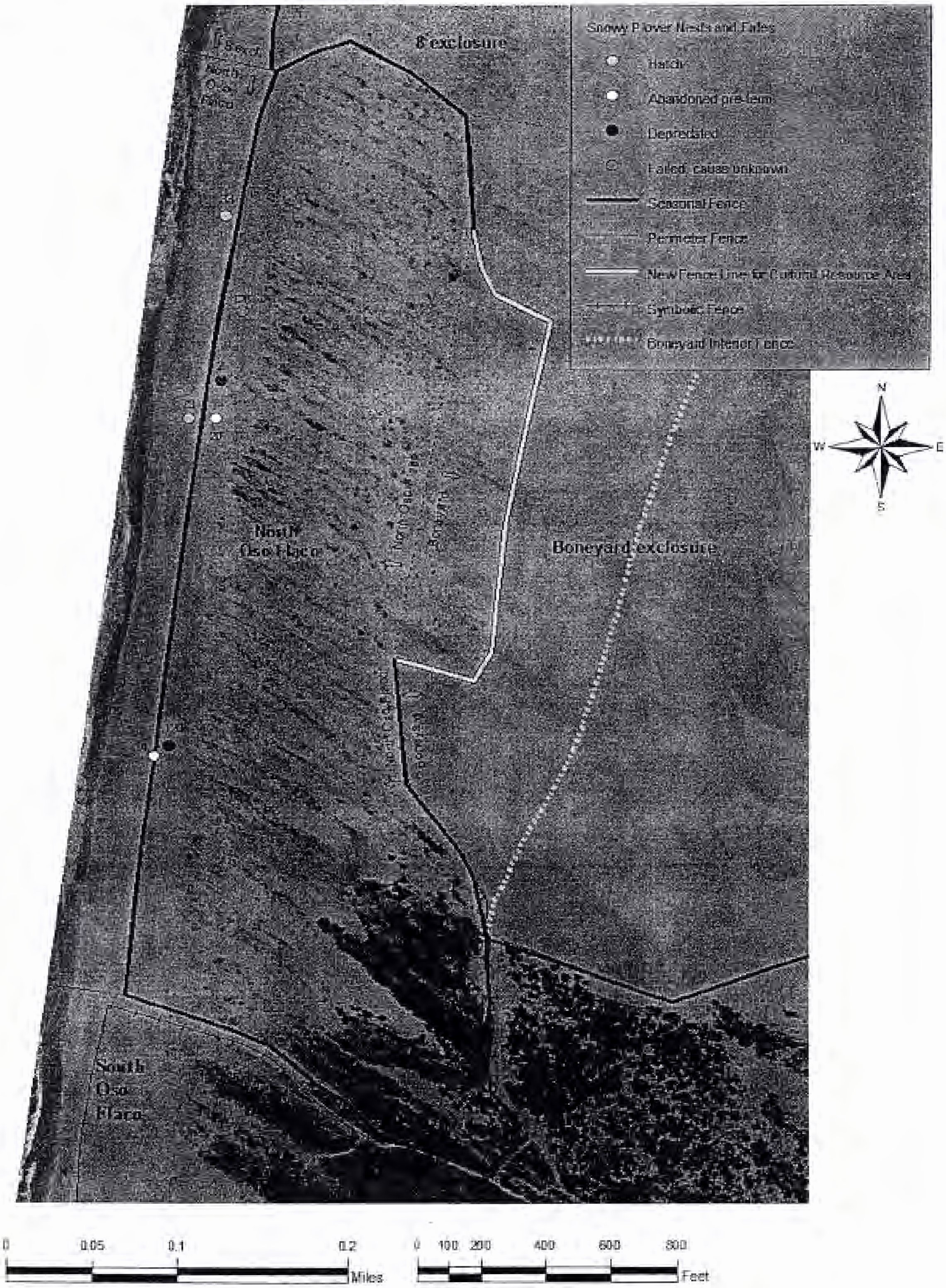


Appendix D. Snowy plover nest locations at ODSVRA in 2009 (8 exclosure).

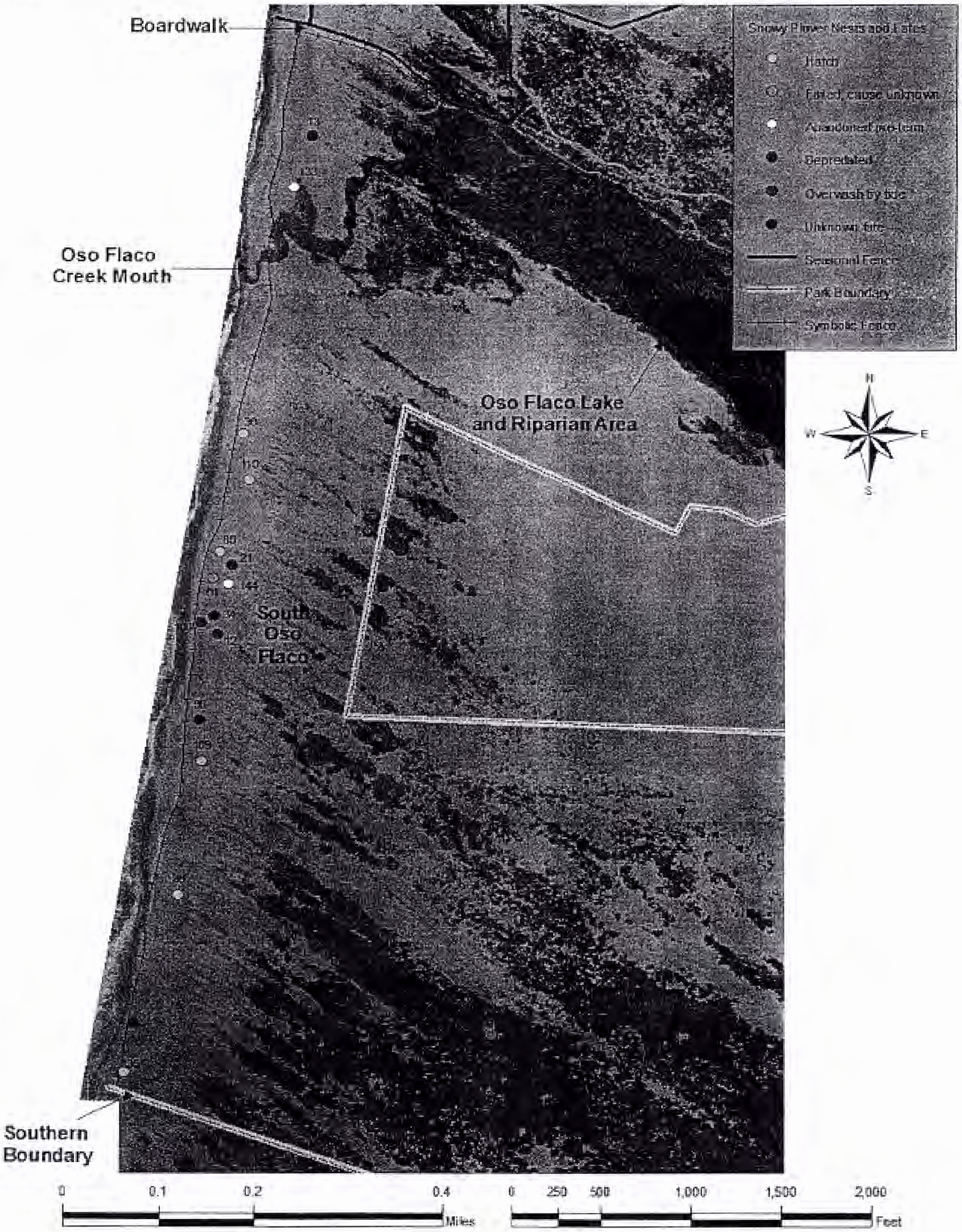


Appendix D. Snowy plover nest locations at ODSVRA in 2009 (Boneyard exclosure).

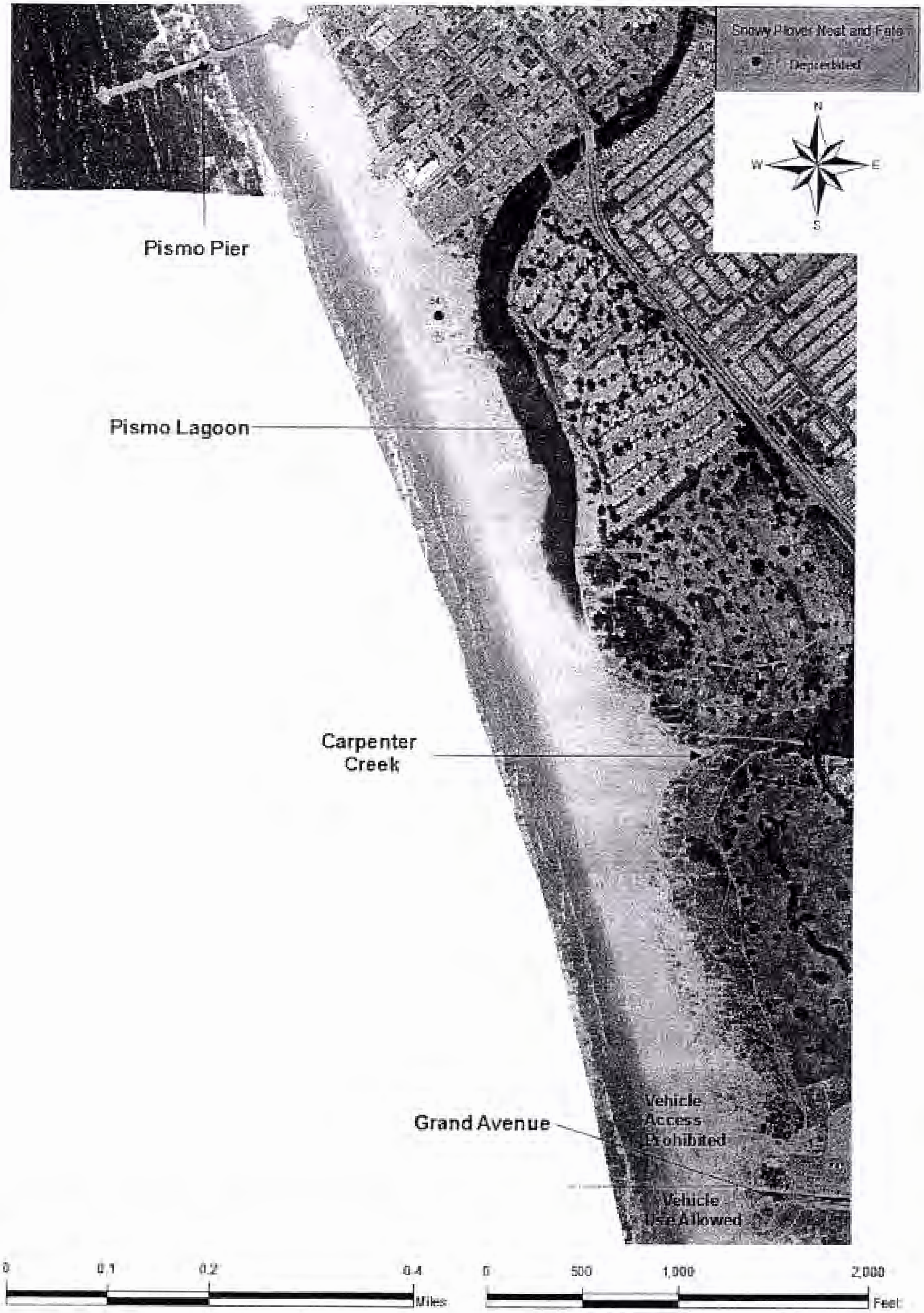
Appendix D. Snowy plover nest locations at ODSVRA in 2009 (North Oso Flaco exclosure).



Appendix D. Snowy plover nest locations at ODSVRA in 2009 (South Oso Flaco exclosure).



Appendix D. Snowy plover nest locations at ODSVRA in 2009 (North of Grand Avenue).
Only a single nest is located north of Grand Avenue.



Appendix E. Banded snowy plovers with known origins seen at ODSVRA 18 February to 30 September 2009.

Juveniles fledged from ODSVRA in 2009 are not included. All birds were banded as chicks unless otherwise noted.

The ULT, LLT, URT notation denotes chicks banded at ODSVRA from 2002 to 2004. Chicks were banded to brood during this time in a way to create combinations unique to each individual. This was done by alternating the leg (left or right) that received the federal band, as well as the location (upper or lower) on this band that remained exposed when color tape was applied:

upper left (ULT) = federal band on left leg, with color tape applied to federal band leaving upper one-third exposed metal.
upper right (URT) = federal band on right leg, with color tape applied to federal band leaving upper one-third exposed metal.
lower left (LLT) = federal band on left leg, with color tape applied to federal band leaving lower one-third exposed metal.

Due to viewing conditions, the federal exposed portion was not always discernible, raising the possibility that two or more different birds were being recognized as the same band combination; in these cases, a note is made in the band combinations below.

ODSVRA=Oceano Dunes SVRA, Guadalupe NWR=Guadalupe-Nipomo Dunes National Wildlife Refuge, VAFB=Vandenberg Air Force Base, SB=State Beach, SP = Salt Ponds, NWR = National Wildlife Refuge

Band	Origin and Year Banded	County Banded	Dates Seen	Notes
AO:WY	Salinas SB 2006	Monterey	2/22, 2/23, 2/25, 3/1, 3/2	
AP:YP	Salinas SB 2009	Monterey	9/4, 9/5, 9/10	
AW:AO	Salinas SB 2007	Monterey	3/26	
AW:WO	Pajaro Spit 2003	Santa Cruz - Monterey border	3/11, 3/21, 4/18, 4/20, 4/21, 4/24, 5/2, 5/4, 5/6, 5/7, 5/10, 5/12, 5/17, 5/18, 5/23, 5/25, 5/26, 5/27, 6/1, 7/2, 7/3, 7/4, 7/6, 7/8, 7/10, 7/16, 7/17, 7/21, 8/1, 8/8, 8/9, 8/11, 8/12, 8/13, 8/14	ODSVRA breeding male.
AY:AW	Reservation Road 2009	Monterey	7/10, 8/20, 8/22, 8/27, 8/28, 8/30, 9/3, 9/6, 9/7, 9/8, 9/11, 9/21, 9/28	
AY:PP	Moss Landing SB 2009	Monterey	9/5, 9/12	
AY:YP	Salinas SB 2009	Monterey	8/21	
B/L/B:G	New River, Oregon 2009	Coos – Curry border	9/11	
BB:–	ODSVRA 2005		3/29, 4/7, 4/22, 4/24, 4/28, 4/29, 5/7, 5/12, 5/13, 5/14, 5/17, 5/22, 5/25, 5/28, 5/29, 6/3, 6/5, 6/10, 6/13, 6/14, 6/15, 6/19, 6/20, 6/22, 6/24, 6/25, 6/27, 7/2, 7/4, 7/8, 7/12, 7/20, 7/23, 8/1, 8/3, 8/6, 8/9	ODSVRA breeding male. Banded in 2005 as BB:WB.
BB:BW	ODSVRA 2006		6/5, 6/8, 7/11	
BB:BY	ODSVRA 2005		3/3, 3/12, 3/29, 4/8, 4/21, 4/24, 5/2, 5/14, 5/18, 5/19, 5/20, 5/22, 5/23, 6/1, 6/11, 6/18, 6/20, 6/22, 6/23, 6/24, 6/25, 6/27, 6/28, 7/2, 7/3, 7/4, 7/5, 7/8, 7/9, 7/10, 7/11, 7/14, 7/16, 7/18, 7/21, 7/22, 7/23, 7/24	ODSVRA breeding male.
BB:GG	ODSVRA 2007		3/3, 3/8, 3/21, 3/27, 3/30, 4/16, 4/18, 4/24, 5/3, 5/6, 5/7, 5/8, 5/9, 5/10, 5/17, 5/20, 5/22, 5/23, 5/24, 5/26, 5/28, 5/29, 5/31, 6/1, 6/2, 6/7, 6/8, 6/9, 6/10, 6/13, 6/19, 6/26, 7/1, 7/4, 7/9, 7/10, 7/12, 7/14, 7/17, 7/18, 7/23, 7/24, 7/25, 9/26	ODSVRA breeding male.
BB:GY	ODSVRA 2006		5/14	
BB:RG	ODSVRA 2007		2/26, 3/3, 3/8, 3/18, 3/21, 3/22, 3/27, 4/20, 4/24, 5/1, 5/2, 5/5, 5/7, 5/17, 5/20, 5/21, 5/23, 5/26, 5/27, 5/29, 5/30, 6/1, 6/3, 6/7, 6/12, 6/13, 6/18, 6/24, 6/25, 6/27, 6/28, 6/29, 6/30, 7/1, 7/2, 7/3, 7/4, 7/8, 7/9, 7/10, 7/11, 7/16, 7/17, 7/19, 7/22, 7/23, 7/24, 7/26, 7/29, 8/1, 8/3, 8/8, 8/28, 9/2, 9/11	ODSVRA breeding male and breeding female.
BB:RW	ODSVRA 2005		7/23, 8/12, 8/16, 8/17, 8/23, 8/25, 8/26, 8/27, 8/30, 9/1, 9/3	ODSVRA breeding male.
BB:VG	ODSVRA 2008		6/1	
BB:VW	ODSVRA 2008		6/11, 6/12, 6/13, 6/25, 6/27, 6/28, 6/29, 6/30, 7/1, 7/4, 7/8, 7/10, 7/23, 7/26	ODSVRA breeding female.
BY:PP	Salinas SB 2009	Monterey	9/3	

Appendix E. Banded snowy plovers with known origins seen at ODSVRA 18 February to 30 September 2009 (continued).

Band	Origin and Year Banded	County Banded	Dates Seen	Notes
GA:AB	ODSVRA 2004		7/23	
GA:AW	ODSVRA 2005		2/25, 3/3, 3/11, 3/12, 4/2, 4/5, 4/20, 4/21, 4/22, 4/28, 6/7, 6/11, 6/20, 7/3, 7/8, 7/9, 7/12, 8/1, 8/28	ODSVRA breeding female.
GA:GG GA:G-	ODSVRA 2004		3/11, 4/20, 4/24, 5/18, 5/23, 6/3, 6/12, 6/27, 7/3, 7/6, 7/8, 7/9, 7/11	ODSVRA breeding female. Seen as GA:G- on 7/8 and later.
GA:R	ODSVRA year unknown		4/29, 5/7, 5/9, 5/12, 5/13, 5/19, 5/22, 5/24, 5/29, 6/5, 6/10, 6/11, 6/19, 6/20, 6/22, 6/24, 6/25, 6/27, 6/28, 7/2, 7/3, 7/4, 7/5, 7/8, 7/9, 7/11, 7/15, 7/16, 7/18, 7/23, 7/26, 7/27, 7/30, 8/6, 8/8, 8/12, 8/13, 8/15	ODSVRA breeding male.
GA:VB	ODSVRA 2008		2/27, 3/2, 3/11, 3/23, 4/7, 4/15, 4/22, 4/23, 4/24, 4/28, 4/29, 5/1, 5/2, 5/3, 5/4, 5/8, 5/9, 5/17, 5/22, 5/25, 5/27, 5/28, 5/29, 5/30, 6/1, 6/3, 6/10, 6/11, 6/12, 6/18, 6/20, 6/24, 6/25, 6/30, 7/9, 7/10, 7/17, 8/3, 8/11, 8/18, 8/22, 9/7, 9/14, 9/28	ODSVRA breeding male.
GA:YB (URT)	ODSVRA 2004		4/30, 5/10, 6/11, 6/12, 6/13, 7/17, 7/23, 7/24, 8/7, 8/19	ODSVRA breeding male. There were 37 additional sightings recorded as GA:YB
GB:PP	Moss Landing SP 2009		9/20, 9/21, 9/28, 9/29	
GG:AB	ODSVRA 2007		2/18, 2/20, 3/3, 3/11, 3/16, 3/17, 3/24, 4/22, 4/27, 5/19, 5/21, 5/22, 5/23, 5/24, 5/27, 5/28, 5/30, 5/31, 6/1, 6/2, 6/7, 6/9, 6/19, 6/20, 6/22, 6/25, 7/11, 7/13, 7/19, 7/21, 8/2, 8/6, 8/8, 8/20	ODSVRA breeding male.
GG:AG	ODSVRA 2006		5/19	
GG:AY	ODSVRA 2007		4/7	
GG:BB	ODSVRA 2005		2/22, 3/23, 4/5, 4/7, 4/8, 5/12, 5/17, 5/18, 5/19, 5/22, 5/23, 5/24, 5/27, 5/31, 6/29, 6/30, 7/2, 7/3, 7/4, 7/8, 7/9, 7/10, 7/12, 7/13, 7/16, 7/17, 7/18, 7/29, 8/2, 8/6, 8/7, 8/8, 8/9, 8/15, 8/23, 8/24, 8/26, 9/4, 9/12, 9/29	ODSVRA breeding female.
GG:BR	ODSVRA 2008		3/30, 4/17, 4/24, 4/28, 5/1, 5/21, 6/11, 7/4, 7/17	ODSVRA breeding female.
GG:BY	ODSVRA 2007		3/24, 3/29, 4/1, 4/7, 4/16, 5/6, 5/7, 5/9, 5/14, 5/17, 5/23, 5/25, 5/28, 5/29, 5/31, 6/5, 6/7, 6/9, 6/10, 6/13, 6/25, 6/27, 6/30, 7/3, 7/4, 7/6, 7/7, 7/8, 7/11	ODSVRA breeding male.
GG:OR	ODSVRA 2007		7/11	
GG:PW	ODSVRA 2007		8/5	
GG:VB	ODSVRA 2008		6/27, 7/29	
GG:VW	ODSVRA 2008		5/22, 5/28, 6/5, 6/12, 6/20, 6/27, 7/2, 7/11, 7/17	
GG:VY	ODSVRA 2008		3/4, 3/5, 3/6, 3/27, 4/7, 4/8, 4/18, 4/19, 4/20, 4/21, 4/23, 4/24, 4/25, 4/29, 5/1, 5/9, 5/13, 5/14, 5/17, 5/18, 5/19, 5/20, 5/22, 5/23, 5/24, 5/26, 5/27, 5/28, 5/29, 6/2, 6/3, 6/5, 6/7, 6/9, 6/11, 6/12, 6/13, 6/14, 6/19, 6/20, 6/21, 6/25, 6/30, 7/1, 7/2, 7/3, 7/4, 7/8, 7/10, 7/11, 7/16, 7/17, 7/23, 7/24, 7/25, 7/26, 7/30, 8/6, 8/7, 8/12, 8/14, 8/19, 8/27, 8/28, 8/30, 9/1, 9/5, 9/11, 9/14	ODSVRA breeding male.
GG:WG	ODSVRA 2008		3/31, 4/2, 4/5, 4/7, 4/20, 4/23, 4/25, 5/1, 5/21, 5/23, 5/26, 5/27, 5/29, 6/11, 6/12, 6/20, 6/28	ODSVRA breeding male.
GL:AR	Pajaro Spit 2009	Santa Cruz - Monterey border	9/5, 9/28, 9/29	
GL:RB	Moss Landing SP 2009	Monterey	9/21, 9/23, 9/29	
GN:RW	Guadalupe NWR	San Luis Obispo	7/8, 7/11, 7/20	

Appendix E. Banded snowy plovers with known origins seen at ODSVRA 18 February to 30 September 2009 (continued).

Band	Origin and Year Banded	County Banded	Dates Seen	Notes
	2005			
NO:GB	VAFB 2009	Santa Barbara	8/1, 8/12	
NO:GY	VAFB 2009	Santa Barbara	8/6	
NO:NB	VAFB 2009	Santa Barbara	9/5, 9/17, 9/21	
NO:OB	VAFB 2009	Santa Barbara	9/14	
NO:OR	VAFB 2009	Santa Barbara	8/16	
NO:OW	VAFB 2009	Santa Barbara	8/24	
NO:WW	VAFB 2009	Santa Barbara	9/4, 9/9, 9/11, 9/12	
NW:AW	VAFB 2004	Santa Barbara	2/22, 2/25, 3/3, 3/11, 4/2, 4/23, 4/24, 5/1, 5/22, 6/2, 6/11, 6/19, 6/20, 6/27, 6/28, 7/8, 8/7, 8/8, 8/26	ODSVRA breeding female.
NW:WR	VAFB 2009	Santa Barbara	8/28	
NW:YW	VAFB 2009	Santa Barbara	9/12	
NY:OG	VAFB 2008	Santa Barbara	4/18, 5/12, 6/18, 6/19, 8/14, 8/28, 9/11, 9/12	ODSVRA breeding female.
NY:RB	VAFB 2008	Santa Barbara	5/21, 6/11, 6/18, 8/6, 8/8, 8/13, 8/25, 8/26, 9/11, 9/12	
NY:WG	VAFB 2008	Santa Barbara	7/23	
OA:GP	Salinas SB 2009	Monterey	8/4, 8/7	
OG:WP	Salinas SB 2009	Monterey	8/21, 8/26, 8/28	
OG:WR	Salinas SB 2007	Monterey	3/2, 3/3, 3/4, 3/5, 3/13, 3/14, 3/15	
OL:GP	Salinas NWR 2009	Monterey	9/5, 9/8	
OO:PP	Moss Landing SB 2009	Monterey	8/31, 9/4, 9/5	
PB:WP	Moss Landing SB 2009	Monterey	9/8	
PG:RR	ODSVRA 2004		7/24	
PG:VB	ODSVRA 2008		2/27, 3/2, 3/10, 4/1, 4/6, 4/8, 4/11, 4/22, 4/23, 4/28, 5/31, 6/9, 6/15, 6/16, 6/17, 6/19, 6/20, 6/21, 6/22, 6/24, 6/25, 6/30, 7/3, 7/5, 7/7, 7/8, 7/9, 7/10, 7/14, 7/15, 7/16, 7/18, 7/21, 7/23, 7/25, 7/28, 7/30, 8/5, 8/6, 8/7, 8/11, 8/12, 8/13, 8/16, 8/25, 8/28, 9/11, 9/12	ODSVRA breeding female
PG:VG	ODSVRA 2008		7/29	
PG:VR	ODSVRA 2008		6/12, 6/21, 6/27, 7/8, 7/10, 7/11, 7/22, 7/24, 7/31, 8/2, 8/3, 8/5, 8/11, 8/13, 8/14, 8/15	
PG:VY	ODSVRA 2008		4/3, 4/4, 4/9, 4/13, 4/14, 4/18, 4/20, 4/21, 4/23, 4/25, 4/28, 4/29, 5/2, 5/7, 5/9, 5/11, 5/13, 5/14, 5/21, 5/27, 5/30, 6/8, 6/11, 6/12, 6/15, 6/18, 6/20, 6/25, 7/8, 7/9, 7/10, 7/14, 7/19, 7/25, 7/26, 7/27, 7/29, 7/30, 8/4, 8/11, 8/12, 8/16, 8/21, 8/22, 8/25, 8/28, 9/7, 9/8, 9/13, 9/23, 9/28	ODSVRA breeding male.
PG:WG	ODSVRA 2005		2/24, 3/3, 3/11, 3/14, 4/2, 4/7, 4/23, 4/24, 5/5, 5/7, 5/18, 5/19, 5/23, 5/27, 5/28, 6/3, 6/7, 6/11, 6/20, 7/3, 7/4, 7/8, 7/9, 7/11, 7/16, 7/17, 7/22, 7/23, 7/26, 7/29, 7/30, 9/4	ODSVRA breeding male
PG:WW	ODSVRA 2005		4/20, 4/21, 4/22, 4/27, 4/28, 5/9, 5/10, 5/13, 5/14, 5/18, 5/19, 5/22, 5/23, 5/27, 5/28, 5/30, 5/31, 6/2, 6/5, 6/10, 6/22, 6/24, 6/25, 6/27, 7/7, 7/8, 7/22, 7/23, 7/25, 7/29, 7/31, 8/1, 8/6, 8/9, 8/10, 8/11, 8/14, 8/15, 8/16, 8/18, 8/20, 8/22	ODSVRA breeding male

Appendix E. Banded snowy plovers with known origins seen at ODSVRA 18 February to 30 September 2009 (continued).

Band	Origin and Year Banded	County Banded	Dates Seen	Notes
PR:GP	Moss Landing SP 2009	Monterey	8/14	
PV:AB	ODSVRA 2007		3/11, 3/22, 3/25, 3/31, 4/2, 4/5, 4/6, 4/27, 4/28, 5/29, 6/5, 7/16, 7/18, 7/19, 7/21	ODSVRA breeding female.
PV:AG	ODSVRA 2008		2/22, 3/3, 3/11, 6/25, 7/9, 7/16, 7/20, 7/25, 7/28, 7/29, 8/1, 8/3, 8/11, 8/14, 8/17, 8/20, 8/21, 8/23, 8/25, 9/1	ODSVRA breeding male.
PV:AY	ODSVRA 2007		2/24, 3/21, 3/24, 3/29, 4/2, 4/6, 4/10, 4/19, 4/24, 4/29, 5/7, 5/25, 5/26, 5/27, 5/28, 5/30, 6/1, 6/2, 6/3, 6/10, 6/11, 6/12, 6/15, 7/3, 7/8, 7/9, 7/10, 7/12, 7/14, 7/16, 7/25, 8/3, 9/1	ODSVRA breeding male.
PV:BB	ODSVRA 2008		2/22, 2/24, 2/25, 2/26, 3/1, 3/2, 3/3, 3/4, 3/11, 3/16, 3/28, 4/8, 4/24, 4/28, 5/31, 6/5, 7/4, 7/9, 7/10, 7/11, 7/15, 7/16, 7/17, 7/18, 7/21, 7/22, 7/24, 7/29, 7/31, 8/3, 8/5, 8/8, 8/11, 8/12, 8/14, 9/6, 9/28	ODSVRA breeding male.
PV:BR	ODSVRA 2007		3/3, 3/11, 3/23, 3/30, 4/6, 4/7, 4/13, 4/20, 4/21, 5/1, 5/13, 5/14, 5/15, 5/18, 5/19, 5/23, 5/24, 5/25, 5/28, 5/30, 6/1, 6/5, 6/11, 6/29, 7/13, 7/14, 7/16, 7/17, 7/18, 7/19, 7/20, 7/23, 7/24, 7/26, 7/31, 8/4, 8/6, 8/12, 8/14, 8/16, 8/23, 8/25, 8/26, 8/28, 8/30, 9/14	ODSVRA breeding males (2).
PV:BY	ODSVRA 2008		4/7	
PV:GB	ODSVRA 2008		2/22, 2/24, 3/23, 3/24, 3/26, 4/3, 4/12, 4/22, 4/23, 4/24, 5/12, 5/17, 5/21, 5/23, 5/26, 5/27, 5/28, 5/30, 5/31, 6/1, 6/7, 6/9, 6/10, 6/24, 6/25, 6/27, 7/15, 7/16, 7/17, 7/18, 7/20, 7/21, 7/23, 7/24, 7/25, 7/29, 8/3, 8/8, 8/11, 8/12, 8/13, 8/17, 8/28, 8/29, 9/12	ODSVRA breeding male.
PV:GR	ODSVRA 2008		8/22	
PV:GY	ODSVRA 2008		2/24, 3/3, 3/11, 3/23, 3/24, 3/30, 4/1, 4/5, 4/6, 4/24, 4/29, 5/2, 5/6, 5/8, 5/9, 5/10, 5/16, 5/17, 5/18, 5/19, 5/21, 5/23, 5/24, 5/25, 5/26, 5/27, 5/31, 6/3, 6/7, 6/12, 6/13, 6/27, 6/29, 7/1, 7/5, 7/10, 7/16, 7/23, 7/24, 7/27, 7/29, 8/3, 8/9, 8/10, 8/13, 8/21, 8/25, 9/5	ODSVRA breeding male.
PV:OW	ODSVRA 2008		3/3, 3/11, 3/28, 4/28, 5/23, 5/29, 6/11, 6/29, 7/3, 7/10, 8/3	
PV:PR	ODSVRA 2008		2/23, 2/24, 3/31, 4/20, 4/23, 4/24, 5/9, 5/19, 5/21, 6/2, 6/3, 6/6, 6/7, 6/19, 6/25, 6/28, 6/30, 7/2, 7/3, 7/4, 7/6, 7/8, 7/9, 7/14, 7/29, 7/31, 8/8, 8/12, 8/15, 8/16, 8/17, 8/20, 8/21, 8/25, 9/2	ODSVRA breeding male.
PV:RG	ODSVRA 2008		4/22, 4/23, 4/25, 6/24, 8/7, 8/10, 8/28, 9/3, 9/17, 9/20, 9/21, 9/23, 9/28	
PV:RR	ODSVRA 2008		7/2, 8/3	
PV:RW	ODSVRA 2008		7/27, 7/28, 7/29, 7/30, 7/30, 8/6, 8/12, 8/23, 8/25, 8/26, 8/28, 9/12	
PV:VG	ODSVRA 2008		7/10, 7/29, 7/31, 8/5, 8/8, 8/20,8/22, 8/25, 8/30, 9/12	
PV:VW	ODSVRA 2008		8/10, 8/12	
PV:WB	ODSVRA 2007		2/22, 2/24, 2/25, 5/31, 6/1, 6/5, 6/19, 6/22, 7/7, 7/8, 7/9, 7/11, 7/21, 8/26, 9/3, 9/4, 9/5, 9/12	ODSVRA breeding female.
PV:WG	ODSVRA 2008		3/20, 5/12, 5/13, 5/18, 5/28, 6/3, 6/5, 6/25, 6/27, 7/2, 7/11, 7/16, 7/17, 7/20, 7/31	ODSVRA breeding male.
PV:WW	ODSVRA 2008		2/24, 3/4, 3/5, 3/6, 3/21, 3/23, 3/27, 4/9, 4/14, 4/16, 4/18, 4/19, 5/3, 5/4, 5/5, 5/6, 5/12, 5/19, 5/21, 5/26, 5/27, 5/28, 6/1, 6/3, 6/12, 6/13, 6/15, 6/18, 6/23, 6/25, 6/28, 7/17, 7/26, 7/31, 8/1, 8/3, 8/7, 8/8, 8/10, 8/11, 8/22, 8/26, 8/28, 8/30, 8/31, 9/1, 9/4, 9/5, 9/11, 9/14	ODSVRA breeding female.

Appendix E. Banded snowy plovers with known origins seen at ODSVRA 18 February to 30 September 2009 (continued).

Band	Origin and Year Banded	County Banded	Dates Seen	Notes
PW:AP	Salinas SB 2009	Monterey	8/27, 8/28, 9/2	
PY:AO	Salinas SB 2007	Monterey	5/19	
PY:GO	Fort Ord Dunes 2007	Monterey	4/22, 4/26, 5/17, 5/21, 5/28, 6/3, 6/5, 6/12, 6/24, 6/27, 6/28, 7/1, 7/3, 7/8, 7/9, 7/10, 7/12, 7/14	ODSVRA breeding male.
PY:YR	Zmudowski SB 2009	Monterey	9/9, 9/11, 9/12	
RB:GP	Moss Landing 2009	Monterey	8/29, 8/31	
RB:YP	Salinas NWR 2009	Monterey	7/31, 8/3	
RO:RW	Pajaro Spit 2007	Santa Cruz - Monterey border	2/22, 2/23, 2/24, 2/25, 3/1, 3/2, 3/3, 3/4	
RO:WR	Salinas SB 2007	Monterey	7/25	
RP:WR	Salinas SB 2006	Monterey	7/13, 7/20, 7/25, 8/6, 8/7, 8/14, 8/16, 8/17, 8/21	ODSVRA breeding male
RR:BB	ODSVRA 2003		3/27	
RR:BR (LLT)	ODSVRA 2003		4/9, 4/21, 5/13, 5/14, 5/29, 6/3, 6/5, 6/24, 7/17, 7/21, 7/24, 8/7, 8/14, 8/18, 9/4, 9/5	RR:BR LLT: ODSVRA breeding male. There were 40 additional sightings recorded as RR:BR between 3/5-9/28
RR:BR (ULT)	ODSVRA 2003		5/29, 5/31, 6/25, 7/18, 7/23, 8/6, 9/23	
RR:BY (ULT)	ODSVRA 2003		7/4, 7/10, 6/20, 6/28, 7/8, 7/17	ODSVRA breeding female. There were six additional sightings recorded as RR:BY between 5/27-7/16
RR:GB	ODSVRA 2007		6/3, 6/11, 7/8, 7/9, 7/11, 7/16, 7/17, 7/31, 8/9, 8/23	ODSVRA breeding female.
RR:GR	ODSVRA 2003		6/1	
RR:OW (ULT)	ODSVRA 2003		4/20, 4/21, 4/24, 5/26, 5/28, 6/11, 7/1, 7/11	RR:OW ULT: ODSVRA breeding male. There were seven additional sightings recorded as RR:OW between 4/28-7/9.
RR:OW(LLT)	ODSVRA 2003		4/2, 5/12, 6/30	
RR:PB	ODSVRA 2007		6/25, 7/25, 7/29, 8/16, 9/11, 9/12	
RR:PR	ODSVRA 2008		3/30	
RR:RR	ODSVRA 2003		7/14	
RR:VB	ODSVRA 2008		2/24, 2/25, 3/4, 3/5, 3/11, 3/13, 3/15, 3/18, 3/22, 3/24, 3/26, 3/28, 3/29, 4/11, 4/16, 4/22, 4/24, 4/28, 4/30, 5/1, 5/3, 5/4, 5/5, 5/14, 5/18, 5/20, 5/21, 5/22, 5/24, 5/28, 5/30, 5/31, 6/2	ODSVRA breeding female.
RR:VG	ODSVRA 2008		3/2, 3/29, 4/6, 4/7, 4/11, 4/16, 4/27, 5/3, 5/23, 5/24, 6/21, 6/25, 6/30, 7/2, 7/9, 7/10	ODSVRA breeding female.
RR:VY	ODSVRA 2008		2/22, 3/2, 6/5, 6/15, 6/28, 8/30	ODSVRA breeding female.
RW:WY	Salinas NWR	Monterey	8/12, 8/28, 8/29	Banded as adult female June 2009
VG:BB	ODSVRA 2003		7/27	

Appendix E. Banded snowy plovers with known origins seen at ODSVRA 18 February to 30 September 2009 (continued).

Band	Origin and Year Banded	County Banded	Dates Seen	Notes
VG:BR (LLT)	ODSVRA 2003		7/29, 8/12, 8/28, 9/4	There were four additional sightings recorded as VG:BR between 7/29-9/14.
VG:OY	ODSVRA 2003		8/16	
VG:RR	ODSVRA 2003		8/18	
VG:VB	ODSVRA 2008		4/21, 4/22, 4/29, 5/5, 5/6, 5/13, 5/14, 5/17, 5/22, 5/23, 5/27, 5/29, 5/31, 6/1, 6/10, 6/12, 6/13, 6/20, 6/24, 6/25, 6/26, 6/29, 6/30, 7/2, 7/4, 7/7, 7/10, 7/12, 7/16, 7/22, 7/23, 7/24, 7/25, 7/29, 7/31, 8/4, 8/6, 8/7, 8/10, 8/12, 8/13, 8/15, 8/16, 8/17, 9/11	ODSVRA breeding male.
VG:VG	ODSVRA 2008		8/25	
VV:BR	ODSVRA 2007		7/24	
VV:BY	ODSVRA 2007		8/7, 8/8, 8/10, 8/12, 8/20, 8/28, 8/29, 9/14, 9/28	
VV:GY	ODSVRA 2007		9/11	
VV:OY	ODSVRA 2007		3/15, 4/5, 4/14, 4/21, 2/24, 4/29, 5/1, 5/31, 6/1, 6/15, 7/3, 7/7, 7/11, 7/17	ODSVRA breeding male.
VV:RB	ODSVRA 2007		9/5, 9/28	
VV:VR	ODSVRA 2008		5/29, 6/20, 7/8, 7/10, 7/16	ODSVRA breeding male.
VV:VW	ODSVRA 2008		2/26, 2/27, 4/28, 5/1, 5/28, 6/1, 6/2, 6/3, 7/8, 7/9, 7/10, 7/16, 7/19, 7/20, 7/21, 7/28, 7/29, 8/6, 8/23, 8/26, 9/1, 9/11, 9/12, 9/19	ODSVRA breeding female.
VV:YB	ODSVRA 2006		7/23	
WL:GP	Salinas NWR 2009	Monterey	9/8	
WN:WB	Guadalupe NWR 2002	San Luis Obispo	4/7, 4/24, 4/27, 4/29, 5/7, 5/13, 5/14, 5/15, 5/22, 5/23, 5/25, 5/27, 5/28, 5/29, 5/30, 6/22, 6/24, 6/25, 6/28, 6/30, 7/3, 7/9, 7/11, 7/15, 7/17, 7/24, 7/25, 7/26, 7/27, 7/29, 8/1, 8/3, 8/8, 8/10, 8/12, 8/14, 8/15, 8/17, 8/20, 8/21, 8/22, 8/24	ODSVRA breeding male. Brown peeled off and is now WS:WB
YB:BP	Fort Ord Dunes 2009 or Zmudowski SB 2009	Monterey	9/8	Same band used at Fort Ord Dunes 2009 and Zmudowski 2009
YB:GW	Monterey Bay	Monterey	7/30, 7/31, 8/18, 8/20, 8/21, 8/22, 8/27, 9/8, 9/17, 9/29	Banded as adult female May 2009
YB:PP	Salinas NWR 2009	Monterey	8/27	
YP:OL	Salinas NWR 2008	Monterey	2/22, 2/26, 3/11, 3/13, 3/15, 3/18, 3/19, 3/22, 3/25	
YW:BG	New River, Oregon 2007	Coos - Curry border	8/7, 8/8, 8/18, 8/22, 8/23, 8/28, 9/12	

Appendix F. Snowy plovers banded as chicks at ODSVRA seen at other sites from 28 December 2008 to 25 September 2009. This is only a partial list based upon information received from PRBO Conservation Science, Morro Bay State Park, Chevron property, Guadalupe-Nipomo Dunes National Wildlife Refuge, and Vandenberg Air Force Base (pers. comm. F. Bidstrup; pers. comm. R. Orr; pers. comm. J. S. Adams; pers. comm. G. Greenwald; pers. comm. T. Applegate; pers. comm. C. E. Holmes, pers. comm. R. Butala Ball) and from sightings by staff of ODSVRA at nearby sites. Unless noted, all dates are of 2009. Note: ODSVRA is banding chicks to brood so it is possible to have more than one bird with the same combination.
Guadalupe NWR = Guadalupe-Nipomo Dunes National Wildlife Refuge, VAFB = Vandenberg Air Force Base, NAB = Naval Amphibious Base, SB = State Beach, SP = State Park; Juv = Juvenile, M = Male, F = Female

Band Combination	Year Banded	Sex	Location Seen	County	Dates Seen	Comments
BB:VG	2008	F	Villa Creek, Estero Bluffs SP	San Luis Obispo	4/16, 4/24, 5/14, 5/15, 5/28, 6/4, 6/9, 6/10, 6/16, 6/17, 6/18, 6/24, 7/9, 7/11, 7/15, 7/24, 8/7, 8/12, 8/18, 8/19, 8/28, 8/29, 9/15, 9/17, 9/21	Reported as possibly nesting
P:AG	unknown	F	Villa Creek, Estero Bluffs SP	San Luis Obispo	4/16, 4/20, 4/21, 4/24, 5/14, 5/26, 5/29, 6/3, 6/11, 6/18, 6/24, 7/9, 7/10, 7/11, 7/15, 7/24, 7/29, 7/31, 8/1, 8/3, 8/12, 8/18, 8/28, 8/29, 9/15, 9/17, 9/21	Reported as nesting
PV:PW	2008	F	Villa Creek, Estero Bluffs SP	San Luis Obispo	4/30, 5/5	
PV:PW	2008	M	Villa Creek, Estero Bluffs SP	San Luis Obispo	4/21, 4/24, 5/13, 5/14	
RR:GB	2007	F	Villa Creek, Estero Bluffs SP	San Luis Obispo	4/16	
VV:VG	2009	Juv	Villa Creek, Estero Bluffs SP	San Luis Obispo	8/18	SP37 nest
GA:RW	2009	Juv	Morro Strand SB	San Luis Obispo	9/17, 9/21	SP80 nest
GA:VR	2009	Juv	Morro Strand SB	San Luis Obispo	9/21	SP81 nest
PV:PW	2008	M	Morro Strand SB	San Luis Obispo	4/8, 4/15, 5/29, 6/1, 6/4, 6/9, 6/10, 6/13, 6/18, 6/22, 6/27, 7/6, 7/18, 8/28	Reported as nesting (6/10), with chicks(6/27), and displaying (7/6).
PV:PW	2008		Morro Strand SB	San Luis Obispo	5/6, 9/21	
RR:GB	2007	F	Morro Strand SB	San Luis Obispo	7/22, 9/21	Reported with small chick (7/22).
VG:VY	2009	Juv	Morro Strand SB	San Luis Obispo	9/15	SP93 nest
PV:RG	2008	F	Morro Bay Sandspit	San Luis Obispo	6/23, 7/15, 7/29	
RR:PR	2008	F	Morro Bay Sandspit	San Luis Obispo	4/28, 5/5	
GA:RW	2009	Juv	Guadalupe NWR	San Luis Obispo	8/26	SP80 nest
GG:OW	2009	Juv	Guadalupe NWR	San Luis Obispo	8/26	SP52 nest
GG:RR	2009	Juv	Guadalupe NWR	San Luis Obispo	7/31	SP63 nest
PG:OG	2009	Juv	Guadalupe NWR	San Luis Obispo	7/31	SP47 nest
RR:PB	2007	F	Guadalupe NWR	San Luis Obispo	6/25	
VG:OB	2009	Juv	Guadalupe NWR	San Luis Obispo	8/7	SP66 nest
VV:BG	2009	Juv	Guadalupe NWR	San Luis Obispo	8/7	SP59 nest
VV:BY	2007	M	Guadalupe NWR	San Luis Obispo	8/7	
VV:OG	2009	Juv	Guadalupe NWR	San Luis Obispo	8/7	SP73 nest
GA:RW	2009	Juv	Chevron property	San Luis Obispo	8/31	SP80 nest
GG:BG	2009	Juv	Chevron property	San Luis Obispo	8/31	SP103 nest
GG:RB	2009	Juv	Chevron property	San Luis Obispo	7/31, 8/26	SP53 nest

Appendix F. Snowy plovers banded as chicks at ODSVRA seen at other sites from 28 December 2008 to 25 September 2009 (continued).

Band Combination	Year Banded	Sex	Location Seen	County	Dates Seen	Comments
PV:YG	2009	Juv	Chevron property	San Luis Obispo	8/28	SP56 nest
RR:PG	2009	Juv	Chevron property	San Luis Obispo	7/31, 8/26	SP43 nest
VV:BG	2009	Juv	Chevron property	San Luis Obispo	7/31	SP59 nest
BB:VY	2008		Rancho Guadalupe Dunes Co. Park	Santa Barbara	9/2	
GG:YB	2009	Juv	Rancho Guadalupe Dunes Co. Park	Santa Barbara	9/2	SP83 nest
PG:VR	2008		Rancho Guadalupe Dunes Co. Park	Santa Barbara	9/2	
VV:GY	2007		Rancho Guadalupe Dunes Co. Park	Santa Barbara	9/2	
BB:OY	2009	Juv	Rancho Guadalupe Dunes Co. Park	Santa Barbara	9/2	SP110 nest
GA:OB	2007		VAFB	Santa Barbara	1/6, 3/6	
GA:OB	2007	M	VAFB	Santa Barbara	3/6	
GA:OR	2004	F	VAFB	Santa Barbara	3/17, 7/11, 7/21	
GA:RG	2007	M	VAFB	Santa Barbara	3/16, 6/4, 8/14, 8/24, 8/28	
GA:RG	2007	F	VAFB	Santa Barbara	5/5, 5/11, 6/18, 6/22, 7/21	
GG:AG	2006		VAFB	Santa Barbara	3/11	
GG:BR	2008		VAFB	Santa Barbara	3/3, 9/3	
GG:BR	2008	F	VAFB	Santa Barbara	3/10, 3/12, 3/17, 7/23	
GG:RB	2009		VAFB	Santa Barbara	8/3, 8/6	
GG:VB	2008	F	VAFB	Santa Barbara	3/3, 3/6, 3/16, 3/19, 3/24, 3/31, 4/9, 4/24, 5/22, 6/3, 6/18, 7/4	Reported as nesting.
GG:WY	2008		VAFB	Santa Barbara	1/6, 3/30, 4/6, 6/18	Reported as nesting.
GG:WY	2008	M	VAFB	Santa Barbara	3/11	
GG:YB	2009	Juv	VAFB	Santa Barbara	8/24	
PG:OR	2004		VAFB	Santa Barbara	3/10	Reported as nesting.
PG:PR	2005		VAFB	Santa Barbara	1/6, 9/8, 9/11	
PG:PR	2005	M	VAFB	Santa Barbara	2/28, 3/5, 3/10, 3/17, 4/8, 5/4, 5/11, 5/19, 5/21, 6/3, 6/4, 7/17, 8/10	
PG:YB	2009	Juv	VAFB	Santa Barbara	7/21	
PV:BA	2009	Juv	VAFB	Santa Barbara	8/13, 8/21, 8/24	
PV:OW	2008		VAFB	Santa Barbara	1/6	
PV:PR	2008		VAFB	Santa Barbara	8/25	
PV:RW	2008	F	VAFB	Santa Barbara	3/3, 3/31	
PV:RW	2008	M	VAFB	Santa Barbara	3/27	
PV:RY	2008	F	VAFB	Santa Barbara	7/1	
PV:WG	2008		VAFB	Santa Barbara	7/23, 8/18, 9/9	
RR:OG	2003	M	VAFB	Santa Barbara	3/19	
RR:PY	2007	F	VAFB	Santa Barbara	7/15	Reported as nesting.
RR:VW	2009		VAFB	Santa Barbara	8/18	
RR:WG	2003		VAFB	Santa Barbara	3/5, 4/9, 5/11, 6/4, 7/13	
RR:WG	2003	M	VAFB	Santa Barbara	3/11	
V V:GB	2009	Juv	VAFB	Santa Barbara	7/29	

Appendix F. Snowy plovers banded as chicks at ODSVRA seen at other sites from 28 December 2008 to 25 September 2009 (continued).

Band Combination	Year Banded	Sex	Location Seen	County	Dates Seen	Comments
V V:GW	2009	Juv	VAFB	Santa Barbara	8/19	
V V:RB	2009	Juv	VAFB	Santa Barbara	8/11	
BB:GW	2009	Juv	Coal Oil Point Reserve	Santa Barbara	8/22, 8/29	SP23 nest
GG:VR	2009	Juv	Coal Oil Point Reserve	Santa Barbara	8/22	SP58 nest
PV:GB	2008		Skunk Point, Santa Rosa Island	Santa Barbara	1/9, 1/11	
PV:PY	2008		Skunk Point, Santa Rosa Island	Santa Barbara	1/11	
VV:GW	2009	Juv	McGrath SB	Ventura	9/3	SP55 nest
VV:OO	2009	Juv	McGrath SB	Ventura	8/27	SP48 nest
PG:VR	2008		Hollywood Beach	Ventura	9/25	
RR:PR	2008		Malibu Lagoon SB	Los Angeles	12/28/2008, 1/6, 2/5	
GA:VB	2008		Zuma Beach	Los Angeles	12/2/2008, 12/3/2008, 12/28/2008, 1/6	
RR:VW	2009	Juv	San Clemente Island	Los Angeles	8/10	SP25 nest
VV:GB	2009	Juv	San Clemente Island	Los Angeles	9/10	SP50 nest
PG:YB	2009	Juv	Batiquitos Lagoon	San Diego	8/4	SP62 nest
GG:BY	2007		NAB Coronado	San Diego	8/21, 9/18	
RR:PG	2009	Juv	Zuniga Point, NAB Coronado	San Diego	9/18	SP43 nest
GA:VB	2008		Naval Radio Receiving Facility	San Diego	7/20	Possible male
GA:VB	2008		Silver Strand SB	San Diego	4/2	

Appendix G. Documented mortality of California least terns and snowy plovers (chicks, fledglings, or adults) at ODSVRA in 2009.

Mortality, other than documented predation, of California least terns at ODSVRA in 2009. Note: there was no documented predation of least tern chicks, fledglings, or adults in 2009.

No. and age of tern	Location	Notes
1 juvenile	Southeast 6 exclosure	On 11 August W/G:W/B fledgling (LT8) with injured wing was taken to rehabilitation facility. This bird died in captivity on 30 September. See Notes Section in report for details.

Documented predation of snowy plovers at ODSVRA in 2009.

No. and age of plover	Predator	Location	Notes
1 chick	Sub-adult California gull	North 6 exclosure shoreline	On 23 July, a subadult California gull was observed swallowing a plover chick whole. This was believed to be a 27-day-old chick of SP78 brood.
2 plovers (juvenile or adult size)	Peregrine falcon	6 and 7 exclosure and shoreline	Prey remains were collected on 18 August and 19 August. In both cases, a peregrine falcon was observed with the prey. Feather and bill remains from 18 August were identified to be from a snowy plover. The prey from 19 August was identified as a snowy plover by a park environmental scientist as it was held by the peregrine.

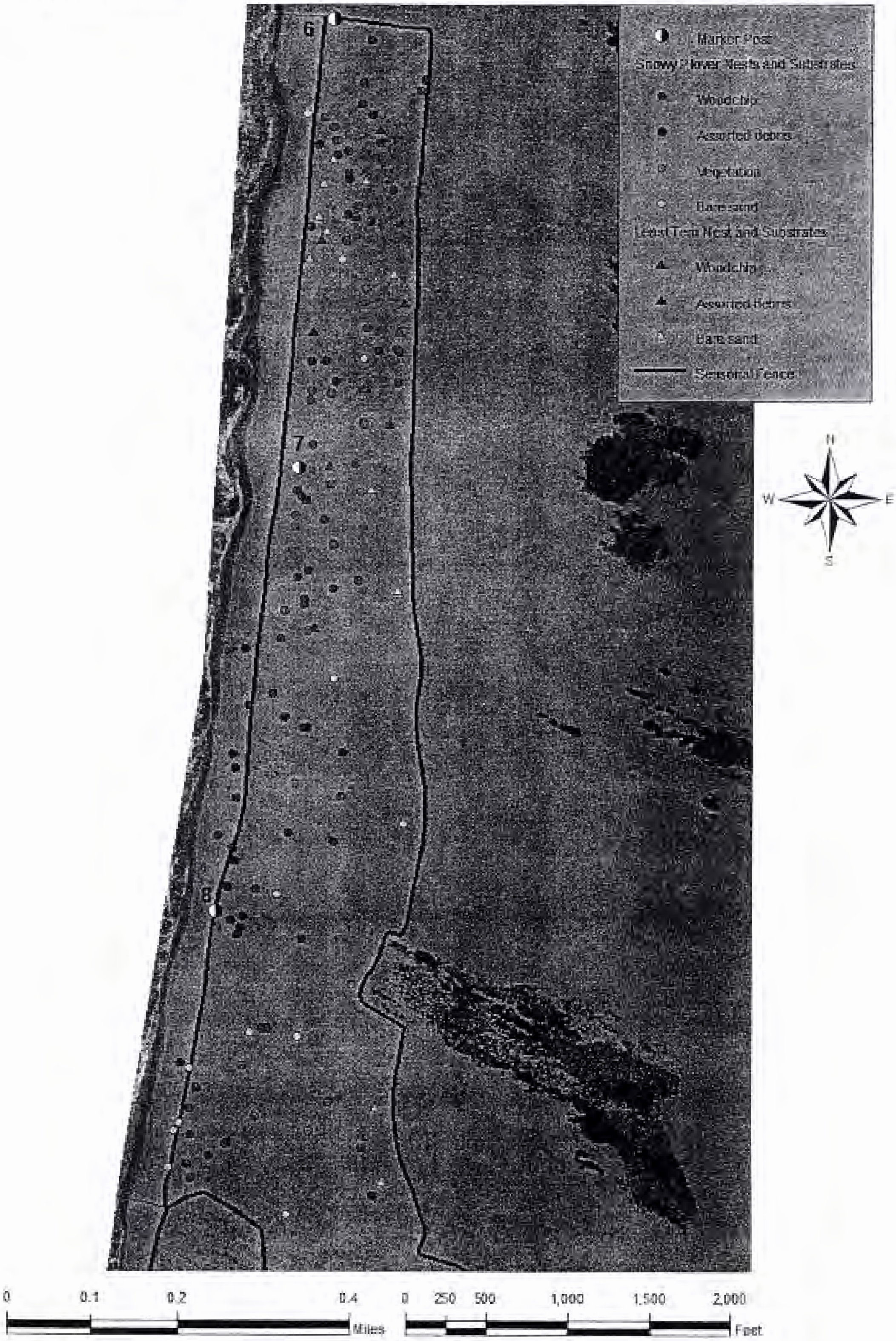
Mortality, other than documented predation, of snowy plovers at ODSVRA in 2009.

No. and age of plover	Location	Notes
1 chick	8 exclosure shoreline	On 28 June, three chicks of SP62 brood were seen and one of the chicks was limping. A chick of this brood was found dead 30 June. Legs and feet of carcass had no breaks, swelling, or discoloration and leg bands moved freely.
1 chick	Mid 8 exclosure shoreline	The partial remains of VV:RY chick from SP98 brood was found on 2 July. SP98 was a two chick brood last observed with both chicks on 28 June on day of hatch.
1 chick	Southern shoreline of North Oso Flaco exclosure	On 17 July one chick (SP60) was found dead. Chick was last seen alive and actively foraging at 27 days old on 15 July. Carcass was intact and decomposing. Chick carcass was too desiccated for necropsy.
1 chick	8 exclosure shoreline	On 5 August, two chicks seen brooded by adult (SP132). One chick was dead and one was alive and actively foraging. The dead chick was collected for necropsy and cause of death was undetermined (see necropsy Attachment).
1 juvenile	Mid 6 exclosure shoreline	On 20 September, BB:LY juvenile from SP145 brood found dead. Carcass had no visible wounds and maggots were present. Only one known fledge from SP145 and the juvenile was last observed on 3 September at 30 days old.
1 juvenile	Riding area, between Pier and Grand avenues on shoreline	On 29 September, GA:RW juvenile (SP80) observed alive at 10:15 a.m. and found dead at 10:55 a.m. in fresh tire tracks. (see necropsy Attachment).
1 adult	Open riding area, just east of mid-6 exclosure	On 26 February, an unbanded adult snowy plover was found dead on the ground approximately one foot east of the Southern Exclosure fence. The necropsy results reported the bird had severe postmortem decomposition and cause of death was unknown (see necropsy Attachment).

Appendix H. Clarifications and corrections to Table 10, nesting success of snowy plovers from 2001-2009. The following are explanations of the further breaking out of locations for comparisons among years; some minor corrections to Table 10 are listed.

Year	Area	Category	Correction
2001	Arroyo Grande Creek	No. nests No. chicks	Three nests and nine chicks formerly included in "Riding area" and now separated out as "Arroyo Grande Creek". In 2001, Arroyo Grande Creek was provided with a seasonal exclosure.
2001	Total	Multiple	During preparations of the 2009 report, the 2001 report was reviewed. Some errors in the 2001 report were noted and these were repeated in the 2002-08 reports in a table referring to snowy plover nesting success in 2001. The correct numbers for total follow (with numbers provided in the 2001 report in parenthesis): number nests with known fate, 32 (33); number nests hatching, 26 (27); percent nests hatching, 81 (82); and number of chicks, 70 (71-74). Note that for the 2001 season only two banded chicks (BB:YB and GG:GR) had been confirmed to fledge at the time the report was written. During the following year, a third fledge was confirmed when BB:GG (SP13 brood, 2001) was seen 5 August 2002 at ODSVRA (included in Banded Bird section of 2002 report).
2003	Dune Preserve	No. nests No. chicks	One nest and three chicks initially included in "Riding area".
2003	Pipeline Revegetation	No. nests No. chicks No. fledged	Three nests, four chicks and two fledges initially included in "Riding area".
2003	East of Boneyard	No. nests No. chicks No. fledged	Two nests, three chicks and two fledges initially included in "Riding area".
2003	Total	No. banded or known fate chicks fledged	In 2008 report, incorrectly reported as 107 (does not include fledge verified after the 2003 report was written). Reported correctly as 108 in 2004-07.
2004	Pipeline Revegetation	No. nests No. chicks	One nest and three chicks formerly included in "Riding area".
2004	Unknown location	No. nests No. chicks	Five nests and 12 chicks formerly included in "Riding area".
2006	Riding Area, Oso Flaco	Multiple	In 2006, numbers were written incorrectly in table and errors were repeated in 2007-08 reports. The corrected numbers follow (with numbers provided in the 2006 report in parenthesis): percent nests hatching in "Riding Area", 76 (74); percent nests hatching in "Oso Flaco", 76 (79); total percent nests hatching, 76 (74); number banded or known fate chicks for "Riding Area", 173 (168), for "Oso Flaco", 57 (53); and percent chicks known fledged for "Oso Flaco", 16 (17).
2007	Riding Area	No. nests with known fate	In 2007 report, incorrectly reported in Table 9 as 75 instead of the correct 76. This was corrected in the 2008 report..

Appendix I. Nest substrates of least terns and snowy plovers in 6, 7, and 8 exclosures at ODSVRA in 2009. The type of substrate in which nests were located was recorded when nests were walked up to.



Oceano Dunes State Vehicular Recreation Area

2012 Predator Management Report

Submitted To:

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Submitted By:

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&
Valerie Burton, Assistant District Supervisor
&
Eric Covington, District Supervisor
San Luis District
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Introduction

Prior to the 2012 California Least Tern (LETE) and Western Snowy Plover (SNPL) nesting season, USDA-APHIS-Wildlife Services entered into an agreement with Oceano Dunes State Vehicular Recreation Area (ODSVRA) to conduct predator management activities in the LETE and SNPL nesting areas. Wildlife Specialist (WS) Matt Campbell and WS Kristen Updike were assigned to the ODSVRA project to monitor, or selectively remove, mammalian and avian predators for protection of nesting LETE and SNPL.

WS Matt Campbell began working the ODSVRA project March 19th, 2012 and WS Kristen Updike relieved him July 17th, 2012. Each underwent mandatory training (ATV training, firearms training, trapping, defensive driving, civil rights, safety in all aspects) used during the project.

Methods of Predator Management

Many methods were used for LETE and SNPL protection throughout their nesting season. Methods include trapping, calling, shooting spotlighting and surveying.

Daytime surveys were performed by either hiking or driving on the dunes and shoreline in an attempt to locate predators through track identification and binoculars or spotting scope. Other predator management methods, such as removal, were implemented when the safety of LETE and SNPL nesting was compromised. Wildlife Services stayed in communication with field monitors in order to stay up to date on their observations of predator activity. Surveys indicating the location of predators were conducted in Eucalyptus, Table Top, Pipeline Revegetation, Boy Scout Camp, Maidenform, Southern Exclosure, North and the South Oso Flaco areas (Appendix 1).

The majority of nighttime surveys were performed through a process called spotlighting. Spotlighting can be described as traveling in and around the dunes searching for a predator's eye shine reflection. Predators can be located by their eye shine, then positive identification can be made with the use of binoculars.

Trapping was an effective method of predator management. Trapping methods used were pole traps, cage traps and padded leg-hold traps. Pole traps were used for certain avian predators, cage traps for raccoons and padded leg-hold traps for coyotes and raccoons. A total of eleven coyotes and four raccoons were removed by padded leg hold traps, two raccoons by cage traps and two barn owls were caught by pole traps and relocated (Table 1).

Calling was another option of predator management. This is most effective early in the morning or near sunset. This is the act of producing a sound that entices the predator to seek out the source of the noise. No predators were removed using this method.

During the 2012 nesting season a new idea was implemented attempting to capture a coyote that continued to be a predation threat on the shoreline. The "Coyote Funnel" was a fence that was established to try and force the coyote through an opening in center where leg holds were placed. Another fence of a similar design was placed near the Cable Fence. The results are in the following section.

Results of Predator Management Methods

In the beginning of the season, Northern Harriers (NOHA) were observed in the nesting areas beginning on April 28th, 2012. One male harrier was observed in exclosures six, seven and eight predating eggs and one chick from SNPL nests. The male NOHA was observed depredating five nests, and was suspected in the loss of an additional five nests. The male Northern Harrier was lethally removed on May 12, 2012 northeast of exclosure six in the open riding area, after live-trapping efforts were unsuccessful. A necropsy showed SNPL egg fragments and yolk on its bill, as well as in the esophagus and stomach. Feathers were also found in the stomach, but were not identified as to what species they belonged to.

Coyotes presented a serious predation threat to LETE and SNPL nesting success this season. Coyotes would frequently enter the shoreline where LETE and SNPL forage, nest and raise their young throughout the season. Multiple SNPL bands and one LETE band from 2012 were found in coyote scat on the boardwalk in South Oso Flaco immediately south of the Boneyard gate. Suspected coyote predation persisted as the season continued, consequently, removal was implemented.

Eleven coyotes were removed throughout the season (Table 1). However, coyote tracks continued to be observed on the shoreline. Alternate ideas were suggested and implemented such as "The Coyote Funnel" fence that was built on the shoreline August 9th, 2012. It was installed in efforts to force the coyote into a small path where padded leg-holds were set. Unfortunately, the tide was always low enough to where the coyote could go around the fencing. Another fence was established August 13th, 2012 farther south on the shoreline along Cable Fence to deter activity. A coyote did step on the trap, but failed to trip set it off and get captured.

On July 11th, padded leg-hold traps were set near a sea lion carcass along the shoreline in an attempt to capture coyotes scavenging on the carcass. On July 12th, a Turkey Vulture was inadvertently captured in one of the traps. The Turkey Vulture sustained a broken leg. WS Specialist Campbell transferred the animal to ODSVRA staff to be taken to a wildlife rehabilitation facility.

Raccoons were hindering removal of coyotes for the protection of nesting LETE and SNPL. Raccoons exposed and interfered with the padded leg hold traps that were set for coyotes. Therefore, removal of six raccoons was permitted (Table 1).

Owl tracks were observed inside exclosures that were thought to belong to Great horned owls. Great horned owls were the focus of avian predation. However, two barn owls were incidentally captured using pole traps at the west and northeast corner of Pipeline Revegetation on July 25th, 2012. Paul Young (Ventana Wildlife Society) relocated the owls to Kern County on July 26th, 2012.

Table 1: Predator Removal Summary

Date	Species	Sex	Location
5/12/2012	Northern Harrier	Male	NE of 6, Open Riding Area
5/15/2012	Coyote	Female	Boyscout
5/15/2012	Coyote	Male	South Oso Flaco
5/17/2012	Coyote	Male	East Boneyard
5/30/2012	Coyote	Female	Boyscout
6/5/2012	Coyote	Male	South Oso Flaco
6/13/2012	Coyote	Male	Boneyard
6/14/2012	Coyote	Male	South Oso Flaco
6/20/2012	Coyote	Male	South Oso Flaco
6/27/2012	Coyote	Female	South Oso Flaco
6/29/2012	Coyote	Male	South Oso Flaco
7/31/2012	Coyote	Male	South Oso Flaco
7/31/2012	Raccoon	Male	South Oso Flaco
7/31/2012	Raccoon	Female	South Oso Flaco
8/1/2012	Raccoon	Female	South Oso Flaco
8/8/2012	Raccoon	Male	South Oso Flaco
8/14/2012	Raccoon	Female	8 exclosure shore
8/17/2012	Raccoon	Female	8 exclosure shore
7/25/2012	Barn Owl	Unknown	Pipeline Revegetation
7/25/2012	Barn Owl	Unknown	Pipeline Revegetation

Recommendations

WS recommends public education on the restriction of feeding wildlife.

WS recommends that all garbage containers have reinforced lids to prevent garbage consumption by wildlife.

WS recommends maintaining the height and strength of the perimeter fence surrounding the enclosures. Maintenance of fencing where sand has shifted to create low spots or places where mammalian predators can go over should be conducted on a regular basis to prevent predators from entering enclosures.

WS recommends that State Parks continue to enforce the leash law for pets on the beach, which is crucial during nesting season.

WS recommends removal of dead animal carcasses from the beach to eliminate alternate food sources that serve as a lure to scavenging predators such as coyotes.

WS recommends the removal of known LETE and SNPL predators, especially on the shoreline and in nesting areas, prior to predation.

WS recommends the ODSVRA to allow WS Specialist to get permitted to enter areas where predators are located and where damage is occurring, such as the shoreline and the South Oso Flaco Dunes. Having the ability to capture the predators where they are located without having to be escorted by ODSVRA staff could make WS more efficient in removing problem predators.

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Appendix 1: Map of ODSVRA SNPL and CALT Nesting Exclosures and Adjacent Areas

Avian Predator Management Project: Trapping and Relocation of Problem Avian Predators At Oceano Dunes State Vehicular Recreation Area in 2012

Department of Parks and Recreation – Oceano Dunes District / Ventana Wildlife Society

Agreement Number – CO853003

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Avian Predator Management Project:
Trapping and Relocation of Problem Avian Predators at
Oceano Dunes State Vehicular Recreation Area in 2012

Introduction

Oceano Dunes State Vehicular Recreation Area (ODSVRA) contains nesting habitat for California least terns *(Sternula antillarum browni)* and western snowy plovers *(Charadrius nivosus)* along approximately nine miles of coastline and 4,900 acres of coastal sand dunes in southern San Luis Obispo County, California. Contiguous nesting habitat continues to the south for approximately nine miles in the Guadalupe- Nipomo Dunes complex. The California least tern is listed as a state and federally endangered species. Western snowy plover is federally listed as threatened.

Due to human activities that alter the coastal environment, modern California coastal bird colonies are often limited to habitat "islands" consisting of native or partially-native habitat surrounded by areas of farmland, housing tracts, recreational areas, marinas, or other developed areas. This fragmentation of habitat has resulted in concentrations of rare or declining bird species in remnant refuges, or "natural" areas. It also may result in concentrations or localizations of predators, because the prey they hunt is restricted to these small islands of habitat. In most predator-prey relationships, predator pressure is not severe enough to cause prey populations to decline. However, intense predation of adults or young at small, isolated breeding colonies can be a problem for some species when mortality or reduced productivity causes severe population declines. In response, many agencies have initiated programs to reduce predation pressure.

Predator translocation is a program initiated at ODSVRA to protect nesting terns and plovers. Because not every avian predator living in the vicinity of nesting terns and plovers will prey on those species, avian predator removal and translocation is designed to selectively address certain individuals that are actually targeting, or are likely to target, terns and plovers. In 2001, before a predator management plan was in effect at ODSVRA, loggerhead shrikes (*Lanius ludovicianus*) were regularly observed hunting within the plover and tern nesting exclosure fencing, and the ODSVRA resource staff discovered at least seven USGS snowy plover bands in loggerhead shrike castings (mass of undigested food parts). California Department of Parks and Recreation contracted with the UC Santa Cruz Predatory Bird Research Group in 2002 to monitor avian predator activities proximate to plover and tern nesting areas, evaluate the threat of avian predators to these nesting birds, determine which individual avian predators pose an unacceptable threat to the reproductive success of the terns and plovers at this site, and capture, band, and relocate the predatory birds. For the last three years, Ventana Wildlife Society has replaced the UC Santa Cruz Predatory Bird Research Group as the fiscal agent for this project, with the objectives of monitoring avian predator activity, and live-trapping, banding, and relocating avian predators. This report presents results for 2012.

Methods

Surveying, Monitoring, and Trapping

Surveying for raptors and other avian predator species (e.g., shrikes) at the ODSVRA is a continual process throughout the tern and plover nesting season. Raptor populations are a combination of resident birds, transients, and later in the season, juvenile birds dispersing into the ODSVRA from natal territories that are mostly outside the park's boundaries. Raptor movements within the park are dynamic, and areas need to be repeatedly surveyed throughout the breeding season to monitor the behavior of resident birds and recognize the arrival of new avian predator species. Days that are not spent trapping are usually spent surveying or monitoring.

Surveys were conducted from February to September by Paul Young, the primary avian predator specialist at this site since 2002. Surveys consisted of moving slowly on foot or in a vehicle through a selected area, recording the sighting of raptors and other predators, and searching for nocturnal avian predator tracks in the sand. In 2012, Young surveyed the north portion of the park from Arroyo Grande Creek (AG Creek) south to the Maidenform Revegetation Area (during 23 days); the ConocoPhillips refinery area, an area beyond the park's eastern boundary (5 days); the Oso Flaco (OF) Area (26 days); the North Oso Flaco (NOF) Foredunes (15 days); and the South Oso Flaco (SOF) Foredunes (12 days). In addition, the Exclosure Shoreline Area was surveyed by vehicle on 21 days. The Dune Lakes Area, beyond the park's eastern boundary, was usually monitored for northern harrier (*Circus cyaneus*) activity at the same time the north portion of the ODSVRA was surveyed. Because gaining access to the privately-owned Dune Lakes was difficult, this area was monitored from the Dune Lakes Overlook Area within the park's boundaries. The historical peregrine falcon *(Falco peregrinus)* nest site at Shell Beach, approximately 1.5 miles north of ODSVRA, was surveyed on 14 days.

Because ODSVRA is not accessible by paved roads, a four-wheel drive vehicle was essential to trap and survey within the park. In addition, an all-terrain vehicle was used to more quickly access certain areas of the park. In 2008, Young was federally permitted to conduct supervised predator control activities within the plover and tern nesting areas that are closed to the public. This included the use of a vehicle along the shoreline area, which greatly facilitated monitoring, surveying, and trapping efforts in these areas.

Monitoring consisted of observing areas for extended periods with binoculars and a spotting scope from a single location, usually a parked vehicle or prominent observation point. Monitoring efforts usually occurred from the shoreline looking for suspicious gull activity, or the Oso Flaco Area near the south end of the NOF Foredunes. The Oso Flaco Area is a sensitive area where avian predators, particularly shrikes, harriers, and kestrels, funnel through the NOF Foredunes and into the 8 Exclosure.

Observations of avian predators were gathered from surveys, monitoring, and the ODSVRA predator sighting logbook. This logbook contained observations from Young; Doug George, PRBO Conservation Science; Matt Campbell and Kristen Updike, United States Department of Agriculture Wildlife Services (USDA Wildlife Services/Wildlife Services); and the ODSVRA resource ecologists in the field each day. Young trained ODSVRA ecologists in raptor identification and behavior. Frequent field visits and meetings between Young and resource ecologists helped keep resource ecologists, contractors, and management involved and up to date with the latest predator sightings and concerns. Regular email updates from Young of his sightings, activities, and concerns provided the primary flow of information regarding his daily activities. Observations of avian predators by ODSVRA resource ecologists greatly assisted with efforts to monitor raptor movements within the park.

Potential avian predators of tern and plover nests and chicks were identified and targeted for trapping and relocation. Young consulted with the Senior Environmental Scientist at the ODSVRA, or his staff, before birds were removed. Young trapped raptors and shrikes using Bal-chatri traps, Dho-gaza nets, bow nets, or mist nets as appropriate for the targeted species. Young and Ventana Wildlife Society were not responsible for removing gulls, ravens, or non-avian predators at ODSVRA, but contributed observations of these other predators to collaborators. Ventana Wildlife Society and Young were fully permitted under state and federal laws to band and relocate avian predators at this site. Once birds were trapped, they were put into padded and darkened animal carriers, transported away from ODSVRA, and released as soon as possible. Sometimes birds were released the same day as trapped, but most birds in 2012 were released the day after they were trapped, far enough away from the ODSVRA that they would be unlikely to return. Before these birds were translocated, they were fitted with an appropriate-sized USGS bird band (Table 1).

This report summarizes avian predator observations, the number of avian predators trapped, and the number of trap days. Results are also summarized by species. Most observations occurred during the morning and early afternoon hours, times when Young and most ODSVRA plover and tern ecologists were in the field. In the mid-afternoon to evening hours, only one or two park ecologists were usually in the field engaged in predator watch or monitoring plover and tern activity. Therefore, there was an increased chance of missing an avian predator in mid-afternoon or later. A trap day is defined as any part of any day or night when trapping was attempted. The length of any one trap day varied with the perceived threat the avian predator posed to the nesting terns and plovers, weather conditions, species targeted, and trapping success.

Results and Discussion

Eighteen raptors or shrikes were trapped and relocated during 65 trap days at ODSVRA in 2012 (Table 1). These were three great horned owls (*Bubo virginianus,* two adult females and one adult male), one northern harrier (adult male), two American kestrels (*Falco sparverius*, adult males), one peregrine falcon (sub-adult female), two barn owls (*Tyto alba*, adults), and nine loggerhead shrikes (one adult and eight juveniles).

Avian predators were trapped throughout ODSVRA, but trapping efforts were focused mostly in the Exclosure Areas or at the Revegetation Areas immediately adjacent to the Exclosure Areas. One great horned owl was trapped at the Pipeline Revegetation Area, one was trapped at the Maidenform Revegetation Area, and one was trapped at the south end of the NOF Foredunes Exclosure (Fig. 2). The northern harrier was trapped at the Oso Flaco Lakes. One kestrel was trapped at the NOF Foredunes Exclosure, and one was trapped at the Dune Preserve. The peregrine falcon was trapped on the 7 Exclosure shoreline. The two barn owls were trapped at the Pipeline Revegetation Area. An adult shrike was trapped on the shoreline at Oso Flaco Creek. Six juvenile shrikes were trapped at the south end of the NOF Foredunes Exclosure. One juvenile shrike was trapped at the Pipeline Revegetation Area, and another was trapped at the Eucalyptus Revegetation Area.

Most of the trapped birds (N=14, 78%) were relocated the day after capture, but two were relocated two days following capture. Because of extreme heat in the relocation areas, a great horned owl trapped the night of 30 May was released on 1 June, and a shrike trapped on 13 August was released on 15 August. During these times, the temperatures at the beach were cool, but the temperatures at the relocation sites in the Cuyama Valley and the Wind Wolves Preserve were extremely hot. The relocations of these birds were delayed slightly in order for the weather to cool in the relocation areas, thereby making the adjustment easier for the released birds. Birds that were held overnight were fed prior to their release.

Thirty days were spent attempting to trap great horned owls, eight days were spent trapping northern harriers, two days were spent trapping kestrels, one day was spent trapping peregrine falcons, one day was spent trapping barn owls, six days were spent trapping red-tailed hawks, and 17 days were spent trapping shrikes. In addition, 14 days were spent assisting Wildlife Services and resource ecologists in an effort to identify individual gulls that might be preying on plover or tern chicks on the Exclosure shoreline.

No relocated birds were recaptured at the ODSVRA in 2012. Since 2002, only one banded raptor that was trapped and relocated from the ODSVRA returned and was recaptured. In 2009, a banded adult male kestrel was trapped near the ConocoPhillips refinery. This bird was originally trapped as an adult by Young near the refinery in 2008 and banded and released near San Jose, California. In 2010, a juvenile female peregrine falcon that was trapped by Paul Young at the ODSVRA was found to be previously banded. It was later determined that this bird was trapped, banded, and relocated by the USDA Wildlife Services earlier that summer near San Diego, California where its presence constituted an unacceptable threat to a tern colony.

Gulls and Ravens

Problem gulls and ravens are primarily dealt with by Wildlife Services. However, predator management at the ODSVRA is a team effort with the ODSVRA resource ecologists, PRBO Conservation Science, Ventana Wildlife Society, and Wildlife Services, all working together to protect plovers and terns. Young assisted in these efforts by notifying Wildlife Services of any Common Raven (*Corvus corax*) sightings or observations of suspicious gull activity on the Exclosure shoreline.

Three plover nests were depredated by corvids at ODSVRA in 2012. Common Ravens were strongly suspected in the depredation of all three of these nests. Ravens were observed foraging over the plover and tern nesting areas on many occasions. Ravens were positively identified overflying the ODSVRA on at least 17 days, with 12 of these days over the nesting areas. Most of these observations occurred in March and April. Ravens were observed on at least five days between 1 May and 1 September. Preliminary information from other plover nesting areas to the south indicates that these areas were more heavily impacted by raven activity.

Gull activity at the ODSVRA is always a concern during the tern and plover nesting season. Gulls have been observed to kill and eat plover chicks at the ODSVRA nearly every year since predator management became a part of the project. At the ODSVRA, a single gull has been observed to eat four plover chicks from multiple broods in less than 30 minutes (Paul Young, personal observation). Despite the fact that there are hundreds of gulls at the park, probably few gulls exploit the plover chicks as a food source each year. In previous years, the removal of a single gull, observed eating plover chicks, was associated with the apparent stabilization of a precipitous decline in plover chick numbers on the shoreline.

If there was a sharp decline in the numbers of plover chicks observed on the shoreline, or if a gull was observed to eat a plover chick, then Wildlife Services and Young monitored the Exclosure Area Shoreline in their vehicles looking for suspicious gull activity. Gulls were usually not removed by Wildlife Services unless they were observed to catch and eat a plover chick or pursue a plover chick.

In 2012, Wildlife Services did not remove any gulls, although four were removed in 2011. The presence of plover chick remains or bands in the digestive tract of three of the four removed gulls provided evidence that predation by gulls was a problem last year. Plover remains and bands found inside of these gulls indicated that a minimum of 16 plovers had been consumed, including 7 chicks, 3 juveniles, 1 juvenile or adult, and 5 unknown age plovers. The extent of the problem in 2012 is unclear, despite the lack of gulls removed. On several occasions, adult plovers with broods were seen to display near gulls in order to distract the gulls from their chicks. At other times, resource ecologists observed what might have been predatory behavior of gulls towards adult plovers or plover chicks. When this occurred, extra observation time was expended on monitoring gull activity. A probable gull casting found and identified by Doug George after the nesting season contained nine plover bands, providing strong evidence that gull predation on plovers occurred in 2012.

American Kestrel

Two American Kestrels were trapped at the ODSVRA and relocated during the 2012 plover and tern nesting season. One adult male kestrel was trapped on 2 February as it perch-hunted at the NOF Foredunes Exclosure. The other was trapped on 7 March as it perch-hunted at the Dune Preserve. The Dune Preserve is an area inside the park's boundaries, but north of the plover and tern nesting exclosures. The kestrel trapped at the NOF Foredunes was observed on two days before it was trapped. The kestrel at the Dune Preserve was observed in this area on 10 days before a decision was made to trap. The kestrel at the Dune Preserve was observed by Young to fly south on two occasions toward the Exclosure Areas. Two days were spent attempting to trap kestrels.

In previous years, an effort was made to trap adult kestrels prior to their nesting at the ConocoPhillips refinery area approximately a mile and a half east of the 8 Exclosure. There have been no kestrel nests found within the park's boundaries, and the refinery provides the closest suitable nesting habitat for kestrels. The refinery provides many nooks and crannies among the building and refinery equipment for the cavity-nesting kestrels to choose from. In previous years, adult kestrels have been seen on many occasions foraging over the ODSVRA foredunes and then flying east towards the refinery, with prey to feed their young. On 28 July 2007, Doug George observed a female kestrel perched at the north end of the NOF Foredunes with a medium-sized plover chick in its talons. Because kestrels are a well-known predator of plover and tern chicks, and one of the more challenging raptors to trap over the open dunes and beaches, the preemptive removal of adult kestrels near their nesting areas at the refinery, in February and March, has been a useful predator management technique at this site. However, fewer kestrels were found at the refinery in 2011 and 2012, and no attempts were made to preemptively remove kestrels from this area for the last two years. In previous years, surveys had sometimes revealed three or four pairs of kestrels in this area. In late 2010, the refinery management removed many of the old buildings and refinery structures at the south end of the refinery that had previously provided nesting sites for kestrels. Early surveys in February and March of 2012 documented only one pair of kestrels near the refinery.

Although the refinery was the nearest suitable kestrel nesting habitat to the ODSVRA, it was not the only suitable kestrel nesting habitat near the park. Along Highway 1, from Oso Flaco Lake Road near the town of Guadalupe, extending north to Pier Avenue, in the City of Oceano, large eucalyptus groves and various man-made structures also provide potential nesting sites for kestrels. Young has observed kestrels in these areas during the spring and summer months. On 20 June 2007, Young observed an adult male kestrel catch prey at the east end of the Pipeline Revegetation Area and fly with this prey item approximately a mile and half east where it was lost to view in the Eucalyptus groves just north of the refinery. On 6 June 2008, park ecologists again observed a kestrel catch a small prey item from this same area and immediately fly to the east where it was lost to view. These birds were probably delivering prey to nests in this area.

In 2012, kestrels were observed at the ODSVRA on 22 days from 1 February to 1 September. Kestrels were observed on seven days in February, seven days in March, zero days in April, May, and June, three days in July, and five days in August. On 31 July and 29 August, two kestrels were seen at the same time in the vicinity of the Exclosure areas. Most of the kestrel sightings in July and August were probably of juvenile birds exploring new territory.

Loggerhead Shrike

Nine shrikes were trapped at the ODSVRA during the 2012 plover and tern nesting season. One adult shrike was trapped in February at the Oso Flaco Creek shoreline. Six juvenile shrikes were trapped in June, July, and August inside the NOF Foredunes Exclosure. One juvenile shrike was trapped in July at the Tabletop Revegetation Area, and one juvenile shrike was trapped in August at the Pipeline Revegetation Area. A total 17 days were spent attempting to trap shrikes.

Loggerhead shrikes have been observed to prey upon least tern and snowy plover chicks at the ODSVRA in previous years. Shrikes have also been strongly suspected in the deaths of several adult plovers killed in previous years inside small single nest exclosures with net tops.

Tern and plover chicks are particularly vulnerable to attacks from diurnal avian predators such as shrikes, kestrels, and red-tailed hawks that might perch-hunt near the shoreline of the exclosure area. The typical plover chick defense response to an avian predator, after the predator is spotted, is to crouch and freeze (Young, personal observation). This response can be effective provided the avian predator does not stay in the area for an extended period of time. The response is less effective with prolonged exposure to predators. Perch-hunting can prolong the exposure. Unlike kestrels or red-tailed hawks, shrikes are exclusively perch-hunters, and have the smallest hunting territories of any of the avian predators found at the ODSVRA. Because their territories are small, a shrike whose territory coincides with an abundance of plover or tern chicks can have relatively easy access to plover or tern chicks every day. These characteristics combined with an aggressive predatory nature that is unusual for such a small bird, and the slow and methodical way that they hunt their territories, make them a species of considerable concern at the ODSVRA. Shrikes within ODSVRA and far removed from the plover and tern nesting areas were rarely trapped.

Early surveys and monitoring efforts at the ODSVRA during the beginning of the 2012 season revealed a single adult shrike whose territory included the NOF Foredunes, the Oso Flaco Creek area, and the north end of the SOF Foredunes. The NOF Foredunes and the SOF Foredunes are a system of elevated sand dunes that run parallel and immediately adjacent to the shoreline. Because these foredunes are elevated and graduate quickly to the shoreline, an avian predator perch-hunting from these areas would have a clear view of plover chicks foraging on the shoreline. This single adult shrike was trapped on 16 February as it perch-hunted the low foredunes just east of the mouth of Oso Flaco Creek. This bird was identified by plumage as an adult (unknown sex), banded, and relocated the next day (Table 1) to the Cuyama Valley in San Luis Obispo County.

Shrikes were observed on 23 days at the ODSVRA during the 2012 season. Shrikes were observed in February on six days (NOF and SOF), zero days in March, April, and May, one day in June (NOF), four days in July (NOF and Tabletop Revegetation Area), and 12 days in August (Pipeline Revegetation Area, NOF, SOF, and the Dune Preserve Area).

Most of the shrike sightings were of birds perch-hunting in the NOF Foredunes Exclosure. Six of the nine shrikes trapped at the ODSVRA were trapped inside the NOF Foredunes Exclosure. From a predator management standpoint, the NOF Foredunes are a particularly sensitive area because conditions favor perch-hunting avian predators. These narrow, almost linear north-south elevated sand dunes provide a clear view of the Boneyard Exclosure Area, the 8 Exclosure Area, and the NOF Shoreline Area. A shrike perch-hunting from the fencing on the west side of the NOF Foredunes would be among the plover chicks on the shoreline in this area. In previous years at the ODSVRA, shrikes have been observed to perch-hunt from the west fence in the NOF Foredunes Area, and then move north along this fence line into the 8, 7, and 6 Exclosures, where the majority of plover and tern chicks are located.

The Pipeline Revegetation Area, as well as the NOF Foredunes and the SOF Foredunes, is an area of special concern associated with perch-hunting avian predators. The Pipeline Revegetation Area juts into the area between the eastern portion of the 7 and 8 Exclosures, and provides an elevated view into the plover and tern nesting habitat. In previous years, shrikes have been observed flying from the west end of the Pipeline Revegetation Area to the 7.5 Revegetation Exclosure Area on the shoreline to the west. One year, a shrike perch-hunting from the 7.5 Revegetation Exclosure Area and the west fence near it, was observed to kill a tern chick in the 7 Exclosure and eat it in the 7.5 Revegetation Exclosure Area. This bird was strongly suspected in the disappearance of additional plover and tern chicks in this area before it was finally trapped. During the 2012 season at the ODSVRA, one juvenile shrike was trapped at the Pipeline Exclosure Area on 15 August. Another juvenile shrike was trapped on 16 July at the Tabletop Revegetation Area approximately 400 yards to the north of the Pipeline Revegetation Area.

The eight juvenile shrikes that were trapped at the ODSVRA this year probably originated from natal territories to the east and south of the ODSVRA park boundaries because surveys early in the season revealed only a single adult shrike within the park's boundaries. This bird was first observed on 1 February and trapped on 16 February. Six of the remaining eight juvenile shrikes were trapped on the same day they were first seen. Two juvenile shrikes were trapped the day after they were first observed. Two shrikes were relocated on the same day they were captured, and six shrikes were relocated the day after they were captured. One shrike that was captured on 13 August was released on 15 August. This bird was kept an additional day due to the extreme temperature differential at this time between the cool coastal habitat where this bird was trapped and the extreme heat at the relocation areas inland. Six shrikes were relocated to the Cuyama Valley in San Luis Obispo County, and three shrikes were relocated to the Wind Wolves Preserve in Kern County.

On 1 August, a shrike was observed at the south end of the Dune Preserve Area. Because shrikes have small territories and the Dune Preserve Area is well north of the plover and tern nesting areas, this bird was not trapped. On 21 August and 27 August, a shrike was observed in the SOF Foredunes at the park's southern boundary. This bird was not trapped because there were no plover chicks in this area at this time. On 26 August, a shrike was seen in the NOF Foredunes, and on 28 August a shrike was seen in the Pipeline Revegetation Area. Neither of these birds was trapped because by that time there were no remaining plover and tern chicks that had not fledged.

Great Horned Owl

Three great horned owls were trapped during the 2012 plover and tern nesting season at the ODSVRA. One adult female great horned owl was trapped at the Pipeline Revegetation Area on 18 April, one adult female great horned owl was trapped at the Maidenform Revegetation Area on 30 April, and one adult male great horned owl was trapped at the south end of the NOF Foredunes Exclosure on 30 May. A total of 30 days were spent attempting to trap great horned owls at the ODSVRA this year.

Great horned owls are a common resident species at the park. Great horned owl predation of incubating adult plovers and terns at night has been documented at other sites, and has occurred in previous years at the ODSVRA. Relatively little is known about great horned owl predation of plover and tern chicks on the shoreline or inside the nesting exclosures.

Great horned owl activity at the ODSVRA is monitored by regular surveys of all the revegetation areas surrounding the plover and tern nesting habitat. In 2012, the Pipeline, Maidenform, Eucalyptus, and Tabletop revegetation areas were surveyed for large owl tracks left in the sand on 23 days. The Oso Flaco Area was surveyed on 10 days, the NOF Foredunes were surveyed on 15 days, and the SOF Foredunes were surveyed on 12 days. Careful attention was also paid to large owl tracks observed by resource ecologists and Doug George inside the 6, 7, and 8 Exclosures, which were generally off limits during the active portion of the plover and tern nesting season. When large owl tracks were observed inside the exclosure area, they were reported over the resource radio immediately so all interested parties were aware of them. Heavily vegetated areas surrounding the exclosure area were sometimes walked during the day with the intent of flushing any roosting owls from the willow thickets in these areas. Because predatory behavior of great horned owls is not easily observed at night, the decision to trap a great horned owl was influenced by the regularity and abundance of owl activity in a particular area, as indicated by track sign and the proximity of this track sign to the concentrations of nesting plovers and terns.

During the 2012 plover and tern nesting season at the ODSVRA, large owl tracks were observed on 75 days either inside the exclosure areas or in, or around, adjacent revegetation areas. In 2011, large owl tracks were observed in these areas on 15 days. In 2010, large owl tracks were observed in these areas on 42 days. These observations do not include the Dune Preserve Area or those areas to the north which are somewhat removed from the plover and tern nesting areas. There were no large owl tracks found at any snowy plover or least tern nests at the ODSVRA in 2012. Large owl tracks were observed on 14 days in March, 9 days in April, 16 days in May, 17 days in June, 10 days in July, and 9 days in August. Large owl tracks were observed in the Pipeline Revegetation Area (43 days), the Eucalyptus Revegetation Area (2 days), the NOF Foredunes (10 days), the SOF Foredunes (6 days), the Boneyard Exclosure (15 days), the 8 Exclosure (16 days), the 7 Exclosure (11 days), and the 6 Exclosure (2 days). These observations are limited to the days that large owl tracks were observed and not the number of owl tracks that were seen in each area on each day.

In 2012, surveys of suitable great horned owl nesting habitat at the ODSVRA, including last year's active nest site in the Oso Flaco Lake Area and the area between the refinery and the park, revealed no active great horned owl nests. However, great horned owls hunting near the Exclosure Areas might be associated with an active nest somewhere. Therefore, a strong effort was made to confirm a targeted owl was roosting in the Eucalyptus, Pipeline, or Maidenform Revegetation Areas before it was trapped in order to avoid trapping a great horned owl that might be incubating eggs or caring for young. A great horned owl that was roosting in these areas during the day would not likely be attached to an active nest site away from these areas because both the adult male and female owls would be expected to roost near their active nest site during the day. Highly territorial and abundant at ODSVRA, great horned owls are the avian species most likely to quickly reoccupy a vacant territory (Young, personal observation). Therefore, the timing of the removal of this species is important so as to provide adequate protection for the nesting plovers and terns without trapping great horned owls in unnecessary numbers.

On 16 April, Matt Campbell (Wildlife Services) and Paul Young surveyed the Maidenform and Pipeline Revegetation Areas in separate vehicles looking for great horned owls that might be emerging from these areas at dusk. Young observed a great horned owl fly out of the Pipeline Revegetation Area at 19:25 and perch at the northwest corner of this area. While this bird was still in view, Matt Campbell observed a great horned owl emerge from the Maidenform Revegetation Area and perch there. An adult female great horned owl was trapped at the northeast corner of the Pipeline Revegetation Area by Young on 18 April and relocated the next day to the Cuyama Valley in San Luis Obispo County. Another adult female Great Horned Owl was trapped by Young at the Maidenform Revegetation Area on 30 April. This bird was first seen to perch in this area at 18:15 and was trapped at 19:50. This owl was released the next day along the Cerro Noroeste Road, in Kern County. An adult male great horned owl was trapped by Young at the south end of the NOF Foredunes Exclosure on 30 May at 20:25. This bird was relocated on 1 June to the Wind Wolves Preserve in Kern County.

On 18 July, a resource ecologist found two clipped wings belonging to a snowy plover approximately five feet from a plover mini nesting exclosure. The mini nesting exclosure was on the shoreline roughly between the 7.5 Revegetation Exclosure and the north end of the NOF Foredunes. This was an abandoned nest and may have been abandoned due to the death of one of the adult plovers. It is possible that this was a depredation event involving a great horned owl.

Peregrine Falcon

One sub-adult female peregrine falcon was trapped at the ODSVRA during the 2012 plover and tern nesting season. One day was spent attempting to trap peregrine falcons.

Peregrine falcons are a common local resident at the ODSVRA. There is a historical peregrine falcon nest site on a sea cliff in the Shell Beach area approximately three miles to the north of the northern boundary of the park. There are also active peregrine falcon nest sites near Avila Bay to the north, near the small town of Edna to the northeast, and near Point Sal to the south. In addition to resident adults, transient adults, sub-adults, immature, and juvenile peregrine falcons are usually seen each year at the ODSVRA during the plover and tern nesting season.

The historical peregrine falcon nest site near Shell Beach has not been active for the last three years, but one or two peregrine falcons are regularly seen perched or flying in this area. From a predator management standpoint, it is important to monitor the active status of this nest site in order to avoid trapping a problem adult peregrine falcon at the ODSVRA that might be attached to an active nest site. In addition, peregrine falcons perched at the Shell Beach nest site can be closely observed, and head markings and plumage characteristics noted, so these individuals might be recognized when they are seen at the ODSVRA. The Shell Beach peregrine falcon nest site was surveyed by Young on 14 days during the 2012 season. It was surveyed in February (4 days), March (4 days), April (4 days), and June (2 days). On most survey days, a peregrine falcon was seen perched near the historical nest site. Peregrine falcons were seen on 3 February (an adult female), 23 February (an adult female), 27 February (an adult male and adult female), 29 February (an adult male and adult female), 13 March (an adult male and adult female), 14 March (an adult male and adult female), 21 March (an adult male and adult female), 26 March (an adult female), 10 April (an adult female), 11 April (an adult male, adult female and a sub-adult male), 24 April (an adult female), 4 June (an adult male), and 23 June (an adult female and adult male) were seen at the historical nest site at Shell Beach. There was just one adult female seen this year at Shell Beach. This bird had a full black head, peachy/buff markings on its upper chest area, and bold horizontal barring on its flanks. This is probably the same bird that was seen last year here as a sub-adult. There were three different male peregrines seen at this nest site this year. All but two of these sightings were of the resident adult male peregrine that has been associated with this nest site for many years. This bird also has a full black head, clear white chest and faint horizontal barring on its flanks. On 11 April, a sub-adult male peregrine was observed courting the adult female but was driven off when the resident adult male returned. On 23 June, the adult female was observed perched near a different adult male peregrine near the nest cliff. This adult male was smaller, and it did not have a full black head. No copulations were seen and no incubation behavior was observed. None of the peregrine falcons here were banded.

The Shell Beach peregrine falcon nest site is the closest peregrine nest site to the ODSVRA. The adult male peregrine that was seen at the old nest cliff in this area has been seen by Young to fly south towards the ODSVRA on many occasions and can reach the northern border of the ODSVRA after only several minutes of level flying. The plumage and head markings of the adult male peregrine are identical to the plumage and head markings of the adult male peregrine that was seen on at least 49 days perched in or near the plover and tern nesting areas in 2011. Adult peregrines with full black heads were rarely seen at the ODSVRA in 2012. Most of the sightings of peregrine falcons at the ODSVRA in 2012 were of peregrines with a more pronounced malar stripe. On 27 May, 3 July, 19 July, and 8 August, an adult male and an adult female peregrine falcon were seen together at the ODSVRA perched inside the Exclosure Area. Both of these birds had a full black head and were probably the resident adult birds associated with the historical nest site at Shell Beach.

Peregrine falcons were observed on 76 days at the ODSVRA in 2012. They were observed on 86 days in 2011 and on 85 days in 2010. In 2012, peregrine falcons were seen in March (16 days), April (18 days), May (10 days), June (4 days), July (14 days), and August (14 days).

It was sometimes a challenge to determine the age and sex of peregrine falcons that were observed in the field at the ODSVRA. The factors that contributed to this challenge were visibility (distance, heat shimmer, and fog), the mobility of the falcon (flying or perched), the similarities between the plumages of peregrines of different ages (adult, sub-adult, immature, or juvenile), the sex of the bird (size), and the experience of the observer in the field. Male peregrines are a third smaller than female peregrine falcons, but their plumages can be similar. Determining the relative size of a single peregrine falcon at a distance is difficult. The challenge of identifying individual peregrine falcons was simplified by photographing these birds when possible and then comparing plumage characteristics and head markings. The photographs, taken with cameras affixed to spotting scopes by resource ecologists and emailed to Young, helped to inventory individual birds and help keep track of individual peregrine falcons that were regularly seen in or around the Exclosure Areas. This was important because peregrine falcons have been the raptors most likely to prey upon adult snowy plovers and least terns at the ODSVRA over the last 10 years, and they are afforded an additional level of protection by regulating authorities. If a peregrine falcon were to become a problem bird, and threaten the breeding success of plovers or terns, then it would be necessary to know exactly which individual peregrine falcon needed to be live trapped.

Despite the challenges of determining peregrine falcon ages and sex, most identifications were reliable enough to include in a breakdown of age and sex-specific peregrine falcon sightings at the ODSVRA for the 2012 season. Adult peregrines of unknown sex were observed on 33 days. They were observed in March (14 days), April (6 days), May (5 days), June (1 day), July (2 Days), and August (5 days). Adult male peregrine falcons were seen on at least 5 days. Adult female peregrine falcons were seen on at least 13 days. Adult peregrine falcons with a full black head were seen on five days at the ODSVRA. Adult peregrine falcons without a full black head and with a more pronounced malar stripe were seen on 15 days.

Sub-adult peregrine falcons were observed on at least 10 days. Sub-adult peregrine falcons were seen in March (1 day), April (1 day), May (4 days), June (1 day), July (2 days), and August (1day).

An immature peregrine falcon was seen at the ODSVRA on 19 April, 2012.

Juvenile peregrine falcons were seen at the ODSVRA this season in July (3 days) and August (4 days).

Peregrine falcons of unknown age or sex were observed on 32 days. These birds were usually seen flying through or near the exclosure areas.

Peregrine falcons were observed catching or consuming birds at ODSVRA on 23 occasions in 2012, similar to the number observed in the two previous years. These observations included a variety of prey species, included a sanderling (*Calidris alba*, 1), a California gull (*Larus californicus*, 1), a western gull (*L. occidentalis*, 1), Heermann's gulls (*L. heermanni*, 2), unidentified gulls (5), snowy plovers (3), a least tern (1), Brewer's blackbirds (*Euphagus cyanocephalus*, 2), unidentified medium-sized shorebirds (3), an unidentified small shorebird (1), and an unidentified small bird (1). Adult peregrines were associated with 15 of these predation events, whereas sub-adult and juvenile peregrines were associated with three and two of these events, respectively. One predation event, on 13 April, involved a peregrine that could not be aged.

In 2012, peregrine falcons were observed eating prey on the shoreline between the park's northern boundary and the Pavillon Hill area on 11 occasions. Most of these prey items were gulls. Peregrine falcons were observed consuming prey inside the 6 Exclosure or on the 6 Exclosure shoreline on five occasions. On two occasions, peregrine falcons landed briefly in the 6 Exclosure with a prey item but did not consume it there. Peregrine falcons were observed consuming prey in the 7 Exclosure on one occasion and the 8 Exclosure on one occasion. A peregrine was observed to catch a Brewer's blackbird over the NOF Foredunes and fly northeast with this bird in its talons.

In addition to those real-time observations of peregrine falcons eating or carrying avian prey, there were bird carcasses of many species found by resource ecologists in the field throughout the season at the ODSVRA. Most of these carcasses were gulls and appeared to be depredated by an avian predator. Many of these carcasses identified as avian depredations were probably peregrine falcon kills.

At approximately 07:00 on 23 May, a resource ecologist observed a peregrine falcon perched on the 6 Exclosure shoreline. This bird appeared to be hunting plover chicks in this area and was observed to catch and eat a small plover chick. Several attempts were made to flush this bird from the Exclosure Area, but the peregrine only flew several hundred feet and then resumed its hunting behavior. Flushing this bird from the Exclosure Area became problematic because of the disturbance to the many plover chick broods on the shoreline and the risk of revealing these chicks to the peregrine while trying to flush it. Paul Young arrived on the shoreline about an hour later, and the peregrine appeared to be still actively hunting plover chicks inside the 6 and 7 Exclosure and the Exclosure shoreline. In addition, this peregrine landed in the 6 Exclosure and was observed by several resource ecologists to depredate a plover nest consisting of eggs in this area. This nest was approached later in the day and found to be depredated with peregrine falcon-sized tracks at the nest site. This peregrine falcon was trapped by Young at approximately 09:00. Once in the hand, this bird was identified as a sub-adult female peregrine falcon. This bird was relocated the next day to the Shasta Valley Wildlife Area, Siskiyou County. Before it was released, this bird was banded, photographed, weighed, and measured. After this bird was released on 24 May, a casting was recovered from the animal carrier this bird was transported in. This casting contained seven plover chick bands and a very small amount of fine feather material. These seven bands account for at least two plover chicks and account for two of the three snowy plovers definitely depredated by peregrine falcons at the ODSVRA in 2012. These bands were turned over to resource ecologists.

On 3 July, an adult peregrine was observed perched in the 6 Exclosure with a small shorebird in its talons. The peregrine flew out of the Exclosure and left the prey item there. The prey item was recovered and identified as a banded juvenile snowy plover.

On 31 July, a sub-adult peregrine falcon was observed in the 6 Exclosure eating a small prey item. Later in the day the prey remains were collected, and the prey was identified from the plucked feathers as a near fledgling or fledgling least tern. This sub-adult peregrine falcon had a blue or black band affixed to its left leg. It probably had a USGS silver band on its right leg, but this band was not seen. The sub-adult female peregrine falcon previously trapped by Young and relocated was banded with a single silver USGS band on its right leg. This banded sub-adult peregrine falcon seen on 31 July was only positively identified on this one day at the ODSVRA.

On 11 August, a feather pile was observed by Doug George in the 6 Exclosure. George collected these feathers as well as a tern band that was associated with the prey remains. These prey remains were of a juvenile least tern and were probably the result of a predatory event involving a peregrine falcon.

Peregrine falcons were flushed from sensitive plover and tern nesting areas by resource ecologists on at least seven days. Adult peregrine falcons were flushed on three days, sub-adults were flushed on three days, and a juvenile peregrine was flushed on one day. Often, an individual bird had to be flushed repeatedly before it would leave a sensitive area. Flushing a raptor can disturb the nesting plovers and terns. Therefore, flushing a raptor entails a complicated effort of coordination with the entire resource staff in order to prevent plovers and terns from suspending incubation duties, chicks from running into the open riding area, and chicks separating themselves from the adults. Resource staff also monitored the peregrine after it was flushed to see if it re-perched in another sensitive location in the large Exclosure Area.

Hazing with a bird-whistler device was another technique that was used on a few occasions in order to dissuade a raptor from frequenting a sensitive area. A bird-whistler device is a small hand-held gun that when fired propels a small whistling projectile approximately 75 yards. Bird whistler devices are commonly used at landfills and vineyards to scare birds. They can be bought at farm supply stores without a permit. On 20 March, Young hazed an adult female peregrine falcon that was perched at the north end of the NOF Foredunes Exclosure. Young was able to get within 100 feet of this bird before firing a bird-whistler device in its general direction. The peregrine flew 200 yards to the south and re-perched in the NOF Foredunes. On 19 July, an adult male and adult female peregrine falcon were perching and hunting inside the 7 Exclosure and the 7 Exclosure shoreline. These were probably the adult falcons associated with the historical peregrine falcon nest site at Shell Beach. Young was able to haze one of the adult falcons with the bird-whistler device from 100 feet as it perched in the 7 Exclosure. This bird flew approximately one hundred yards to the north and re-perched in the 7 Exclosure. Young hazed the second falcon as it perched near the west fence of the 7 Exclosure and shortly afterwards, both peregrines flew together northwest over the water. Prior to hazing these falcons, Young tried to tempt the falcons out of the Exclosure area by releasing pigeons on a long line with a weight attached and then recover the pigeons before the peregrines could reach them. Young did this in the open riding area well east of the Exclosure's east fence. Both peregrines responded immediately from 300 to 400 yards away on two separate occasions but returned to the exclosure afterwards. This technique, however, might prove useful in the future in order to lure a peregrine out of a sensitive area when the object is not to trap the falcon.

Northern Harrier

One adult male northern harrier was trapped and relocated at the ODSVRA during the 2012 plover and tern nesting season. This bird was trapped near the Oso Flaco Lakes area. A total of eight days were spent attempting to trap harriers.

Harriers were observed on at least 53 days at the ODSVRA in 2012. Harriers were observed in March (15 days), April (10 days), May (15 days), July (7 days), and August (6 days). Often, there were multiple sightings of harriers on a single day. These sightings were of both sexes and all age classes. Adult harriers are easily identified according to sex by differing plumage characteristics. Immature harriers have the general plumage characteristics of juvenile harriers but are not as richly colored and were seen at the ODSVRA before July. Juvenile male and female harriers, seen after they had fledged in July, have the same plumages, but juvenile male harriers are a third smaller. Juvenile harrier sightings were not categorized according to the sex of the bird.

Adult female harriers were observed on at least 31 days at the ODSVRA during the 2012 plover and tern nesting season. They were seen in March (15 days), April (7 days), May (7 days), and August (2 days). A "brown" harrier was seen on 15 July and this could have been an adult female or a juvenile bird.

Adult male harriers were observed at ODSVRA on 19 days. Adult male harriers were seen in March (3 days), April (5 days), May (10 days), and July (1 day).

Immature harriers were seen at the ODSVRA on 27 March and 25 April.

Juvenile harriers were seen at the ODSVRA on 9 days. They were seen on 5 days in July and 4 days in August.

In 2008-2010, most of the plover nests that were lost to avian depredation were believed lost as a result of depredation events involving an adult male harrier. In 2008, Doug George was able to investigate a freshly depredated plover nest in the Boneyard Exclosure Area after an adult male harrier was seen to immediately leave this area. The egg contents were still wet in the sand, and tracks consistent in shape and size to a male harrier were found at the nest site. On 10 June 2009, resource ecologists observed an adult male harrier landing at an active plover nest in the 8 Exclosure and eating all three plover eggs. Eggshells were at the nest site and egg contents were clumped into the sand beneath the nest bowl.

In 2011, an adult male harrier was not observed to depredate a plover nest, and harrier tracks were not found at a depredated plover nest. Nevertheless, an adult male harrier was suspected in the loss of some plover nests at the ODSVRA in 2011. Ten plover nests were lost to avian depredation in 2011. Five of these were lost to corvids (probably a raven), and five of these were lost to an unknown avian predator. Of the nests that were lost to an unknown avian predator, eggshell fragments were sometimes found at the nest site and the egg contents were found clumped into the sand beneath the nest bowl. The spillage of the egg contents was similar to those depredation events attributed to the adult male harrier in 2008 and 2009. A snowy plover nest depredation involving ravens usually involved less spillage and the eggs are usually carried a short distance from the nest before being consumed. It is possible that the size and shape of the harrier beak is the cause of this spillage. Avian predator tracks at a depredated plover nest might not provide additional evidence of predator identity because these tracks are over-tracked within minutes as the adult plovers investigate their depredated nest and carry off any remaining egg shell fragments. All the plover nests that were lost to an unknown avian predator were lost in June, and an adult male harrier was observed at the ODSVRA on 15 days during that month.

We observed early signs of an active northern harrier territory at Oso Flaco Lake, and it was here that an adult male was trapped. On 23 March 2012, a resource ecologist observed an adult male harrier and an adult female harrier flying together over Oso Flaco Lake. Oso Flaco Lake is within the park's boundaries and drains to the ocean via Oso Flaco Creek. It is approximately one quarter mile from the SOF Shoreline and less than a quarter mile to the Boneyard Exclosure Area. On two days in late March and one day in early April, Young surveyed the Oso Flaco Lake Area and observed an adult male and adult female harrier frequenting a marshy area on the east side of the lake. The adult male harrier was observed to feed the adult female here on two occasions, and territorial aggression was observed between the adult female and another female harrier, and also between the adult male harrier and a red-tailed hawk. The adult female harrier had not laid eggs in this area yet, but it was strongly suspected the pair would nest if left undisturbed. Because of the close proximity of the Oso Flaco Lake Area to the nesting habitat of the plovers and terns, it was decided to trap the adult male harrier. On 6 April, an adult male harrier was trapped at this marshy area on the east side of the Oso Flaco Lake. This bird was relocated the next day to an area near Lone Pine in Inyo County. No attempt was made to trap the adult female harrier seen in this area.

After this bird was trapped, there were no adult male harrier sightings at the ODSVRA until 27 April. There were sightings of an adult male and adult female harrier seen together south of the park's southern boundary. Between 28 April and 12 May, an adult male harrier was seen on almost a daily basis hunting low over the 6, 7, 8, and Boneyard Exclosure Areas. An adult male harrier was seen in these areas on every day but one between 2 May and 12 May. On many days during this time period, there were multiple sightings of an adult male harrier hunting the Exclosure Area. An adult male harrier was observed to land at plover nests inside the 6 and 7 Exclosures and consumed eggs and one small chick during at least four occasions. Five plover nests were lost to a depredation event involving an adult male harrier between 2 May and 12 May, and an adult male harrier was strongly suspected in the loss of an additional five nests during this time period. On 10, 11, and 12 May, Paul Young attempted to trap this bird with a remote controlled bow net and bal-chatri traps set up inside the 7 Exclosure. These trapping efforts were unsuccessful and the adult male harrier was lethally removed by Wildlife Services on 12 May. When examined, this bird was found to be unbanded. There was only one sighting of an adult male harrier after 12 May at the ODSVRA in 2012.

It is unknown if the adult male harrier removed by Wildlife Services this year is the same bird that has been depredating plover nests at ODSVRA since 2008.

Red-tailed Hawk

No red-tailed hawks (*Buteo jamaicensis*) were trapped at the ODSVRA during the 2012 plover and tern nesting season. Six days were spent attempting to trap red-tailed hawks.

Red-tailed hawks are a common local resident at the ODSVRA. There were at least two active red-tailed hawk nests located between the refinery and the eastern boundary of the park. On 16 March, Young found an active red-tailed hawk nest in a large tree in a willow thicket along the sand road between the refinery and the park's eastern boundary. This nest site was visited later, when there should have been young, but no adults or young were seen. No juvenile red-tailed hawks were seen at the ODSVRA in June, July, and August of 2012. Last year, the resident pair of red-tailed hawks fledged at least two young, and the adults and young could be seen perched together in the Maidenform Area in August.

Red-tailed hawks have not been observed to take adult plovers or terns or their chicks at the ODSVRA over the last 10 years. They have been observed to depredate plover nests and kill plover and tern chicks at other sites. Red-tailed hawks were the most commonly observed raptor at the ODSVRA. Most of these sightings were of a resident pair of adults that were seen almost daily hunting the heavily vegetated areas east of the plover and tern nesting areas. Earlier in the season, there were sightings of immature and sub-adult red-tailed hawks at the ODSVRA, but these birds were usually driven off by the resident pair of red-tailed hawks as their own eggs approached hatching each year (Young, personal observation). The resident pair of red-tailed hawks has not been trapped because they usually hunt to the east of the plover and tern nesting areas and usually do not perch in areas that overlook the areas where plover and tern chicks are found. Red-tailed hawks perch-hunting at the west end of the Pipeline Revegetation Area, the NOF Foredunes Exclosure, the SOF Foredunes Area, or the 7.5 Revegetation Exclosure, are a greater concern. Red-tailed hawks that are observed perched in these areas are identified according to age, if possible, so the correct individual can be trapped if necessary.

During 2012, red-tailed hawks were observed perched in the NOF Foredunes (36 days), the 7.5 Revegetation Exclosure (26 days), the SOF Foredunes (7 days), and the west end of the Pipeline Revegetation Area (3 days). Red-tailed hawks were observed in the same areas in 2011 but on fewer days.

During 2012, red-tailed hawks were observed perched in these sensitive areas in March (20 days), April (7 days), May (8 days), June (17 days), July (15 days), and August (4 days). In March, the red-tailed hawks that were observed in these sensitive areas that were identified according to age were adults (2), sub-adults (2), and immatures (11). In April, the red-tailed hawks that were observed in these sensitive areas were an adult (1), and immatures (5). After mid to late April, all of the observations of red-tailed hawks that were perched in these sensitive areas and could be identified according to age were of adult red-tailed hawks. Regular observations of these birds indicated that they were the resident pair of adult red-tailed hawks.

From 12-22 June, an adult red-tailed hawk was observed perched in the 7.5 Revegetation Exclosure on 9 days. It was usually seen here at first light, and if it was flushed, it would rarely come back to this area for the rest of the day. Young attempted to haze this bird during this time period but was not able to get close enough for the hazing to have the desired effect. During this 11-day period, an adult red-tailed hawk was flushed from this area on several occasions by Young or resource ecologists. After 22 June, a red-tailed hawk was not observed in this area until 4 July. In July, there were four red-tailed hawk sightings at the 7.5 Revegetation Exclosure, and in August there was one.

The increased number of adult red-tailed hawk sightings in sensitive areas at the ODSVRA in 2012 might be because the resident pair of red-tailed hawks had a nest failure or their young died. This lack of responsibility might have freed them from nest defense duties farther east and may have allowed them increased time to hunt less substantial prey in the foredunes.

Merlin

No merlins were trapped and no trapping efforts were made at the ODSVRA during the 2012 plover and tern nesting season.

Merlins are small, highly migratory falcons that spend the fall and winter months in California and migrate out of the ODSVRA by approximately mid-April to their nesting areas to the north. Merlins and peregrine falcons are the diurnal raptors most likely to take adult snowy plovers at the ODSVRA. Merlins have usually migrated north before the snowy plover chicks have hatched and are almost always gone before the least terns arrive to begin nesting.

In 2004-2006 at the ODSVRA, merlins were seen to catch and consume an adult plover once each year. Merlins have not been documented depredating snowy plovers since then at the ODSVRA, but an adult female was found eating a small shorebird in 2011 that might have been a snowy plover. Merlins were seen on at least 3 days during the 2012 season. They were seen in March (1 day), April (1 day), and in August (1 day).

Barn Owl

Two adult barn owls were trapped on 24 July by Kristen Updike (Wildlife Services) and Paul Young. These birds were trapped at the Pipeline Revegetation Area. One day was spent trapping barn owls.

Barn owls are rarely seen at the ODSVRA. While great horned owl trapping at night, barn owls are sometimes heard vocalizing. On 24 July, while attempting to trap a great horned owl in the Pipeline Revegetation Area, Updike and Young unintentionally trapped two barn owls in their traps. Because barn owls have become a problem at other sites, and the Pipeline Revegetation Area is a sensitive area, these birds were relocated the next day to the Cerro Noroeste Road Area in Kern County.

Other Raptors

Red-shouldered hawks (*Buteo lineatus*) were seen regularly at the campgrounds near Pier Avenue and probably nested in this area. They were also occasionally seen near AG Creek.

Cooper's hawks (*Accipiter cooperii*) were observed on 9 days at the ODSVRA and were usually just passing through or hunting the more heavily vegetated portions of the park. Most of these sightings were in the AG Creek Area or the Dune Preserve Area.

Sharp-shinned hawks (*A. striatus*) were seen on two days at the ODSVRA.

Ospreys (*Pandion haliaetus*) were regularly seen at the ODSVRA. These fish-eating raptors were occasionally flushed by resource ecologists when their presence constituted a disturbance factor for the plovers and terns.

Golden eagles (*Aquila chrysaetos*) were seen on one day at the ODSVRA.

Burrowing owls (*Athene cunicularia*) were seen on one day in March in the Oso Flaco Area.

White-tailed kites (*Elanus leucurus*) were seen on 8 days at the ODSVRA. Six of these sightings were in August.

Prairie falcons (*Falco mexicanus*) were seen on one day at the ODSVRA. A prairie falcon was observed eating a small bird in the 7 Exclosure on 20 July. This falcon was banded with a silver band on its right leg and a green band on its left leg.

Recommendations

Ventana Wildlife Society encourages the ODSVRA management to continue the practice of depositing wood chips and other substrates into the 6, 7, and 8 Exclosures early in the season. This substrate probably makes it harder for avian predators to locate incubating terns and plovers and their chicks. In addition, the manufactured tern shelters and the larger pieces of wood can provide a hiding place for tern and plover chicks should an avian predator suddenly appear. The practice of depositing wrack on the Exclosure Shoreline, while ultimately creating an invertebrate food source for the plovers, also provides cover for the tern and plover chicks.

In 2012, a large portion of the west fence on the 6 and 7 Exclosure Shoreline was moved 100 feet to the east to increase the size of the shoreline area to allow natural wrack deposition to increase on the shoreline habitat. This probably provided more available food resources for the plovers, and a larger, more complicated topography on the shoreline that was more difficult for mammalian and avian predators to hunt thoroughly. It is recommended that the west fence stay in its present location and not be moved to the west where it would functionally create a narrower shoreline.

It is also important to maintain the current size of the fenced tern and plover nesting exclosures. One of the most basic advantages nesting terns and plovers enjoy at the ODSVRA is the considerable size of the exclosure area. If the exclosure area were to be reduced in size, the nesting plovers and terns would be more concentrated and probably more easily discovered, and then targeted, by mammalian or avian predators.

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Table 1. Avian Predators Trapped at the ODSVRA and Relocated in 2012

Date	Species	Age/Sex	Location	Relocation Date	Relocation Site, County	Band Number
6 Feb	American kestrel	adult male	North Oso Flaco	7 Feb	Windwolves Preserve, Kern County	1593-52102
16 Feb	loggerhead shrike	adult	South Oso Flaco	17 Feb	Cuyama Valley, SB County	8101-08414
7 Mar	American kestrel	adult male	Dune Preserve	8 Mar	Windwolves Preserve, Kern County	1593-52103
6 Apr	northern harrier	adult male	Oso Flaco Lake	7 Apr	Lone Pine, Inyo County	1004-10601
18 Apr	great horned owl	adult female	Pipeline revegetation area	19 Apr	Cuyama Valley, SLO County	0928-11972
30 Apr	great horned owl	adult female	Maidenform revegetation area	1 May	Cerro Noroeste Road, Kern County	0928-11973
23 May	peregrine falcon	sub-adult female	7 exclosure shoreline	24 May	Shasta Valley Wildlife Area, Siskiyou County	1687-08001
30 May	great horned owl	adult male	North Oso Flaco	1 Jun	Windwolves Preserve, Kern County	0928-11974
29 Jun	loggerhead shrike	juvenile	North Oso Flaco	30 Jun	Cuyama Valley, SB County	8101-08415
12 Jul	loggerhead shrike	juvenile	North Oso Flaco	12 Jul	Cuyama Valley, SB County	8101-08416
16 Jul	loggerhead shrike	juvenile	Table-top revegetation area	17 Jul	Cuyama Valley, SB County	8101-08417
24 Jul	barn owl	adult	Pipeline revegetation area	25 Jul	Cerro Noroeste Road, Kern County	2206-79503
24 Jul	barn owl	adult	Pipeline revegetation area	26 Jul	Cerro Noroeste Road, Kern County	2206-79504
26 Jul	loggerhead shrike	juvenile	North Oso Flaco	27 Jul	Cuyama Valley, SB County	8101-08418
3 Aug	loggerhead shrike	juvenile	North Oso Flaco	4 Aug	Cuyama Valley, SB County	8101-08419
6 Aug	loggerhead shrike	juvenile	North Oso Flaco	6 Aug	Cuyama Valley, SB County	8101-08420
13 Aug	loggerhead shrike	juvenile	Pipeline revegetation area	15 Aug	Cuyama Valley, SB County	8101-08421
14 Aug	loggerhead shrike	juvenile	North Oso Flaco	15 Aug	Cuyama Valley, SB County	8101-08422

Figure 1. General locations at ODSVRA

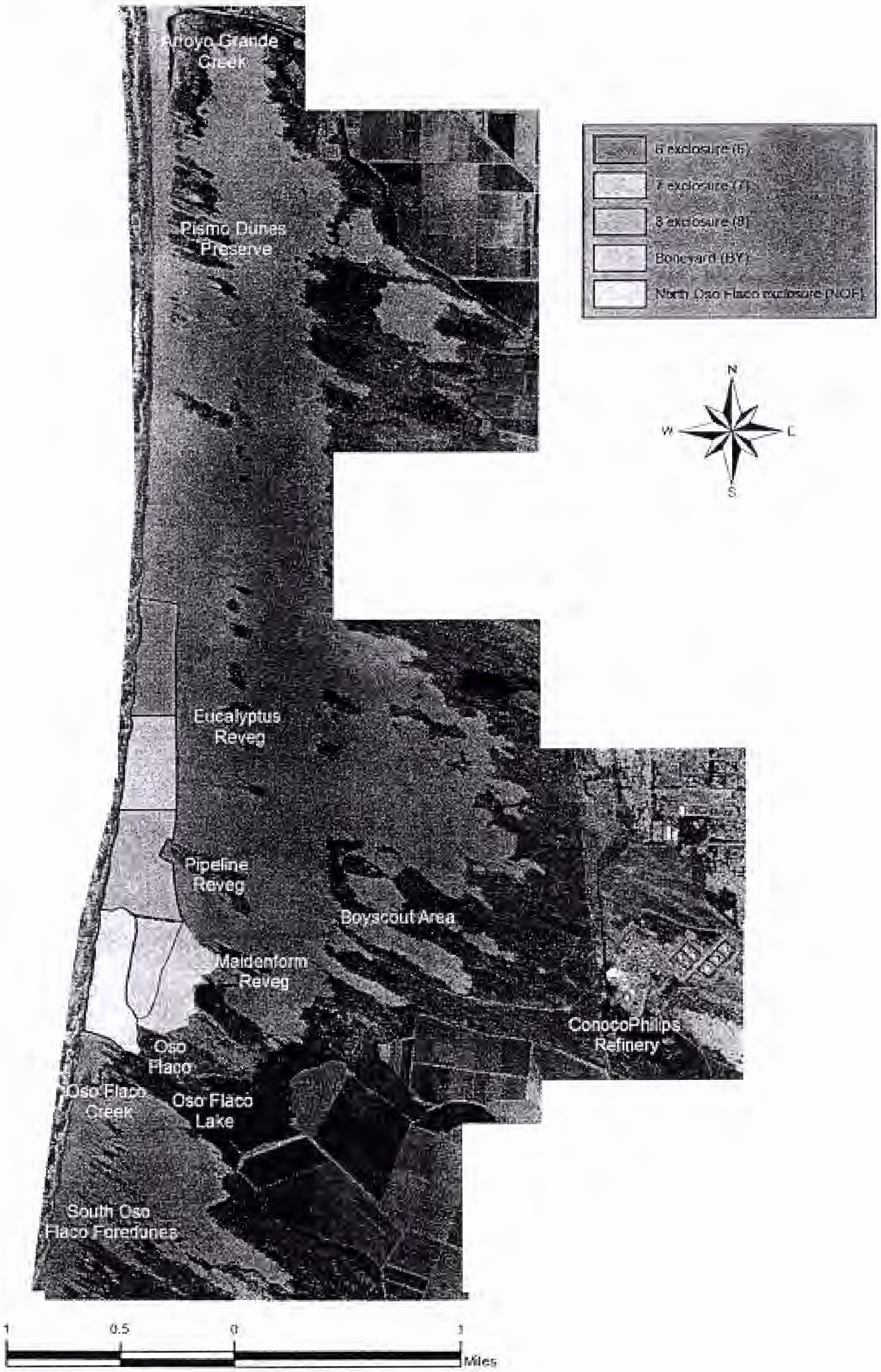
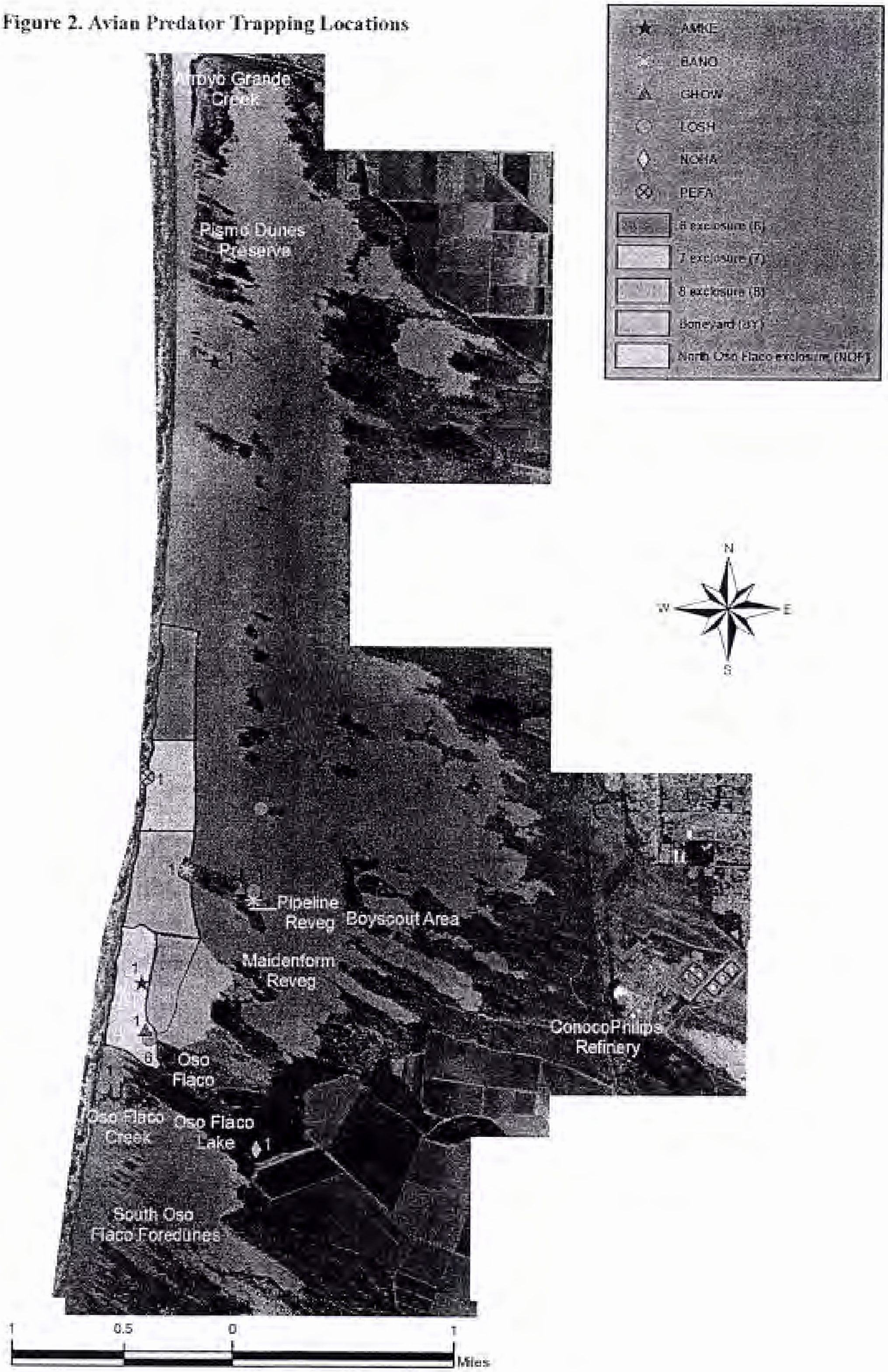


Figure 2. Avian Predator Trapping Locations



California Animal Health & Food Safety Laboratory System
18830 Road 112
Tulare, CA 93274-9042
(559) 688-7543

Final
Version 1
This report supersedes all previous reports for this case

CAHFS Case #: T1201430
Referral #: SCPA #815
Date Collected: 05/23/2012
Date Received: 05/25/2012
Case Coordinator: H. L. Shivaprasad BVSc, PhD
Electronically Signed and Authorized By: Chin, Richard P. on behalf of Shivaprasad, H.L. on 6/11/2012 11:00:30AM

Fax To:
MURRAY, MICHAEL
831-644-7597

Collection Site:
MONTEREY BAY AQUARIUM
886 CANNERY ROW
Monterey, CA 93940

Specimens Received: 1 Carcass;

Comments: Carrier: FedEx

Case Contacts

Bill To	MONTEREY BAY AQUARIUM	831-644-7507	886 CANNERY ROW MONTEREY, CA 93940
Submitter	MURRAY, MICHAEL	831-644-7507	886 CANNERY ROW MONTEREY, CA 93940

Specimen Details

ID	ID Type	Taxonomy	Gender	Age
SPCA#815	Tag	Snowy Plover	Unknown	2.00 Days

Laboratory Findings/Diagnosis

1. Nephrosis, kidneys; probably due to dehydration.

Case Summary

05/25/12: Bacteriology and histopathology are pending. In the meantime if you have any questions please give me a call.

06/11/12: Histopathology confirms nephrosis probably due to dehydration. Liver and yolk sac are negative for bacteria including salmonella. This completes all the tests on this case.

Clinical History

Submitted for necropsy is a 2 day Snowy plover chick bought day 1 of age - very weak, lethargic - euthanized. Unresponsive to feeding with 50% dextrose or warm slurry.

Gross Observations

GENERAL APPEARANCE OF ANIMAL:
A 2-day-old Snowy Plover chicks (ID # SPCA 815) is presented dead for necropsy. The bird is in fair postmortem condition and weighs 4 gms.

SKIN: Unremarkable.

UPPER RESPIRATORY: Unremarkable.

LUNG AND AIR SACS: Unremarkable.

CARDIOVASCULAR: Unremarkable.

UPPER DIGESTIVE/INTESTINE:
Gizzard: is empty.

...autolyzed with grey pasty contents.
...contains orange colored contents.

...ER AND PANCREAS: Unremarkable.

SPLEEN, BURSA AND THYMUS: Unremarkable.

KIDNEYS: are pale.

MUSCULOSKELETAL: Unremarkable.

NEUROLOGIC SYSTEM: Unremarkable.

REPRODUCTIVE TRACT: Unremarkable.

ENDOCRINE SYSTEM/OTHER: Unremarkable.
There are no other gross lesions of diagnostic significance.

Bacteriology

BACTERIAL AEROBIC CULTURE

Animal/Source	Specimen	Specimen Type	Results
SPCA#815	1	Liver Tissue	No growth after 48 hours
SPCA#815	1	Yolk Sac Tissue	No growth after 48 hours

SALMONELLA CULTURE - AVIAN

Animal/Source	Specimen	Specimen Type	Results
SPCA#815	1	Yolk Sac Tissue	No Salmonella detected

Histology

Brain, spinal cord, heart, trachea, lung, liver, kidneys, esophagus, proventriculus, gizzard, intestine, pancreas, bone marrow, skin, skeletal muscles, are examined.
Except for some dilated tubules in the kidneys there are no significant lesions.

DECALCIFICATION

Animal/Source	Specimen	Specimen Type	Results
SPCA#815	decal tissue	Tissue - Fixed	COMPLETED

California Animal Health & Food Safety Laboratory System
PO Box 1770
Davis, CA 95617
(530) 752-8700

Final
Version 1
This report supersedes all previous reports for this case

CAHFS Case #: D1209066
Referral #:
Date Collected: 08/17/2012
Date Received: 08/21/2012
Case Coordinator: Asli Mete. DVM, PhD
Electronically Signed and Authorized By: Mete, Asli on 8/23/2012 10:50:42PM

Email To:
OCEANO DUNES SVRA
rglick@parks.ca.gov

Collection Site:
OCEANO DUNES SVRA
340 JAMES WAY, SUITE 270
PISMO BEACH, CA 93449

Specimens Received: 1 Carcass;

Case Contacts

Submitter	OCEANO DUNES SVRA	805-773-7180	340 JAMES WAY, SUITE 270 PISMO BEACH, CA 93449

Specimen Details

ID	ID Type	Taxonomy	Gender	Age
	CAHFS Internal ID	Snowy Plover		

Laboratory Findings/Diagnosis

- Proventricular serosa and coelomic nodules: Chronic granulomatous polyserositis and mesenteritis with intralesional nematode parasite
- Small intestines: Cestodiasis
- Lungs: Diffuse, severe bilateral hemorrhage
- Kidneys, ventriculus T muscularis, and equivocal liver and lungs: Multifocal mineralization
- Kidney: Focal collection of parasite eggs, similar to that of a fluke
- Skeletal muscle: Multifocal lymphohistiocytic myositis

Case Summary

8/23/2012:
The gross examination of this Snowy plover had revealed severe post-mortem changes however most internal organs were intact and several significant findings are noted. The hemorrhagic lungs observed grossly are confirmed by microscopy however I am not sure on the cause. The mineralization in the kidneys and ventricular wall are also curious, and in another species these findings may have called in for a rodenticide toxicosis (predominantly causing vitamin D toxicity leading to the mineralization) however I don't think these birds eat possible contaminated material? The additional overall significant finding was the presence of various parasites; the adult nematodes on the proventricular serosa and within the coelomic granuloma are similar, and there were also cestodes in the small intestines as well as yellow-brown eggs in the renal parenchyma resembling trematode eggs.
All tests are completed on this case, there are no other findings. Please call me if you have questions or would like additional testing done.

Clinical History

Bird found dead at Oceano Dunes SVRA on 8/17/12 near post 5.75. Specimen in the refrigerator until shipped on 8/20/12.

Gross Observations

Examined is the carcass of a Snowy Plover with severe post-mortem changes; the ventral skin is torn and the coelomic cavity is exposed, with abundant sand stuck on the tissues, the fascia and filling the eye socket (scavenging presumptive). Most organs are intact, although caudally displaced. The lungs appear very hemorrhagic; dark red and wet. The liver and spleen are small. On the cranial pole of the serosa of the proventriculus there are two, 2 mm diameter nodular formations. Also in the left caudao-distal coelom, there is a 2 mm diameter firm, well encapsulated granuloma-like formation adhered near the peritoneal wall. The gastrointestinal tract overall has scant contents, the gizzard contains small amounts of fragmented oyster/sea shells. There are segments of cestode parasites in the small intestines.

Bacteriology

BACTERIAL AEROBIC CULTURE

Animal/Source	Specimen	Specimen Type	Results
D1209066-01	Oceano	Lung Swab	No growth after 48 hours
D1209066-01	Oceano	Liver Swab	No growth after 48 hours

Salmonella PCR and Confirmation Culture

Animal/Source	Specimen	Specimen Type	Results
D1209066-01	Oceano	Feces	No salmonella detected

Biotechnology

Avian Influenza matrix gene qRT-PCR

Animal/Source	Specimen	Specimen Type	Results
D1209066-01	Oceano	Oropharyngeal Swab	Negative

Histology

Examined are sections of brain, skeletal muscle, heart, trachea, esophagus, proventriculus, ventriculus, lungs, liver, spleen, air sacs, small and large intestines, and adrenal gland (T5):

Bilaterally diffusely the lungs are hemorrhagic; sheets of red blood cells fill the airspaces and air ways and expand the perivascular spaces. There is multifocal osseous metaplasia. In one section of skeletal muscle adjacent to the lung, probably brachial muscle there is a multifocal pleocellular infiltrate. In the kidneys, there are multiple medullary and cortical tubules with mineralized epithelia often sloughing off into the lumen. Some dispersed tubules have acute necrosis with mineralization. There is a focal collection of oval, yellow-brown pigmented eggs (trematode eggs) in the renal parenchyma. In the liver, there are scattered basophilic cells (artifact or mineralized). Air sacs and peripheral nerves are unremarkable.

Prominent helminth parasites are present in the gastrointestinal system and conform the core of the coelomic granuloma. The proventricular serosal protuberations observed on gross exam are composed of a cross section of an adult nematode parasite embedded within the serosa and surrounded by multinucleate giant cells and fibrosis with pleocellular inflammatory infiltrates around it. The nematode is characterized by a smooth cuticle, pseudocoelom, platymyarian musculature and a reproductive tract, as well as an esophagus are observed in the proventricular serosa. The intracoelomic granuloma is composed of a central cystic cavity with abundant eosinophilic amorphous necrotic material interspersed with some areas that appear to be parts of a parasite and there are also some bacterial colonies adjacent to the necrotic area. Multinucleate giant cells encircle the necrotic core with a peripheral rim of fibroblasts. Some heterophils, lymphocytes, plasma cells and macrophages with multinucleate giant cells also infiltrate the surrounding tissues, primarily the peripheral ganglia adjacent to the granuloma and extend significantly into the mesentery. There is a smaller granulomatous nodule with an encapsulated necrotic parasite cross section with similar features to that in the proventricular serosa adjacent to the larger granuloma. Several cross sections of cestodes are evident in multiple cross sections of the intestinal lumen. The muscle bundles of the ventricular wall are multifocally mineralized.

NESTING OF THE CALIFORNIA LEAST TERN AND WESTERN SNOWY PLOVER AT OCEANO DUNES STATE VEHICULAR RECREATION AREA, SAN LUIS OBISPO COUNTY, CALIFORNIA 2012 SEASON

Prepared for
California Department of Fish and Game
United States Fish and Wildlife Service

Prepared by
California Department of Parks and Recreation
Off-Highway Motor Vehicle Division
Oceano Dunes District

November 2012

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Attachments

U.S. Department of Agriculture Wildlife Services. Oceano Dunes State Vehicular Recreation Area 2012 Predator Management Report

Ventana Wildlife Society. Avian Predator Management Project: Trapping and Relocation of Problem Predators at Oceano Dunes State Vehicular Area in 2012

Necropsy examination results: one snowy plover chick and one snowy plover adult

SUMMARY

Staff of Oceano Dunes State Vehicular Recreation Area (Oceano Dunes SVRA, ODSVRA) and PRBO Conservation Science (PRBO) monitored breeding California least terns (*Sternula antillarum browni*) (least tern, tern) and western snowy plovers (*Charadrius nivosus nivosus*) (snowy plover, plover) at ODSVRA, San Luis Obispo County, California in 2012.

All least tern nests were inside a large seasonally fenced exclosure in the southern portion of the vehicle riding area. There was a minimum of 41 breeding pairs, an increase of 24.2% from 33 breeding pairs in 2011, and slightly above the average of 38.8 pairs (range=20-55) from 2002-11. There were 46 known nesting attempts. Of the 40 nests with known location and fate, 33 hatched, for a nest hatching rate of 83%. Of the seven nests that failed, one was abandoned pre-term (prior to the expected hatch date), two were abandoned post-term (after the expected hatch date), three were abandoned unknown if pre- or post-term, and one failed due to an unknown cause. Fifty-two chicks hatched and 45 were color-banded to individual. Forty-two of the 52 chicks (including six unbanded chicks) are known to have fledged (seen when 21 days old or older), for a chick fledging rate of 81% and 1.02 chicks fledged per pair. Predation of chicks or juveniles was documented for, but not necessarily limited to, three terns. The maximum known number of juveniles produced that may have survived to leave the site was 40.

There was a minimum of 190 breeding snowy plovers (105 males and 85 females), compared to 160 in 2011. Eighty-five banded birds were documented as breeding, 76 of these were banded as chicks and fledged from ODSVRA from 2003-11. There were 216 known nesting attempts, 194 were in the southern riding area seasonal exclosure (Southern Exclosure), 14 in Oso Flaco, three in the open riding area, and five from unknown locations (nesting known only by detection of brood). Of the 203 nests with known location and fate, 152 hatched, for a nest hatching rate of 74.9%. Fifty-one nests failed, attributed to the following causes: abandoned pre-term (16), abandoned post-term (2), abandoned suspected due to wind (7), abandoned unknown pre- or post-term (3), unknown cause (3), unidentified predator (3), unidentified avian predator (6), corvid (3), northern harrier (5), peregrine falcon (1), coyote (1), and flooded (1). Of the 386 hatching chicks, 341 were color-banded to brood, and the fate of 45 unbanded chicks is known (three fledged). Of the 386 chicks with known fate, 96 fledged for a chick fledging rate of 24.9% and predation is suspected as the primary cause for the low 2012 chick survival rate. One chick fledged per breeding male is the estimated number needed to prevent the population from declining (assuming approximately 75% annual adult survival and 50% juvenile survival) (U.S. Fish and Wildlife Service 2007). In 2012, an estimated 0.91 juveniles fledged per male at ODSVRA. For the 11-year period 2002-12, average productivity was 1.31 juveniles fledged per breeding male.

INTRODUCTION

Oceano Dunes SVRA, located in southern coastal San Luis Obispo County, California, is a popular park with high attendance and was visited by over 1.4 million people in 2011 for a variety of recreational opportunities, including driving vehicles on the beach and dunes.[1] In 2011, an estimated 265,815 street-legal vehicles and 153,514 off-highway vehicles were driven on the shoreline and dunes in the designated riding area of the park.[2]

Within ODSVRA there is extensive breeding habitat for two special-status ground-nesting birds, the state and federally endangered California least tern and the federally threatened Pacific Coast population of the western snowy plover. Monitoring of the least tern and snowy plover at ODSVRA during the breeding season began in 1991 and 1992, respectively. Least terns are present at ODSVRA only during the breeding season, migrating to wintering areas well south of California. The snowy plover population at the park is comprised partly of birds present year-round and partly of migrant birds present only during the breeding or wintering season.

This report summarizes the results of the 2012 nesting season for least terns and snowy plovers at ODSVRA. Maps in figures and appendices use digital satellite photos taken in 2007 by DigitalGlobe © 2008, unless otherwise noted.

State park staff conducts monitoring activities at ODSVRA under U.S. Fish and Wildlife Service (USFWS) permit 10(a)(1)(A) TE-815214-7, California Department of Fish and Game (CDFG) Memorandum of Understanding (MOU), and CDFG Scientific Collecting Permits. Predator removal activities are conducted under USFWS Depredation Permit MB25976A-0. PRBO conducts monitoring and banding activities under USFWS permit 10(a)(1)(A) TE-807078-14.1, Federal US Geological Survey Bird Banding Laboratory Banding Permit 09316, CDFG Scientific Collecting Permit SC-006691, and a CDFG Letter of Authorization.

[1] ODSVRA 2011 Annual Attendance figures (source ODSVRA)
[2] ODSVRA 2011 Monthly Carrying Capacity Summaries (source ODSVRA)

SITE DESCRIPTION

ODSVRA is part of the 18-mile-long Guadalupe-Nipomo Dunes complex. The Oceano Dunes District, California Department of Parks and Recreation, manages approximately 4,900 acres with approximately 9.1 miles of ocean shoreline on the western edge. On the northern border of the park is the city of Pismo Beach. Located to the east of the park are Phillips 66 Refinery (formerly ConocoPhillips Refinery), the cities of Grover Beach and Oceano, and private lands that consist of dunes, coastal scrub, and agricultural fields. The southern border of the park abuts the Guadalupe-Nipomo Dunes National Wildlife Refuge (NWR). Inside the park, dunes that are open to vehicles extend inland in some areas for over one mile. Eight numbered marker posts, located approximately 0.5 miles apart, are located along the coastal strand of the riding area to orient park visitors and staff. Street-legal vehicles are allowed throughout the riding area. Off-highway vehicles, as well as overnight camping, are allowed along the beach and dunes south of marker post 2 (approximately one mile south of Pier Avenue). In the southern portion of ODSVRA is Oso Flaco Lake area (Oso Flaco) with a shoreline of approximately 1.7 miles. Pedestrians are allowed at Oso Flaco but it is closed to camping, equestrian, dog, and vehicle use. The beach at Oso Flaco west of the foredunes is narrower than in the riding area.

The following are descriptions of sites and terms as used in this report (Figure 1, Figure 2).

<u>ODSVRA</u>: All areas that are administered by the Oceano Dunes District, including the Oceano Dunes SVRA, Pismo State Beach, Pismo Dunes Natural Preserve (Dunes Preserve), Pismo Lake, and Oso Flaco Lake area. Management of the Dunes Preserve and Pismo State Beach was transferred to the Oceano Dunes District in December 2004. The Pismo Lake property was acquired from the California Department of Fish and Game in 2007. ODSVRA provided tern and plover monitoring for the Dunes Preserve prior to 2004 and continues to do so. Pedestrian and equestrian use is permitted in the Dunes Preserve, but vehicles and dogs are not allowed. The Pismo Lake property is currently closed to the public.

<u>Riding area</u>: The area within ODSVRA that is open to recreational vehicles. This area changes in size based on seasonal restrictions. Street-legal vehicles are allowed along approximately 5.3 miles of beach, from the Grand Avenue park entrance south to the southern boundary of the riding area (approximately 0.4 miles south of marker post 8). Off-highway vehicles are only allowed south of marker post 2.

<u>Open riding area</u>: The area within ODSVRA open to recreational vehicle use during the nesting season.

<u>Southern Exclosure</u>: A single contiguous area within the southern portion of the riding area that is fenced and closed to entry during the breeding season to protect nesting terns and plovers. The adjoining shoreline is also part of the Southern Exclosure and is closed to public entry during the nesting season. From 2001 to 2004, the amount of seasonally protected nesting habitat in the riding area periodically increased in size. Subsequent to 2004 there has been no increase in size of this protected area. The area of the Southern Exclosure (including the area at and above the high tide line on the closed shoreline) for 2012 was approximately 296 acres, compared to a range of 271-294 acres (and an average of 284 acres) between 2004 and 2011. Although the

basic configuration of the Southern Exclosure has remained consistent since 2004, changes in dune topography and public safety issues impact the placement of the east fence, resulting in small variations in acreage from year to year. Individually identified areas (Figure 2) within the Southern Exclosure include the following:

6 exclosure: The area from marker post 6 to marker post 7, north of 7 exclosure (approximately 0.5 miles of shoreline and approximately 60 acres), first incorporated into the Southern Exclosure for a full season in 2004. Vegetation within the exclosure is very sparse.

7 exclosure: The area from marker post 7 to the south side of 7.5 revegetation area (approximately 0.4 miles of shoreline and approximately 61 acres). Habitat includes extensive areas of bare sand, limited areas of vegetated hummocks, limited areas of organic surface debris (shells, driftwood, dried algal wrack), and moderate to heavy vegetation in the small 7.5 revegetation area located within the 7 exclosure.

8 exclosure: The area from the south side of the 7.5 revegetation area to the North Oso Flaco fencing south of marker post 8 (approximately 0.5 miles of shoreline and approximately 83 acres). Habitat includes extensive areas of bare sand, limited areas of vegetated hummocks, and limited areas of organic surface debris (shells, driftwood, and algal wrack).

Boneyard exclosure: The area east of the North Oso Flaco dunes. Habitat is primarily bare sand and active sand dunes. This inland area does not have a shoreline component and is approximately 92 acres. A portion of the west side (7.4 acres) has been closed year-round since 2005 due to the presence of a cultural resource area. This area has developed small vegetated hummocks. Straw bales, placed within the protected cultural area, to build up sand to cover and protect cultural resources, persist. The east fence is not maintained as predator fencing due to the rapidly shifting open sand dunes in the area. Instead, beginning in 2003, a two inch by four inch mesh interior fence (six foot tall predator fencing) has bisected Boneyard exclosure during the nesting season, resulting in 44 acres in the western portion (contiguous with 6, 7, and 8 exclosures) and 49 acres in the eastern portion.

Oso Flaco: The shoreline and dunes in ODSVRA located south of the riding area. The approximately 1.7 miles of beach length is narrow in width, and the dunes are typically heavily vegetated, relative to the riding area. The area is part of the Oso Flaco Lake area, open to pedestrian use but closed to vehicles. Beginning in 2006, an additional 0.4 miles of shoreline at the southern end of the park were included in the ODSVRA (a survey conducted by the Guadalupe-Nipomo Dunes NWR in 2005 determined this area was part of ODSVRA and not the NWR, as was previously thought). For purposes of discussion in this report, Oso Flaco is divided into North Oso Flaco and South Oso Flaco (Figure 2).

North Oso Flaco: The area extending south from 8 exclosure to the pedestrian boardwalk access trail to the Oso Flaco shoreline (approximately 0.5 miles of shoreline and approximately 68 acres). Beginning in 2002, the upper beach and dunes were closed to pedestrians during the nesting season with symbolic fencing. Since 2005, the North Oso Flaco area has been part of the seasonal exclosure and managed in a similar manner; predator fencing has replaced symbolic fencing and the shoreline has been closed to the public during the nesting season.

South Oso Flaco: Extends from the boardwalk to the ODSVRA southern boundary (approximately 1.2 miles shoreline length). Oso Flaco Lake drains through Oso Flaco Creek and the mouth of this creek is within the northern portion of South Oso Flaco. The shoreline is open to the public and symbolic fencing and signage have been used since 2002 to designate the seasonally closed upper beach and dune habitat. Snowy plover nests found in this area receive individual nest exclosures.

Pipeline revegetation area: Located adjacent to the east side of 8 exclosure. The area is heavily vegetated.

Arroyo Grande Creek: Seasonally flows into the Pacific Ocean approximately two miles north of the Southern Exclosure. The associated lagoon is variably located east of the area between marker post 1 and marker post 2. The upper creek area and lagoon are closed to vehicle use year-round to protect sensitive aquatic habitat. Pedestrian and equestrian entry is prohibited during the nesting season and permitted during the nonbreeding season. Posts and signs delineate the closed area during the nonbreeding season; symbolic rope fence is added during the nesting season.

Carpenter Creek: Seasonally flows into the Pacific Ocean approximately 4.5 miles north of the Southern Exclosure. No vehicles are allowed in the area as it is approximately 0.4 miles north of the riding area. The area receives a high level of pedestrian use.

Pismo Creek lagoon: Seasonally flows into the Pacific Ocean approximately 4.8 miles north of the Southern Exclosure. Standing water persists all year, with low vegetated hummocks west of the lagoon and tall vegetated dunes and housing to the east. No vehicles are allowed in the area as it is approximately 0.75 miles north of the riding area. The area receives a high level of pedestrian use. Only a small portion of the lagoon is part of state park property.

MONITORING AND MANAGEMENT ACTIONS

MONITORING

Daily monitoring occurs from 1 March – 30 September. At a minimum, ODSVRA maintains three monitors during morning and early afternoon hours. As the season progresses, monitoring increases to include the late afternoon and early evening hours. Monitoring involves walking to assess or find new nests as well as scanning nests and broods from parked vehicles (a proven and effective blind). Monitoring occurs in a manner to minimize disturbance or adverse effects to adult birds, nests, and chicks.

Open riding area
Monitoring of the open riding area by vehicle occurs daily along defined transects, as any nests initiated or chicks in this area require immediate protection from recreational activities. Areas along transects with plover activity indicating potential nesting (scraping or copulating) are checked more thoroughly on foot and with increased frequency using binoculars or spotting scope. When staff finds chicks in the open riding area the area is closed to vehicles and chicks are slowly directed back into the protected Southern Exclosure. Staff continues to monitor chicks to confirm they do not move back into the open riding area.

Breeding least terns and snowy plovers
<u>Finding and monitoring nests:</u> The least tern and snowy plover management program attempts to find, monitor, and determine all tern and plover nest and chick fates. Staff checks most nests daily and conducts regular nest searches using binoculars and spotting scopes from parked vehicles outside of the seasonal fencing. Additional nest searches are conducted on foot. Staff maps nest locations using a Global Positioning System (GPS). Egg-laying dates provide estimates for least tern and snowy plover clutch hatching dates; for nests found at full clutch, floating the eggs (snowy plovers only) offers an estimate.

<u>Nest substrates:</u> Monitoring staff documents substrate of each nest with a known location in 6, 7 and 8 exclosures. Staff analyzes nest substrate information to assess the benefits of ongoing habitat enhancement activities. See Appendix F for more information.

<u>Nest fates:</u>
The following categorizes nest fates used in this report:

> *Hatch*: Nest hatched at least one egg.
>
> Nesting attempts known only by detection of brood are given the category of "unknown location nests" and egg numbers from such nests are minimums derived from the number of chicks first observed.
>
> *Abandoned pre-term*: Nest abandoned prior to the expected hatch date; causes may include, but are not limited to, disturbance or adult mortality.

Abandoned suspected due to wind: Nest abandoned pre-term during periods of high wind, with eggs typically found almost or completely buried.

Beginning in 2010, the category of "abandoned suspected due to wind" was added to nest fates. Prior to this, nests lost where wind may have been the cause were included in the broader category of "abandoned pre-term." For the 2010 report, least tern nests in the abandoned pre-term category for the previous eight years were reviewed and a limited number were reassigned to the abandoned suspected due to wind category. Tables in this report include the reassigned tern nest fates for years prior to 2010.

Abandoned post-term: Nest abandoned after the expected hatch date, and includes nests with nonviable eggs.

Abandoned, unknown if pre- or post-term: Nest abandoned, but unknown if pre- or post-term.

Depredated: Nest lost to a predator. If possible, staff identifies the predator to species or group (mammalian, avian), or describes the nest as lost to an unidentified predator.

Flooded: Nest overwashed by tide, or flooded by a shifting creek or expanding lagoon.

Failed to unknown cause: Nests that disappeared before expected hatch date with cause of failure undetermined.

Unknown fate: Nests where eggs disappear around the estimated hatch date, but not enough evidence exists to determine whether they hatched or failed.

Banding chicks: In 2012, least tern chicks received a single blank size 1A aluminum band (covered with blue over white vinyl tape) on the right leg, and a size 1A numbered aluminum federal band on the left leg. Colored tape placed on the federal band creates color band combinations unique to each individual chick. Weighing chicks occurs immediately prior to banding, typically at one to three days old.

Banding of plover chicks was inconsistent prior to 2001. Since 2002, the goal has been to band all chicks to brood, with all chicks within one brood given the same color band combination. Since 2010, some ODSVRA band combinations on birds that may be alive have been reused due to the limited number of combinations available. Therefore, the age of adult plovers with certain ODSVRA band combinations is sometimes unknown.

Chick monitoring: Searching for broods occurs multiple times each week from vehicle surveys on the shoreline of the Southern Exclosure and Oso Flaco. Staff records band combinations, chick numbers, adults present, location and direction of movement, and any interaction or aggression with nearby broods.

Fledging success: At ODSVRA, juvenile terns can be widely dispersed over a large area. Monitoring efforts directed specifically for terns are needed in estimating the number of juveniles produced as well as identifying threats to survival. Tern chicks surviving to 21 days or older are considered fledged (21 days after the hatch date, which counts as day zero). Tracking of juvenile terns occurs on park property (in the Southern Exclosure, at Oso Flaco Lake and Pismo Lagoon) and at nearby sites.

The fledgling tern counting method varies among years as follows: single day high counts for 1991-97, and 2000-01; a single day high count at Oso Flaco Lake for 1998; count method for 1999 unknown; and three-week interval day count conducted from 2002-04 (chicks banded to site 2003-04). In 2005, chicks were color-banded to brood and from 2006-12 almost all chicks were color-banded to individual, resulting in more accurate documentation of fledge rate than previous methods. Earlier estimates prior to banding to individual may represent substantial undercounts or overcounts.

Plover chicks surviving to 28 days or older from the time of hatch are considered fledged (28 days after the hatch date, which counts as day zero). Prior to 2001, monitoring in Oso Flaco and Pismo Dunes Natural Preserve was intermittent, and fledgling information was not obtained.

<u>Measures describing breeding success</u>:
The following categorizes measures describing breeding success used in this report:

> *Hatch rate:* Total number of hatching nests divided by total number of nests with known location and fate.
>
> *Percentage chicks fledging*: Total number of chicks fledging divided by total number of chicks (includes chicks fledged from unknown location nests).
>
> *Number of chicks fledging per nest*: Total number of chicks fledging from known location nests divided by total number of nests with known location and fate.
>
> *Productivity*: Number of least tern fledglings per breeding pair (consistent with the annual statewide California least tern report produced by CDFG). Number of snowy plover fledglings per breeding male (consistent with USFWS Pacific Coast western snowy plover recovery plan).

<u>Banded adults</u>: Documenting banded least terns and snowy plover adults provides detailed information on history of birds including: origins, age, breeding status, and movement between sites. Staff attempts to record all band combinations of adult least terns and snowy plovers.

<u>Number of breeding adults</u>: For least terns, the minimum number of breeding pairs equals the maximum number of concurrently active nests and broods. Banding chicks to brood in 2005 and to individual since 2006 provides for increased accuracy in counting the number of active broods on a given date. From 1991 to 2001, the estimated number of breeding pairs was not always reported or was based only on the number of concurrent nests. These reports were reviewed in 2005, looking at both nests and the limited brood information. For some years this resulted in identifying an increase in the minimum number of pairs and this revised information has been provided in annual reports since 2005.

Individually banded snowy plover adults provide the most accurate means to identify breeding population size but currently at ODSVRA too few adults are banded to rely solely on this method. A minimum number of breeding females is derived from the maximum number of nests active on the same day plus any additional nests hatching one day before or initiated one day after this date. A minimum number of breeding males is estimated from the highest same day count of active nests and broods (males typically raise the chicks; males with broods three weeks of age or older were not included if they could be associated with a new nest) and number of nests initiated the day after the high count. Beginning in 2009, numbers of color-banded adults confirmed breeding are compiled, and any number of this group that could not be accounted for on the same day high count, including nests or broods with unknown adults, are added to the same day high count for the appropriate sex.

ODSVRA also participates in the annual U.S. Pacific Coast Snowy Plover Breeding Season Window Survey coordinated by USFWS.

Least tern night roost: During the breeding season, terns may assemble in a night roost. Monitors record the night roost location and total numbers of individuals present as the terns arrive at dusk. Night-vision goggles are available and used for this task, but they have a limited range for distance viewing. There are occasions when terns are not seen, but are heard vocalizing as they arrive to roost after it is too dark to see. Counts are considered a minimum due to the inherent limited visibility of the night roost. It is typically too dark to distinguish between adults and juveniles.

Least tern use of freshwater lakes: Freshwater lakes can provide a source of prey fish in addition to the near-shore ocean. Periodically surveying nearby small freshwater lakes documents tern use and gives a better understanding of regional food resources. An important component of this monitoring is to determine if lakes provide additional appropriately-sized fish to feed chicks (chicks require fish small enough that they can be swallowed whole). Observations of adults in flight provide information about the direction of foraging sources and, occasionally, fish size.

Wind speed monitoring

Beginning in 2011, ODSVRA monitors wind speed from a tower (S1 tower) east of 6 exclosure, with anemometers at two, seven and ten meters high. In 2010-11, a portable anemometer with data logger (from WindLog Rainwise, Inc.) was placed in the breeding habitat. Before 2010, wind speeds were measured inconsistently by hand-held weather gauges (Kestrel 2000 Weather Meter by Kestrel Meters).

Predator activity

Monitoring predator activities: Park staff and contractors (Ventana Wildlife Society, U.S. Department of Agriculture (USDA) Wildlife Services, and PRBO) collect information on predator presence at ODSVRA from February through September. From direct observation of mammalian and avian predators or their sign (e.g., tracks, scats, regurgitated pellets (castings), prey remains, depredated nests), monitors record species, type of sign, behavior, duration of observation, direction of travel, and characteristics that may identify an individual. Summarizing these observations by count of days detected, location of animal sighting or sign, and observation duration allows for comparison across years. For additional details, see section titled Predators and predator management on page 40.

Gull monitoring: Gulls depredate snowy plover and least tern eggs, chicks, and juveniles. Gulls are of particular concern because they are a subsidized predator often responding to human activity. Conducting daily and more detailed weekly surveys, in addition to general predator monitoring, documents flock locations and numbers within the park.

Nonbreeding season monitoring of snowy plovers

Beginning in 2009, more consistent weekly surveys for snowy plovers occurs during the months of October through February. During these surveys staff divides the shoreline into the following five sections, listed from north to south:

1) approximately 0.5 miles north of Pismo Pier to Grand Avenue (pedestrian use only, no vehicle use allowed);
2) Grand Avenue south to marker post 2 (street-legal vehicles and day use only, no camping);
3) marker post 2 south to marker post 6 (street-legal vehicles, off-highway vehicles, and camping allowed year-round);
4) marker post 6 south to the southern shoreline riding area boundary (shore and portion of upper beach closed to public use during 1 March to 30 September and open to all activities during the rest of the year); and
5) Oso Flaco (southern shoreline riding area boundary to ODSVRA's southern boundary with pedestrian use only and portion of shore and upper beach closed to pedestrian use 1 March to 30 September).

ODSVRA also participates in the annual U.S. Pacific Coast snowy plover winter window survey coordinated by USFWS.

Investigation of least tern and snowy plover carcasses

ODSVRA sends fresh carcasses of least terns or snowy plovers to an approved facility (the California Health and Food Safety Laboratory at the University of California, Davis) for necropsy. Fresh carcasses must be immediately refrigerated and then sent by overnight delivery service within one day to preserve the integrity of tissues to be tested to determine cause of death.

Management Actions

ODSVRA manages for least terns and snowy plovers to optimize breeding success and reduce the potential for take. To reduce visitor disturbance to breeding birds, ODSVRA installs fence, seasonally closes areas to visitors, and posts signage. Staff augments existing habitat with branches, woodchips, wrack, plants and seed. An active predator management program reduces disturbance and depredation by mammalian and avian predators.

Informational signage and enforcement of regulations

Interpretive panels at access points, and signs identifying closed areas, serve to increase public awareness of threats to nesting terns and plovers. The public can access a low wattage radio station with a repeated recording of park information, including information about protection of sensitive species. State Park rangers enforce park regulations enacted to protect terns and plovers.

Seasonal closure and fencing

Every year from 1 March through 30 September, ODSVRA closes least tern and snowy plover breeding habitat to vehicle and pedestrian use with wire or symbolic fencing. The wire fencing, referred to as the seasonal exclosure (see details below), provides a higher level of protection when compared to symbolic fencing, composed of rope with signs to keep visitors from entering sensitive areas. When nesting occurs outside of the seasonal exclosure, staff chooses an alternative wire exclosure type with consideration for the species, topography, proximity to recreational activities, predator threats, and duration of disturbance to the area during exclosure construction. The seasonal exclosure and large single nest exclosures are collectively referred to as seasonal fencing in this report.

ODSVRA uses the following exclosure types:

<u>Seasonal exclosure (Southern Exclosure and North Oso Flaco) protected area</u>: ODSVRA fences this approximately 350-acre area during the nesting season to limit vehicle and human trespass into protected nesting and brood-rearing habitat. Wire fencing five feet high (bottom eight inches buried) with two inch by four inch mesh discourages coyote entry. Beginning in 2006, an additional layer of fence material was attached to overlap the top of the fence, increasing fence height above the surface to approximately six feet as a further deterrent to coyotes. Staff attaches bird barrier spikes to the wood posts in an effort to discourage perching by avian predators. Tall posts with large stop signs extend into the intertidal area at marker post 6 and the south end of North Oso Flaco. Rope with additional signage extends between the shoreline posts to clearly designate a closed shoreline to visitors.

<u>Symbolic fencing (South Oso Flaco)</u>: Symbolically fencing approximately 1.2 miles of nesting and brood-rearing habitat in South Oso Flaco identifies the closure area (lower shore remains open to public). Nests in this area typically receive some type of individual nest exclosure.

<u>Large single nest exclosure</u>: Staff installs a minimum 200-foot diameter, circular single nest exclosure with height of five feet (bottom eight inches buried) around any least tern or snowy plover nest found in the open riding area. Single nest exclosures of differing sizes may also be

used to protect snowy plover nests in areas where vehicles are not permitted (Oso Flaco, Southern Exclosure shoreline, Arroyo Grande Creek area, Pismo Creek area, and areas north of Grand Avenue).

10 foot by 10 foot, circular, and mini-exclosures: Staff selectively uses a small circular or two small square nest exclosure (made of two inch by four inch wire) around snowy plover nests inside or outside of seasonal fencing for protection from predators, including roosting gull flocks. Staff uses different exclosures based on a variety of factors including, but not limited to, weather, topography, predator threats, and proximity of young broods.

The 10 foot by 10 foot exclosure (used since 2003) and seven-foot diameter circular exclosure (used in 2012) are built with five-foot-high sides and the bottom eight inches buried when outside of the seasonal exclosure protected area. A 1/2 inch by 1/2 inch mesh net top is added when avian predation is a concern.

Mini-exclosures (used since 2010) are three feet by three feet by three feet with a wire mesh top and buried four to eight inches when appropriate. Of the three types, mini-exclosures take the least amount of time and staff to install.

Bumpout: A nest in the Southern Exclosure located within a minimum of 100 feet to the east or north fence requires temporary additional fencing extending into the open riding area to allow an adequate buffer between recreational activities and the nest. This type of extended fence is termed "bumpout." Staff extends bumpouts when recreational activities continue to cause disturbance to nesting birds. ODSVRA maintains a safe vehicle corridor adjacent to the east fence and any bumpouts.

Habitat enhancement

Following the nesting season, and for the five-month period October through February, camping, street-legal vehicles, and off-highway vehicles use portions of the Southern Exclosure. This recreational use results in large areas of flattened terrain and barren sand with very limited scattered natural debris and vegetation.

Staff place material in 6, 7, and 8 exclosures to offer more areas of disruptive cover for terns and plovers, providing shelter from wind and blowing sand, reducing exposure to predators, and augmenting potential nesting substrate. Beginning in February or March, and prior to nest initiation, natural materials such as driftwood, woodchips, and wrack (surf-cast kelp) are added to the exclosures, including to the shore, to enhance habitat features. No habitat enhancement occurs within 100 feet of the fence that borders the open riding area to discourage nesting near recreation that may cause disturbance to breeding birds.

Wrack and talitrids: Results from studies conducted by Drs. Jenny Dugan and Mark Page, researchers from the Marine Science Institute at the University of California Santa Barbara, suggest that the seven month seasonal closure (March through September) is not a sufficient period of time for invertebrates to effectively recover species diversity and abundance on the Southern Exclosure shoreline following five months of recreational vehicle use.

ODSVRA collects wrack in the open riding area and disperses it in the Southern Exclosure. Heavy equipment aides in this process if available, but most collection and distribution is done by hand and moved using a truck and trailer. In addition to providing cover, wrack on the shoreline provides a food resource supporting invertebrates, which in turn are prey for plover chicks, juveniles, and adults. Talitrids (commonly called beach hoppers) are collected from outside the vehicle use area north of Grand Avenue. Staff inoculates the wrack addition areas of the Southern Exclosure shoreline with talitrids in order to establish a breeding population, thus increasing the food resources available for plover chicks and juveniles during the breeding months.

Woodchips, branches and driftwood: Staff adds woodchips to supplement the existing assorted debris that snowy plovers often choose as nesting substrate. Woodchips are spread in patches of less than a quarter-acre in size in the 6, 7, and 8 exclosures in areas of barren sand and over thinning woodchip patches remaining from the previous year(s). OSDVRA heavy equipment assists in loading woodchips to be distributed.

Staff distributes cut branches and driftwood in patches from the mid-portion of 6 and 7 exclosures to the west fence and upper shoreline west of the exclosure. Staff collects the branches and driftwood from the exclosures at the end of each season and stores them for use in the following season.

Plants and seeds: Prior to expected rain, staff broadcasts locally collected seed and installs container plants grown from seed of locally collected native foredune species in an effort to provide scattered plants in 6 and 7 exclosures. Scattered plants, and the associated development of small hummocks, can benefit plovers and terns during the breeding season. See Appendix F for more details.

Least tern chick shelters: Staff places tern chick shelters in the 6 and 7 exclosures in areas of historical tern nesting and chick rearing. Tern chicks and juveniles use these shelters during high winds, typically sheltering on the leeward side. These simple structures are two or three pieces of plywood attached together to form either an A-shape shelter (typically six inches high by 12 inches long by 11 inches wide), L-shape shelter (typically seven inches high by 19 inches long by 14 inches wide), T-shape shelter (12 inches by 12 inches flat roof with a center support partially buried in sand), or a double-T-shape shelter (16 inches by 22 inches flat roof with two supports eight inches deep and five inches apart buried in the sand).

Predator management

In addition to preventative measures such as fencing, individual nest exclosures, and cover provided by habitat enhancement, ODSVRA park staff and contractors consistently monitor predator activity to assess impacts on breeding terns and plovers (as discussed in Monitoring). Staff removes animal carcasses (which attract scavengers) in or adjacent to nesting and brood-rearing habitat and harass predators to flush them from sensitive areas. When additional options for managing predators are needed, selective live-trapping and relocation of avian predators is conducted by Ventana Wildlife Society and selective live-trapping and relocation or lethal removal of mammalian and avian predators is conducted by USDA Wildlife Services. See section titled Predators and predator management on page 40 for additional information.

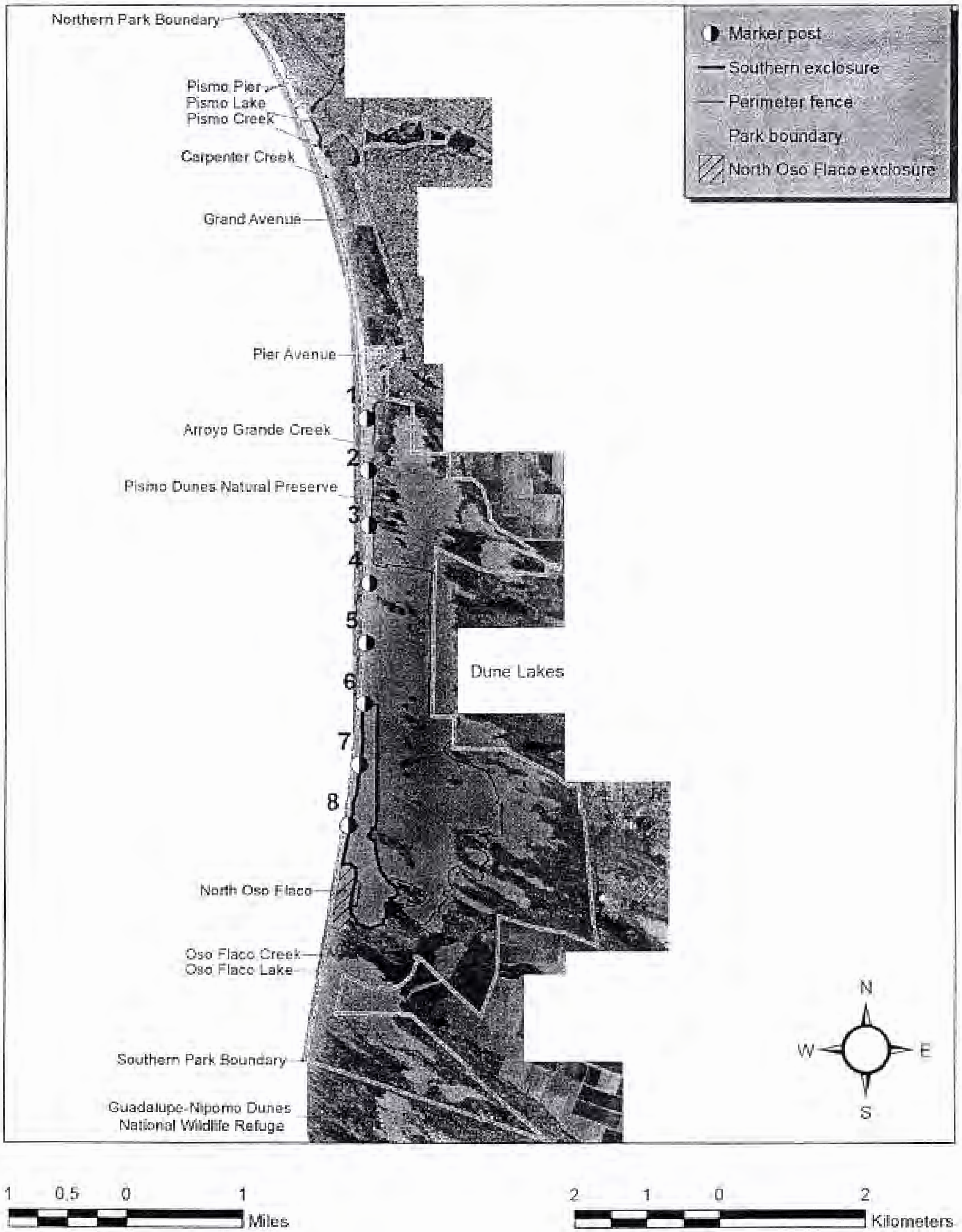


Figure 1. ODSVRA site map.

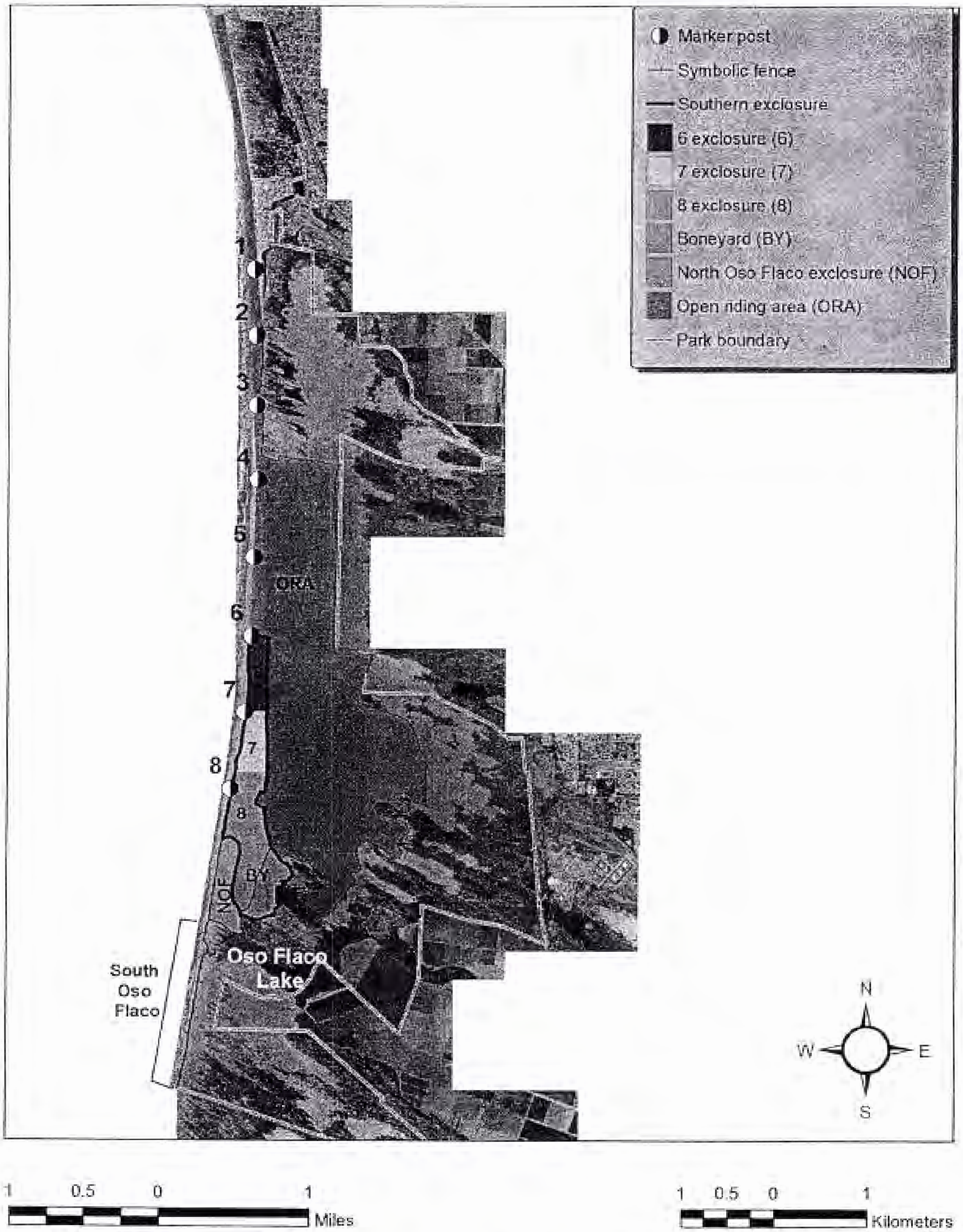


Figure 2. ODSVRA Southern Exclosure and Oso Flaco seasonally protected areas for breeding California least terns and snowy plovers in 2012.

RESULTS AND DISCUSSION

CALIFORNIA LEAST TERN

Number of breeding pairs

In 2012, least terns were first seen at ODSVRA on 6 May with two flying over the exclosure and from 8 May onward, terns were seen or heard daily. Terns were last seen on 29 August with three adults and two juveniles at Oso Flaco Lake. During the previous 10 years, first sightings occurred between 8 April and 15 May (median=9 May) and last sightings occurred between 20 August and 28 September (median=4 September). There was a minimum of 41 breeding pairs in 2012, a 24.2% increase from 33 breeding pairs in 2011, and slightly above the average of 38.8 pairs (range=20-55) from 2002-11 (Table 1, Figure 3).

Number of nests

There were 46 nesting attempts documented, with the first nest initiated approximately 27 May and the last 12 July (Appendix A). During the ten-year period 2002-11, there was an average of 47 nests per year (range=22-79) with initiation dates for first nests ranging from 26 May to 8 June (median=4 June). In 2012, a high count of 34 nests were active at the same time on 21 and 24 June. Of the 39 nests with known complete clutch size, six had one egg, 31 had two eggs, and two had three eggs. The average number of eggs in completed clutches was 1.90. This compares to an average of 1.85 for 2002-11 (range=1.55-2.10), and statewide averages of 1.62, 1.75, 1.76, 1.82, and 1.75 in 2007–11, respectively (Marschalek 2007, 2008, 2009, 2010, 2011). All nests were located in 6 exclosure (36 nests) and 7 exclosure (10 nests). Since 2005, the percent of total nests at ODSVRA in 8 and Boneyard exclosures decreased from 69% in 2005 to 12% in 2009, when nesting last occurred in these exclosures (Table 2, Figure 4).

Clutch hatching rate

For six of the 46 nests, the nest fate (hatch or fail) was unknown. Of the 40 nests with known fates, 82.5% hatched and 17.5% failed. This compares to an average clutch hatching rate of 80% (range=66-89%) during the period 2002-11 (Table 1). The hatching rate for known fate and known location nests in 6 exclosure was 86.7% (26/30) and in 7 exclosure was 66.7% (6/9) (specific exclosure location for one hatching nest not determined) (Table 2). Of the seven nests that failed, one was abandoned pre-term, two were abandoned post-term, three were abandoned unknown if pre- or post-term, and one failed to unknown cause (Table 3). The two nests abandoned post-term were observed incubated a minimum of 43 and 51 days.

Table 1. Nesting success of California least terns at ODSVRA from 1991-2012.

Year	Estimated minimum no. breeding pairs	No. nests (no. known fate)	No. hatched nests	Percent nests hatched	No. chicks	Percent chicks fledged	No. juveniles	Juveniles fledged per known fate nests	Juveniles fledged per pair
1991	4	6 (6)	2	33	4	50	2	0.33	0.50
1992	3	4 (4)	1	25	2	50	1	0.25	0.33
1993	0	0 (0)	0	0	0	0	0	0.00	0.00
1994	2	2 (2)	0	0	0	0	0	0.00	0.00
1995	1	1 (1)	0	0	0	0	0	0.00	0.00
1996	0	0 (0)	0	0	0	0	0	0.00	0.00
1997	16	21 (10)	3	30	6	67	4	0.40	0.25
1998	33	40 (32)	26	81	40	60	24	0.75	0.73
1999	28	34 (30)	21	70	38	45	17	0.57	0.61
2000	4	5 (5)	4	80	8	50	4	0.80	1.00
2001	12	18 (18)	13	72	22	55	12	0.67	1.00
2002	20	22 (19)	15	79	27	37	10	0.53	0.50
2003	53	79 (77)	60	78	101	37	37	0.48	0.70
2004	47	63 (60)	44	73	69	36	25	0.42	0.53
2005	47	59 (59)	39	66	66	30	20	0.34	0.43
2006	31	38 (38)	28	74	45	80	36	0.95	1.16
2007	54	66 (66)	51	77	90	78	70	1.06	1.30
2008	55	56 (56)	50	89	99	71	70	1.25	1.27
2009[1]	25	26 (26)	23	88	43	77	33	1.27	1.32
2010[2]	23	23 (23)	20	87	35	83	29	1.26	1.26
2011[2]	33	35 (35)	31	89	55	91	50	1.43	1.52
2012[3]	41	46 (40)	33	83	52	81	42	1.05	1.02

[1] Six unbanded chicks, four were identified as fledging and are included.

[2] One unbanded chick identified as fledging and is included.

[3] Six unbanded chicks identified as fledging and are included.

Table 2. Nesting success of California least terns at different sites within the Southern Exclosure at ODSVRA in 2012.

Southern Exclosure	No. nests (no. known location and fate)	No. eggs	No. nests hatching	Percent nests hatching	No. chicks	No. chicks fledging	Percent chicks fledging	Juveniles fledged per known fate nests
6 exclosure	36 (30)	62	26	86.7	41	33	80.5	1.10
7 exclosure	10 (9)	19	6	66.7	10	8	80.0	0.89
TOTAL[1]	46 (40)	82	33	82.5	52	42	80.8	1.05

[1]Six chicks from four known hatching nests were not banded (one of these found dead at nest). In addition, there were seven nests identified with unknown fate (unknown if hatched or failed). A total of six unbanded fledglings were seen in 6 exclosure on 4 August. Five are assumed to be from the five known unbanded chicks and the sixth from an unknown fate nest that did hatch in 6 or 7 exclosure. This sixth fledgling is accounted for in the total number of eggs, hatching nests, chicks, and fledglings for ODSVRA.

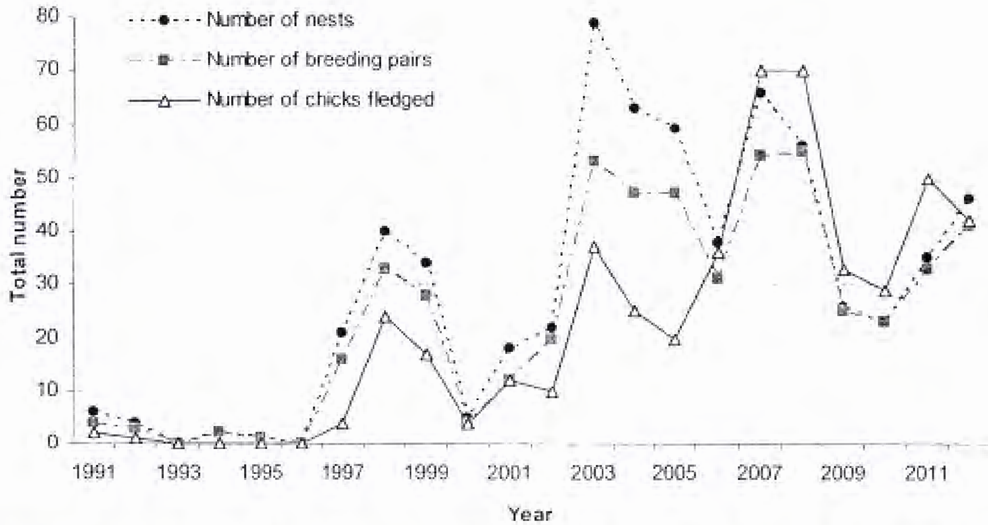


Figure 3. Number of California least tern nests, pairs, and fledglings at ODSVRA from 1991-2012.

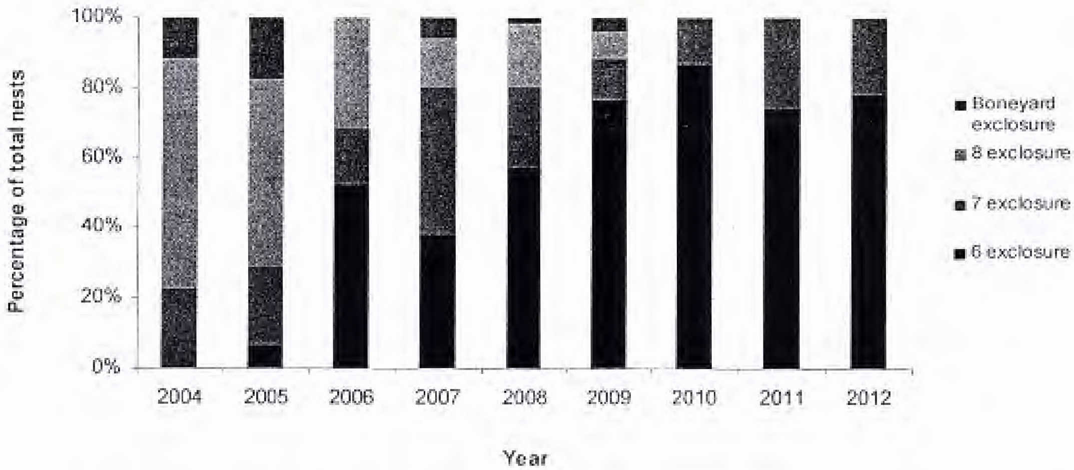


Figure 4. Distribution of least tern nests as a percent of total nests at ODSVRA from 2004-12.

6 exclosure was first incorporated into the Southern Exclosure for a full season in 2004.

Table 3. Causes of California least tern nest loss at ODSVRA from 2002-12.
Ab.=Abandoned

Year	Ab. pre-term	Ab. post-term	Ab., susp. wind	Ab., unknown if pre- or post-term	Failed, cause unknown	Coyote	Gull	Opossum	Unknown predator	Chick dies in egg at hatch	Total no. failed nests
2002	1	1				2					4
2003	6	3				1			2		12
2004	9	1				2			1		13
2005	7	3		4	4				1	1	20
2006[1]	5	3		1					1		10
2007	1	4	4		6						15
2008	3	2					1				6
2009	1	1		1							3
2010		1			1			1			3
2011	2	2									4
2012	1	2		3	1						7
Total 2002-12	36 (37.1%)	23 (23.7%)	4 (4.1%)	9 (9.3%)	12 (12.4%)	5 (5.2%)	1 (1%)	1 (1%)	5 (5.2%)	1 (1%)	97

[1] Ab. pre-term and Ab. unknown if pre- or post-term numbers for 2006 were incorrectly reported as three and three, respectively, in 2006-09 reports (CDPR 2006, 2007, 2008, 2009). The fates were listed correctly in Appendix A of the 2006 report.

Chick fledging rate and juveniles

Forty-five of the 52 known hatching chicks were banded with a unique color combination. Forty-two of the 52 chicks were seen when 21 days old or older for a fledging rate of 81% (36 fledglings were banded and six were unbanded) (Appendix A). This compares to an average fledging rate of 80% (range=71-91%) during the previous six years when most chicks were also banded to individual. Of 19 two-chick broods, 53% fledged both young; this compares to an 86% fledging rate for 22 two-chick broods in 2011 and an average of 64% (range=54-80%) for 131 two-chick broods during the period 2006-10. In 2012, the number of fledglings produced per pair was 1.02. This is 21.5% lower than the average for the previous six years (mean=1.3, range=1.16-1.52), but well above the statewide range of 0.17-0.25 for 2011. (Table 1). Statewide, the reported number of least tern fledglings per pair (given in a range) was 0.35-0.52, 0.33-0.39, 0.29-0.37, 0.24-0.30, 0.29-0.35, and 0.17-0.25 in 2006-11, respectively (Marschalek 2006, 2007, 2008, 2009, 2010, 2011).

There were three documented predation events involving least terns. On 31 July, a peregrine falcon was observed eating a fledgling or near-fledging tern in 6 exclosure (identification confirmed with collected feather remains). On 9 August, a tern band was present, along with snowy plover bands, in a coyote scat found east of the southern portion of North Oso Flaco. On 11 August, the fresh feather remains of an avian predator's prey were collected from 6 exclosure. The feathers were those of a least tern (likely a juvenile), and found along with the feathers was a least tern band. This band, and the one found in the coyote scat, were not the federal numbered bands and did not provide information on the identity of the depredated terns.

On 7 July, an unbanded chick, approximately one to two days old, was found dead at the nest from unknown cause. This chick was observed alive earlier in the day (observed by spotting scope from outside the exclosure).

During the last three years, 2010-12, there have been three occurrences of a least tern chick moving east of the exclosure into the open riding area (zero in 2012; one in 2011; and two in 2010, by the same chick on the same day). These chicks were being monitored closely and documented moving a few feet east of the exclosure fence before being directed back into the exclosure.

Of the current or recent breeding sites in San Luis Obispo and Santa Barbara counties, only ODSVRA bands chicks. Marking least tern chicks with individual color band combinations has increased the ability to detect juveniles at ODSVRA and provides greater accuracy in documenting fledging rate. In the absence of such banding, one method used to estimate the number of juveniles produced at least tern sites in California is to add together high counts of juveniles that are seen on dates at intervals of three weeks or more (Marschalek 2007). This is based on the assumption that juveniles typically depart the colony with their parents within two to three weeks of fledging (at 21 days old) and that any juveniles seen are not from other sites. A juvenile count using the three-week count method is not available for 2012 at ODSVRA. For the previous six-year period 2006-11, the three-week count method consistently underestimated the minimum known number of juveniles produced each year, identifying an average of 49.0% (range=38.0-66.7%) of the known minimum total number (Table 4).

Table 4. Number of fledglings counted at ODSVRA from 2006-11 using two methods: three-week interval daytime counts and identification of individuals in the mostly color-banded population of juveniles.

Data not available for 2012. Chicks banded to individual for all years.

Year	Three-week interval daytime count	Identification of individuals in the mostly color-banded population of juveniles	Percent of documented juveniles identified by three-week interval daytime count
2006	17	36	47.2
2007	38	70	54.3
2008	30	70	42.9
2009	22	33	66.7
2010	13	29	44.8
2011	19	50	38.0
		Average for 2006-11	49.0

Color banding chicks to brood in 2005 and to individual since 2006 has also provided information on juvenile length of stay at ODSVRA. In 2012, 33.3% (12/36) of the color-banded juveniles were documented remaining at ODSVRA for 21 days or longer post-fledging. Over the eight-year period 2005-12, 333 color-banded fledglings were tracked at ODSVRA with 36.9% remaining 21 days or longer (Table 5, Figure 5). This is in contrast to the premise of the three-week count that most fledglings depart the colony site prior to three weeks after fledging. Similar findings are reported from a two-year study of three least tern colony sites in the eastern United States which found that methods dependent upon counting non-individually identified fledglings tend to underestimate fledgling production and residency time as compared to information available from counting individually banded fledglings (Bailey and Servello 2008).

Table 5. Number of days that color-banded California least tern juveniles hatched at ODSVRA continued to be seen on-site after reaching fledge age (21 days old) during the eight-year period, 2005-12.

During this period, 333 color-banded fledglings (21 days old or older) were tracked at ODSVRA (sightings outside the park are not included). A minimal number of juveniles identified as becoming permanently unable to fly (e.g. broken wing) are included up to (but not including) the day first noted as injured. Numbers in parentheses are percentages of all fledglings for the year.

Year	0 - 6 days post-fledge	7 - 13 days post-fledge	14 - 20 days post-fledge	21 - 27 days post-fledge	28 - 34 days post-fledge
2005	0 (0%)	4 (20%)	2 (10%)	10 (50%)	4 (20%)
2006	4 (12%)	5 (15%)	9 (26%)	14 (41%)	2 (6%)
2007	12 (17%)	14 (20%)	17 (25%)	21 (30%)	5 (7%)
2008	14 (21%)	30 (44%)	15 (22%)	9 (13%)	0 (0%)
2009	3 (10%)	14 (48%)	8 (28%)	3 (10%)	1 (3%)
2010	3 (11%)	4 (14%)	12 (43%)	9 (32%)	0 (0%)
2011	2 (4%)	5 (10%)	9 (18%)	31 (63%)	2 (4%)
2012	4 (11%)	6 (17%)	14 (39%)	10 (28%)	2 (6%)
TOTAL 2005-12	42 (13%)	82 (25%)	86 (26%)	107 (32%)	16 (5%)

Least tern use of nearby small freshwater lakes

During the chick-rearing period, adult least terns are noted foraging over the ocean, but can also be seen at the following nearby small freshwater lakes: Pismo Lake, Oso Flaco Lake, Dune Lakes, and Cypress Ridge Lake. Of the freshwater sources noted, Oso Flaco Lake and Pismo Lake are located on State Park property. Pismo Lake was first monitored for tern presence in 2010 with one day of recorded observations. Terns were also noted in 2011 flying over Pismo Lake on one day. Tern use of this lake is suspected to be minimal. There were no observed sightings in 2012; however, this area was not actively monitored by staff. Oso Flaco Lake is more accessible to monitors and in 2012 there were 26 surveys (lasting an average of 57 minutes) conducted between 30 July and 4 September. The high count of least terns seen at Oso Flaco Lake on one day was 13 on 9 August. Over the season, a total of 13 individually banded fledglings and a minimum of 12 banded adults were seen at Oso Flaco Lake, including 11 adults identified as banded as chicks at ODSVRA. Adults were observed foraging and roosting, while juveniles were observed flying and roosting, but not foraging. Terns were observed flying over Dune Lakes, but no detailed information is available because these lakes are only visible from a distance. There were many observations of adult terns with fish flying into the exclosure from the east (the direction of Dune Lakes). In 2007, monitors first documented terns foraging at Cypress Ridge Lake, located approximately 3.2 miles from the tern colony site. This lake had moderate levels of foraging in 2007-10, none in 2011, and minimal use in 2012.

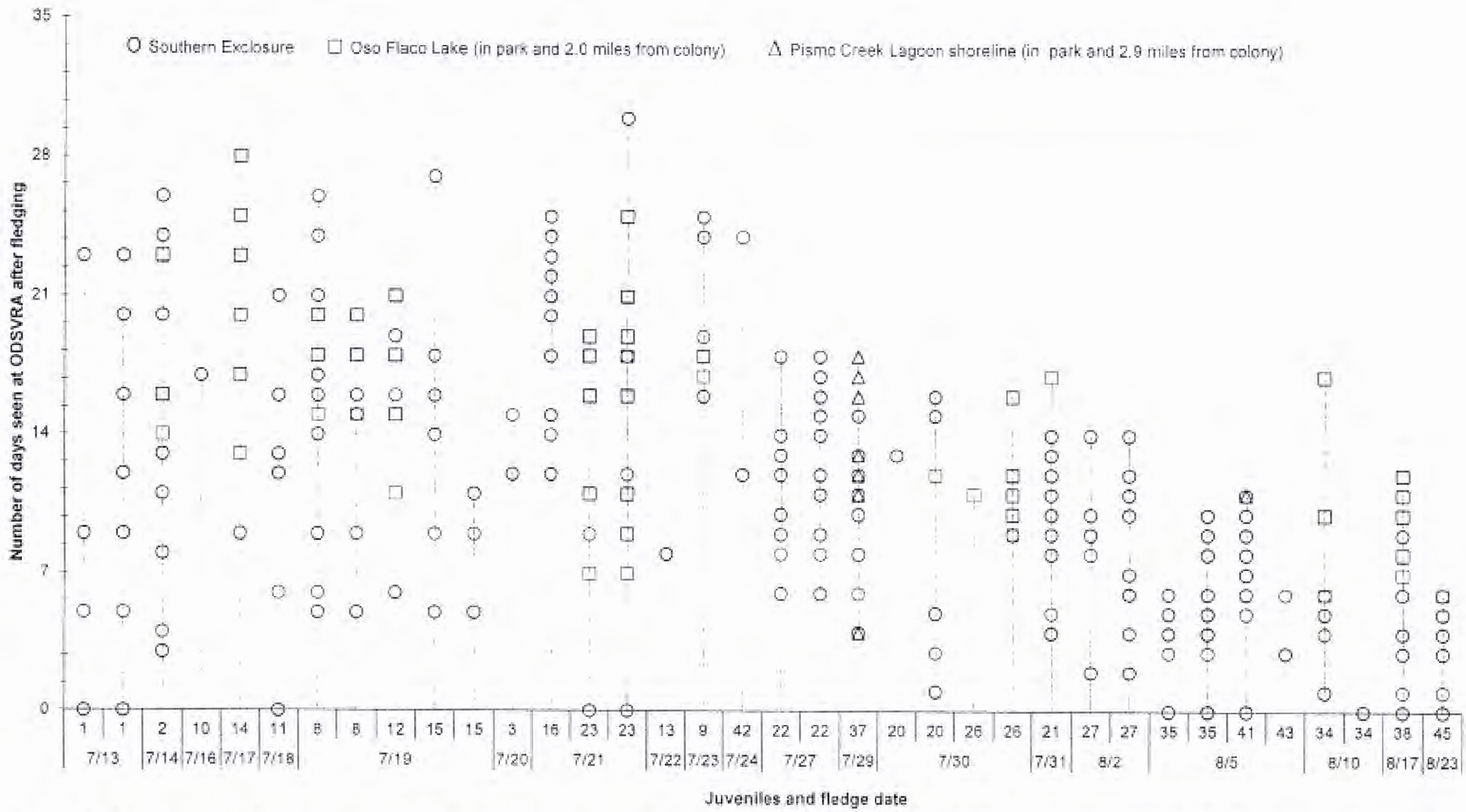


Figure 5. Number of days California least tern juveniles that hatched at ODSVRA in 2012 continued to be seen on-site after reaching fledge age (21 days old).
The horizontal axis provides the nest number from which each fledgling hatched and the date it fledged. All juveniles included in graph were color-banded to individual.

Banded adult least terns at ODSVRA

Recording color combinations is more difficult for adult least terns than snowy plovers, as the behavior of the terns provides fewer opportunities for observations. Of the 38 banded adults documented at ODSVRA in 2012, 33 were banded as chicks at the site from 2006-11. Five adults had only a federal aluminum band and may or may not have been banded at ODSVRA. Breeding was documented for eight of the 38 banded adults (all banded at ODSVRA from 2006-10) (Table D.1 in Appendix D).

ODSVRA banded least terns seen away from vicinity of colony

In 2012, six color-banded least terns from ODSVRA were seen in southern San Diego County on their southward migration. Four were juveniles and two were adults. All were banded at ODSVRA when chicks.

Two sibling juveniles from nest LT23 (O/G:B/W and Y/G:B/W) were observed. The O/G:B/W juvenile (last observed at ODSVRA on 17 August) was at Chula Vista Wildlife Reserve (CVWR) on 21 and 28 August and 4 September. The Y/G:B/W juvenile (last observed at ODSVRA on 20 August) was at the mouth of the Tijuana River on 23 August.

One juvenile from nest LT27, O/R:B/W (last observed at ODSVRA on 16 August), was observed at CVWR on 28 August and 4 September.

One juvenile from nest LT38, Y/B:B/W (last observed at ODSVRA on 29 August), was observed at CVWR with an associated adult, Y/W:W/B/W, banded in 2008 (last observed at ODSVRA on 25 August with Y/B:B/W). While at ODSVRA, this adult was identified as a parent of this juvenile.

O/A:W/B adult was observed at CVWR on 28 August (last observed at ODSVRA on 15 August). This bird was banded while a chick at ODSVRA in 2009.

Night roost

During the breeding season, adult least terns not engaged in incubation or chick care may assemble in a communal night roost and are often joined by fledglings later in the breeding season. Reduced exposure to disturbance from predators is likely an important factor in the selection of a night roost location. There can be a high degree of site fidelity, both within a breeding season and between years, with birds continuing to roost in the same location. In 2012, the night roost continued in the same area of northern 6 exclosure used since 2004 (when 6 exclosure first became available as protected habitat for a complete season) (Figure C.2 in Appendix C). Counts at the night roost are minimums, as some or all birds would often arrive after it was too dark to count individuals. In 2012, there was a high count of 62 birds at the night roost on 14 June (Figure 6). This compares to night roost high counts of 95, 63, 37, 35, and 52 in 2007-11, respectively. Both adults and juveniles were seen but it typically was too dark to distinguish plumage and age class.

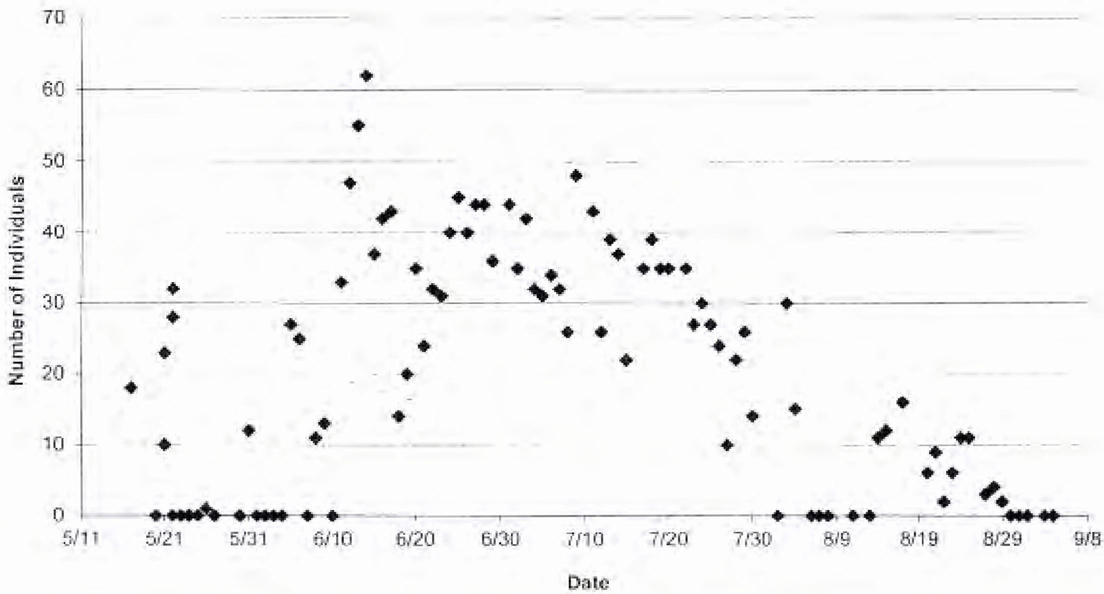


Figure 6. Number of California least terns counted at the ODSVRA 6 exclosure night roost in 2012.

On occasions when zero terns were observed prior to 30 August, vocalizations were often heard as terns arrived after dark.

Importance of ODSVRA least tern breeding colony

The ODSVRA least tern breeding colony has benefited from the increased level of protection and management actions provided since 2002. The colony is important in meeting statewide recovery goals as loss of breeding habitat has resulted in a fragmented population distribution and a limited number of remaining breeding sites (USFWS 1985, 2006). On a regional level, there are very few active breeding sites along the central coast of California and none remain between ODSVRA and San Francisco Bay. Within San Luis Obispo and Santa Barbara counties, there are four least tern colony sites with annual or intermittent use, all sites have management providing protective measures and monitoring. ODSVRA is the only site in San Luis Obispo County. Rancho Guadalupe Dunes County Park (RGDCP), Vandenberg Air Force Base (VAFB), and Coal Oil Point Reserve (COPR) are in Santa Barbara County and approximately 7, 22, and 85 miles south of the ODSVRA colony, respectively. For this regional population, ODSVRA has become an important source of productivity. During the period 2004-12, ODSVRA produced a minimum of 375 juvenile terns while RGDCP, VAFB, and COPR combined produced 129 juveniles (Table 6, Table 7).

Table 6. California least tern reproductive success reported for current or recent breeding sites in San Luis Obispo and Santa Barbara counties from 2004-12.

Note that chicks are not banded at RGDCP, VAFB, and COPR. In this table, ODSVRA calculations for number of juveniles per nest are made using all nests (known and unknown fates) in order to compare with method used for other sites. Sources: RGDCP (pers. comm. managers), VAFB (pers. comm. Dan Robinette for all years), and COPR (pers. comm. C. Sandoval).

ODSVRA=Oceano Dunes SVRA RGDCP=Rancho Guadalupe Dunes County Park
VAFB=Vandenberg Air Force Base COPR=Coal Oil Point Reserve

Year	Site	No. pairs	No. nests	No. nests hatching	No. chicks	No. juveniles	No. juveniles per total no. nest	No. juveniles per pair
2004	ODSVRA	47	63	44	69	25	0.40	0.53
	RGDCP	8	8	3	7	0	0.00	0.00
	VAFB[1]	1	1	0	0	0	0.00	0.00
	COPR	6	6	0	0	0	0.00	0.00
2005	ODSVRA	47	59	39	66	20	0.34	0.43
	RGDCP	4	4	0	0	0	0.00	0.00
	VAFB	44	44	18	32	1	0.02	0.02
	COPR	0	0	0	0	0	0.00	0.00
2006	ODSVRA	31	38	28	45	36	0.95	1.16
	RGDCP	0	0	0	0	0	0.00	0.00
	VAFB[1]	2	2	0	0	0	0.00	0.00
	COPR	5	5	4	7	7	1.40	1.40
2007	ODSVRA	54	66	51	90	70	1.06	1.30
	RGDCP	1	1	1	1	1	1.00	1.00
	VAFB	18	18	13	20	16	0.89	0.89
	COPR	4	6	2	4	0	0.00	0.00
2008	ODSVRA	55	56	50	99	70	1.25	1.27
	RGDCP	0	0	0	0	0	0.00	0.00
	VAFB	18	18	17	32-33	19	1.06	1.06
	COPR	1	1	0	0	0	0.00	0.00
2009	ODSVRA	25	26	23	43	33	1.27	1.32
	RGDCP	2-3	3	2	3	3	1.00	1.00-1.50
	VAFB	30	31	28	56	37	1.19	1.23
	COPR	0	0	0	0	0	0.00	0.00
2010	ODSVRA	23	23	20	35	29	1.26	1.26
	RGDCP	1	1	1	2	2	2.00	2.00
	VAFB	33	34	29	57	29	0.85	0.88
	COPR	0	0	0	0	0	0.00	0.00
2011	ODSVRA	33	35	31	55	50	1.43	1.52
	RGDCP	0	0	0	0	0	0.00	0.00
	VAFB	32	32	19	36	4	0.13	0.13
	COPR	1	1	0	0	0	0.00	0.00
2012	ODSVRA	41	46	33	52	42	0.91	1.02
	RGDCP	0	0	0	0	0	0.00	0.00
	VAFB	18	18	12	21	10	0.56	0.56
	COPR	0	0	0	0	0	0.00	0.00

[1] Minimum counts of adult terns at the VAFB colony site were 60 and 40 in 2004 and 2006, respectively, but nesting was limited.

Table 7. Number of reported breeding least tern pairs and juveniles produced at ODSVRA and the combined sites of Rancho Guadalupe Dunes County Park (RGDCP), Vandenberg Air Force Base (VAFB), and Coal Oil Point Reserve (COPR) from 2004-12.

During this period, almost all tern chicks were banded at ODSVRA and observation of color-banded individuals was an important means to document juvenile production. Banding does not occur at the other sites and other methods are used to estimate number of juveniles produced.

Year	ODSVRA		RGDCP, VAFB, and COPR combined	
	No. breeding pairs	No. juveniles	No. breeding pairs	No. juveniles
2004	47	25	15	0
2005	47	20	48	1
2006	31	36	7	7
2007	54	70	23	17
2008	55	70	19	19
2009	25	33	32-33	40
2010	23	29	34	31
2011	33	50	33	4
2012	41	42	18	10
Total juveniles produced		375		129

Western Snowy Plover

Number of breeding adults

In the absence of a population of individually banded snowy plover adults, which provides the most accurate means to identify breeding population size, ODSVRA uses a method that includes examining the single day high count of concurrent nests (for females) and concurrent nests and broods (for males) (see Monitoring and Management Actions section for additional information on determining number of breeding adults). In 2012, there was a minimum of 190 breeding adults (85 females and 105 males), an increase of 18.8% from 160 breeding adults in 2011, and the fifth consecutive year of increase in the breeding population size (Table 8, Figure 7).

Beginning in 2005, USFWS has coordinated a rangewide window survey count of the U.S. Pacific Coast breeding population of the snowy plover between the last week of May and first week of June. In 2012, the survey at ODSVRA counted 145 plovers (48 males, 59 females, and 38 of unknown sex), 76% of the minimum number documented by breeding activity. In seven of the eight years from 2005-12, the window survey count at ODSVRA was lower than the calculated minimum number of breeding birds (54-86% of calculated minimum number). It was higher (107%) than the calculated minimum number in 2008 (Table 9) (CDPR 2011).

Table 8. Number of snowy plover breeding adults, breeding males, fledglings, and chicks fledging per breeding male for the 11-year period, 2002-12.

Year	Min. no. breeding adults	Min. no. breeding males	No. fledglings	No. fledglings per breeding male
2002	32	18	35	1.94
2003	84	52	107	2.06
2004	121	67	66	0.99
2005	116	65	82	1.26
2006	107	58	17	0.29
2007	79	47	66	1.40
2008	95	54	72	1.33
2009	114	66	81	1.23
2010	137	78	107	1.37
2011	160	94	152	1.62
2012	190	105	96	0.91
Average for 11-year period 2002-12	112	64	80	1.31
Average for 5-year period 2008-12	139	79	102	1.29
Average for 3-year period 2010-12	162	92	118	1.30

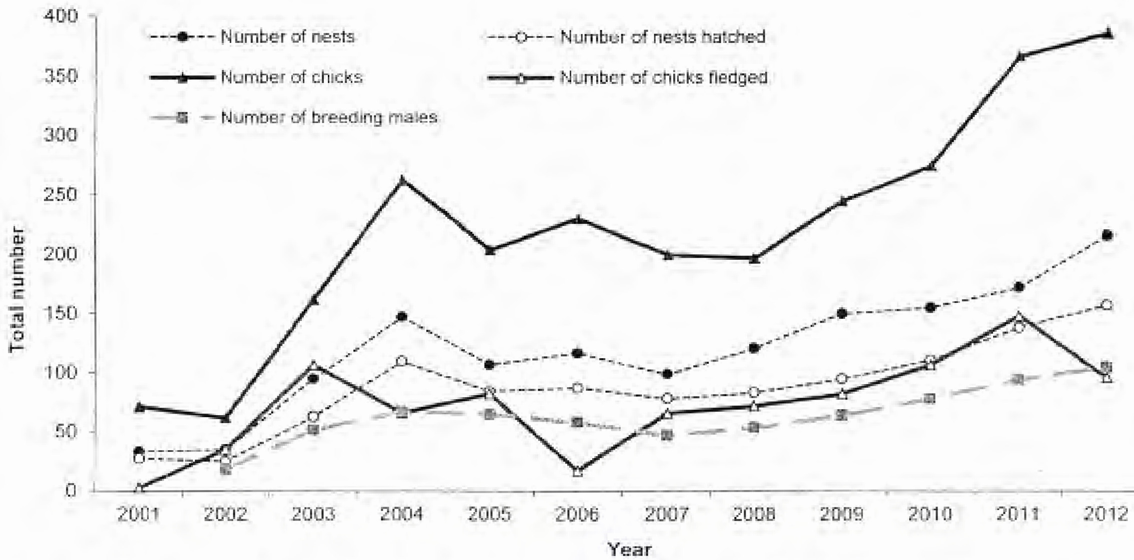


Figure 7. Number of snowy plover breeding males, nests, nests hatched, chicks, and chicks fledged at ODSVRA from 2001-12.

Prior to 2001, monitoring in Oso Flaco and Pismo Dunes Natural Preserve was intermittent and fledgling information was not obtained.

Table 9. Number of adult snowy plovers counted on USFWS breeding season window surveys versus calculated minimum number of breeding adults at ODSVRA from 2005-12.

Year	Calculate minimum number of breeding adults	Breeding window survey numbers	Breeding window numbers/ calculated minimum numbers
2005	116	92	79%
2006	107	87	81%
2007	79	60	76%
2008	95	102	107%
2009	114	98	86%
2010	137	74	54%
2011	160	112	70%
2012	190	145	76%

Number and distribution of nests

There were 216 known nesting attempts, including five identified only by detection of brood (unknown nest location) and eight with nest fate (hatch or fail) unknown. Of the 211 nests from known locations, 194 (91.9%) were in the Southern Exclosure, five (2.4%) in North Oso Flaco, nine (4.3%) in South Oso Flaco, and three (1.4%) in the open riding area. More specifically for the Southern Exclosure, there were 97 nests in 6 exclosure, 57 in 7 exclosure, 31 in 8 exclosure, and nine in Boneyard exclosure. In 2012, three nests were initiated in the open riding area; one was found east of 6 exclosure and two were found north of the Southern Exclosure with the northernmost nest approximately 3,000 feet north of 6 exclosure and northeast of marker post 5 (Appendix C). The maximum number of known location nests active at one time was 79 on 26 June, with the highest number in 6 exclosure (49 nests, 62% of total active nests). (Table 10, Table 11, Table E.1 in Appendix E).

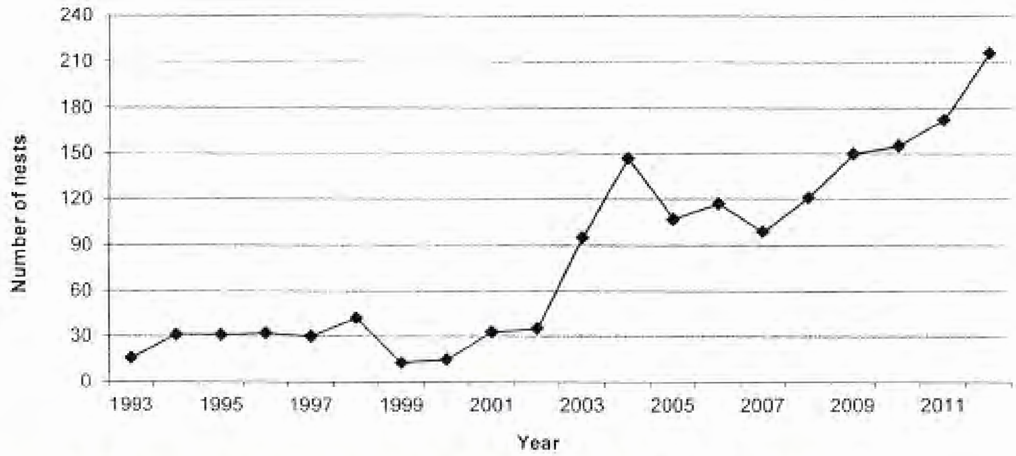


Figure 8. Number of snowy plover nests at ODSVRA from 1993-2012.

Table 10. Snowy plover nest distribution and success at ODSVRA in 2012.

Area	No. nests (no. known location and fate)	No. eggs laid	No. nests hatching (no. known location)	Percent hatching	No. chicks (no. known fate)	No. known fate chicks fledged (percent fledged)	No. fledglings per nest
6 exclosure	97 (92)	275	78 (78)	84.8	190 (190)	41 (22)	0.45
7 exclosure	57 (55)	159	41 (41)	74.5	99 (99)	24 (24)	0.44
8 exclosure	31 (30)	88	21 (21)	70.0	57 (57)	19 (33)	0.63
BY exclosure	9 (9)	21	3 (3)	33.3	7 (7)	1 (14)	0.11
TOTAL SOUTHERN EXCLOSURE	194 (186)	543	143 (143)	76.9	353 (353)	85 (24)	0.46
North Oso Flaco	5 (5)	15	5 (5)	100.0	11 (11)	2 (18)	0.40
South Oso Flaco	9 (9)	25	4 (4)	44.4	10 (10)	2 (20)	0.22
TOTAL OSO FLACO	14 (14)	40	9 (9)	64.3	21 (21)	4 (19)	0.29
Open riding area	3 (3)	8	0 (0)	0	0 (0)	0 -	0.00
Unknown location	5 (0)	12	5 (0)	-	12 (12)	2 (17)	-
Unassigned broods	7 (0)	19	7 (0)	-	19 (19)	5 (26)	-
2012 GRAND TOTAL	216 (203)	603	157 (152)	74.9	386 (386)	96 [1] (25)	0.46 [1]

[1] Includes five fledglings from seven broods that could not be assigned to a specific nest and exclosure.

Table 11. Nesting success of snowy plovers at ODSVRA from 2001-12.
A more detailed table of nesting success for 2001-12 is included as Table E.1 in Appendix E.
For 2001: NA=not available and the number of fledglings per nest is an estimate.

Year	No. nests (no. known location and fate)	No. eggs laid	No. nests hatching (no. known location)	Percent hatching	No. chicks (no. known fate)	No. known fate chicks fledged (percent fledged)	No. fledglings per nest
2001	33 (30)	NA	27 (27)	90	71-74 (69)	2 (3)	0.07
2002	35 (35)	99	25 (25)	71	62 (62)	35 (56)	1.00
2003	95 (93)	254	63 (62)	67	162 (159)	108 (67)	1.16
2004	147 (140)	415	110 (105)	75	263 (263)	66 (25)	0.47
2005	107 (103)	290	84 (80)	78	204 (204)	82 (40)	0.80
2006	117 (114)	336	87 (87)	76	230 (230)	17 (7)	0.15
2007	99 (91)	290	78 (70)	77	200 (198)	66 (33)	0.73
2008	121 (119)	341	83 (81)	68	197 (197)	72 (37)	0.61
2009	150 (147)	418	95 (94)	64	245 (245)	81 (33)	0.55
2010	155 (150)	431	111 (109)	73	275 (275)	107 (39)	0.71
2011	172 (160)	487	138 (131)	82	365 (365)	152 (42)	0.95
2012	216 (203)	603	157 (152)	75	386 (386)	96 (25)	0.46

Nest hatching rate

There were 216 identified nesting attempts initiated between 29 March – 17 July (Figure 8, Figure 9). An average of 2.94 eggs per clutch was calculated from the total number nests from known location with known complete clutch size (n=200) (Appendix B). Excluding 13 nests (eight with unknown fate and five detected by brood only), the clutch hatching rate was 74.9% (152/203). This compares to 81.9% in 2011 and an average of 73.1% (range=64-82%) from 2002-11 (Table 10). The nest hatching rate in 2012 was higher in the Southern Exclosure (76.9%) compared to Oso Flaco (64.3%), as has been the case in nine of the previous 11 years (Table E.1 in Appendix E). Fifty-one nests failed, with losses attributed to abandoned pre-term (16), abandoned post-term (2), abandoned suspected due to wind (7), abandoned unknown pre- or post-term (3), cause unknown (3), unidentified predator (3), unidentified avian predator (6), corvid (3), northern harrier (5), peregrine falcon (1), coyote (1), and flooded (1) (Table 12, Table 13).

While the percentage of nests with unknown fate was low in 2012, there has been an increase over the last five years: 2008 (0.0%), 2009 (1.3%), 2010 (2.0%), 2011 (3.0%), and 2012 (3.8%). This is primarily due to an increasing number of nests with nearby young tern and plover broods, resulting in limited access to examine these nests.

Table 12. Attributed causes of snowy plover nest loss at specific locations at ODSVRA in 2012.

Area	Abandoned pre-term	Abandoned post-term	Abandoned, suspected wind	Abandoned unknown pre- or post-term	Failed, cause unknown	Unidentified predator	Avian predator	Corvid	Northern harrier	Peregrine falcon	Coyote	Flooded
Southern Exclosure												
6 exclosure	2	1	2	3		1	2		1	1		1
7 exclosure	2		2		2	1	2	1	4			
8 exclosure	5				1	1	1	1				
Boneyard exclosure	2		2					1			1	
TOTAL SOUTHERN EXCLOSURE	11	1	6	3	3	3	5	3	5	1	1	1
Oso Flaco												
North Oso Flaco												
South Oso Flaco	3	1	1									
TOTAL OSO FLACO	3	1	1	0	0	0	0	0	0	0	0	0
Open Riding Area	2						1					
ODSVRA TOTAL	16	2	7	3	3	3	6	3	5	1	1	1

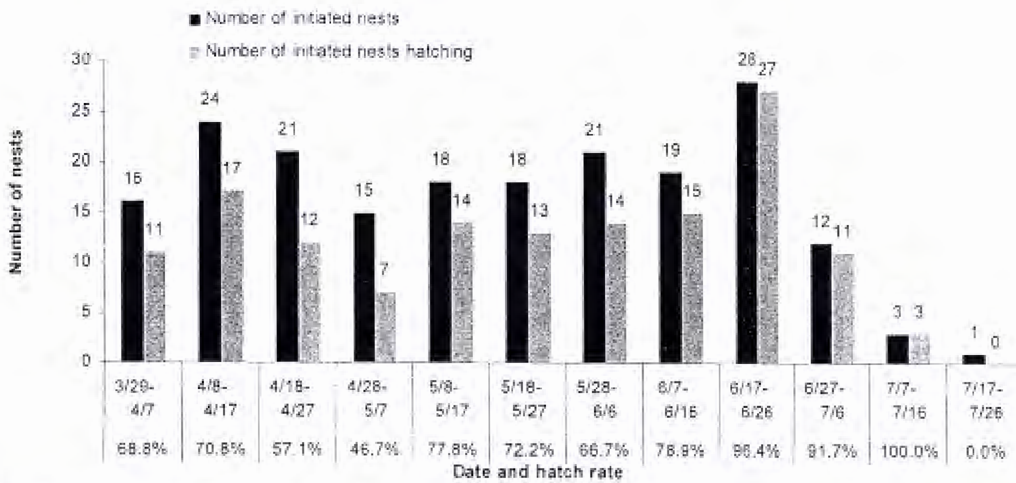


Figure 9. Number of known location and known fate snowy plover nests with known initiation date (n=197) initiated per 10-day period and number known to hatch at ODSVRA in 2012.

Table 13. Attributed causes of snowy plover nest loss in Southern Exclosure and Oso Flaco at ODSVRA from 2002-12.
So. Excl. = Southern Exclosure. The percentage of total loss for each cause is shown for the 11-year period 2002-12. In 2003, both Oso Flaco nests were abandoned pre-term due to death of adult(s). In 2004, one Oso Flaco nest was abandoned pre-term due to death of adult(s). Prior to 2010, nests abandoned suspected due to wind were included with nests abandoned pre-term; these causes of nest loss are shown separately for 2010-12.

Year	Area	Abandoned pre-term	Abandoned post-term	Abandoned, suspected wind	Abandoned unknown pre- or post-term	Failed, eggs removed by staff	Failed, cause unknown	Unidentified predator	Avian predator	Gull	Corvid	Raven	Northern harrier	Peregrine falcon	Coyote	Raccoon	Skunk	Flooded
2002	So. Excl.				6		1								1			
	Oso Flaco				2													
2003	So. Excl.	17	2					3				1						
	Oso Flaco	2					1	1				4						
2004	So. Excl.	12					7	2				2			1			
	Oso Flaco	4					2	3										1
2005	So. Excl.	9	3				7											
	Oso Flaco	2	1					1										
2006	So. Excl.	5	4				2	1		3					4			
	Oso Flaco				1			1		3								2
2007	So. Excl.	4	1				9					1						
	Oso Flaco	2					2					1			1			
2008	So. Excl.	10			3		7	4		1			1					1
	Oso Flaco	3			1			5										2
2009	So. Excl.	9				3	1	8	13	2			1					1
	Oso Flaco	4					2	2	4								1	1
2010	So. Excl.	3	2	11				4	6									2
	Oso Flaco	1		2					2							1	2	1
2011	So. Excl.	6	3	1	1		2	1	5		3							
	Oso Flaco							2			2					1	2	
2012	So. Excl.	11	1	6	3		3	3	5		3		5	1	1			1
	Oso Flaco	3	1	1														
2002-12 Total failed nests	So. Excl.	86 32.3%	16 6.0%	18 6.8%	13 4.9%	3 1.1%	39 14.7%	26 9.8%	29 10.9%	6 2.3%	6 2.3%	4 1.5%	7 2.6%	1 0.4%	7 2.6%	0 0.0%	0 0.0%	5 1.9%
	Oso Flaco	21 25.3%	2 2.4%	3 3.6%	4 4.8%	0 0.0%	7 8.4%	15 18.1%	6 7.2%	3 3.6%	2 2.4%	5 6.0%	0 0.0%	0 0.0%	1 1.2%	2 2.4%	5 6.0%	7 8.4%
2002-12 Grand Total So. Excl. and Oso Flaco		107 30.7%	18 5.2%	21 6.0%	17 4.9%	3 0.9%	46 13.2%	41 11.7%	35 10.0%	9 2.6%	8 2.3%	9 2.6%	7 2.0%	1 0.3%	8 2.3%	2 0.6%	5 1.4%	12 3.4%

Chick fledging rate

Of the 386 snowy plover chicks hatched, 341 were banded and the fate of 45 unbanded chicks is known (three fledged) (Table 10, Table 11, Appendix B). The primary reason chicks remained unbanded was their close proximity to young plover or tern broods and the need to avoid undue disturbance. Unbanded chicks were tracked by a combination of the following: chicks observed with a banded adult, with banded sibling(s), and near-daily monitoring attempts to locate all broods and determine number and size of chicks. In the absence of a high percentage of chicks being banded at ODSVRA, it would not be possible to obtain accurate chick survival and fledging rates. Between 23 June and 6 August, seven unbanded broods (19 chicks) were observed on the shore and are assumed to be from known hatched nests whose chicks were not banded while at the nest. Six of the seven broods were subsequently banded. Although these broods could not be assigned to a specific nest and exclosure, all chicks were tracked and fledglings are included in totals. The chick fledging rate in 2012 was a relatively low 24.9% (96/386). This compares to 41.6% (152/365) in 2011 and an average rate of 37.9% (range=7-67%) for the nine-year period 2002-10. Predation is the suspected cause for the majority of chick loss (Table 10, Table E.1 in Appendix E) (CDPR 2007, 2008, 2009, 2010, 2011).

The dates when chicks first and last hatch, as well as the number of days between these events, can vary every season. To provide for a comparison between years, a common date separating early and late season was derived by determining the midpoint between dates of the first and last chick hatching for each year during the four-year period 2007-10 There was a 13-day span between these midpoints with a median date of 20 June; the following full day was used for both midpoints and median if they contained a fraction (e.g., median of 19.5 June became 20 June). Early season for chick production is defined as prior to 20 June and late season as 20 June or later (same separation periods also applied to years prior to 2007 and after 2010 when comparisons are made). Similar to nine of the previous ten years, chick survival in 2012 was lower in the late season compared to the early season. The early season fledging rate (36%) was third lowest of the previous ten years (range=8-84%, mean=46%), while the late season fledging rate (15%) was third lowest for the same period (range=7-54%, mean=26%). Chick survival was particularly poor in the latter portion of the late season. Of the 141 chicks hatching on or after 13 July, only seven fledged for a fledging rate of 5.0%. (Table 14, Figure 10, Figure 11).

Table 14. Number of chicks hatching in early season (prior to 20 June) and late season (20 June or later) and subsequent fledging rate at ODSVRA from 2007-12.

					Early season (chicks hatched on or before 19 June)		Late season (chicks hatched on or after 20 June)	
Year	Date first chick hatched	Date last chick hatched	No. of days between first and last chick hatched	Date of midpoint between first and last chicks hatched	No. chicks	Percent fledged	No. chicks	Percent fledged
2007	29 Apr	20 Aug	114	17 Jun	88	43%	110	25%
2008	20 Apr	4 Aug	107	22 Jun	94	46%	103	28%
2009	20 Apr	22 Aug	125	13 Jun	106	55%	139	17%
2010	27 Apr	6 Aug	102	25 Jun	143	34%	132	45%
2011	22 Apr	12 Aug	113	17 Jun	145	58%	220	31%
2012	4 May	14 Aug	103	24 Jun	174	36%	212	15%

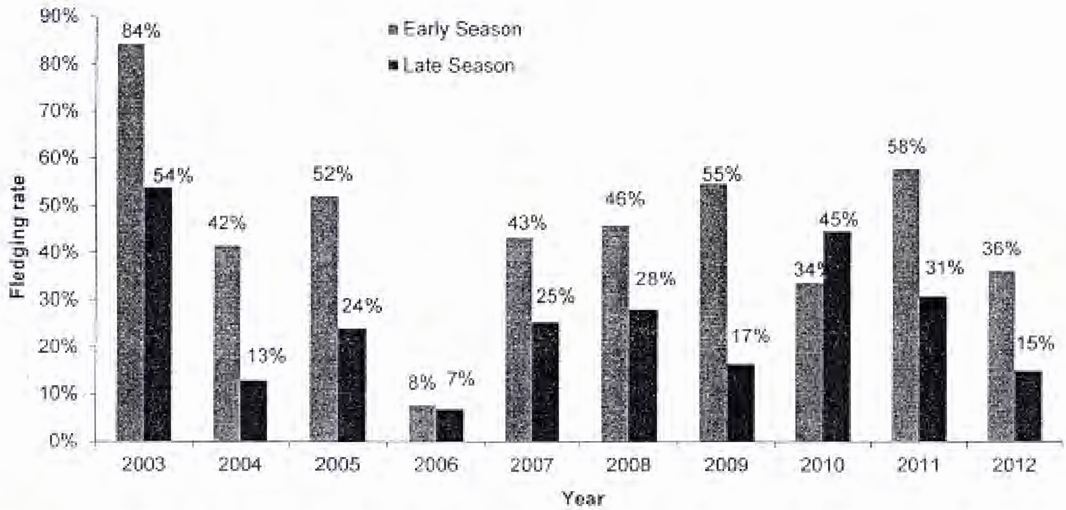


Figure 10. Fledging rate of chicks hatching in early season (prior to 20 June) and late season (20 June or later) at ODSVRA from 2003-12.

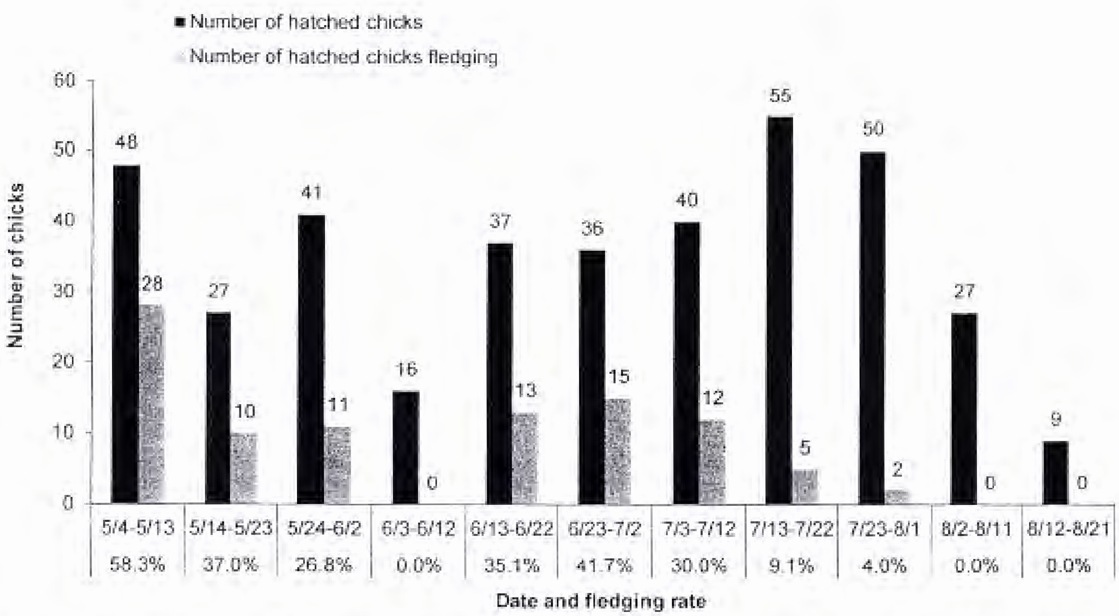


Figure 11. Number of snowy plover chicks hatching per 10-day period and number subsequently fledging at ODSVRA in 2012.

For five broods originating from unknown location, a hatch date was estimated based on chick size (all chicks were very young when first seen).

Brood movement and age of chick loss

Close proximity of quality shoreline habitat for raising chicks can benefit productivity, as mortality rates are typically highest for young chicks. At ODSVRA, most snowy plover broods are initially led from the nest by the parent(s) to the nearest shore to forage. In 2009-12, the majority of broods (75%, 76%, 78%, and 65%, respectively) were not known to move beyond the individual beach section (6, 7, and 8 exclosures, North Oso Flaco and South Oso Flaco) nearest to where they hatched. Sites south of ODSVRA in the contiguous coastal dune system also manage and monitor snowy plovers and report any sightings of broods banded at ODSVRA.

Of the 96 fledglings produced in 2012, 77 were from broods remaining in the same general area where hatched. Chick loss was highest for very young chicks (0-4 days of age), accounting for 51% of total loss, which compares to 38%, 39%, and 49%, in 2009-11, respectively (Figure 12) (CDPR 2011). Disproportionate loss of very young chicks increases the observed proportion of broods remaining in the area where hatched, as the entire brood may be lost before further movement outside of that area could occur (Table 15). For 136 chicks reaching 16 days of age in 2012, the fledge rate was 71%. This compares to 73% (111 chicks reaching 16 days of age), 76% (141 chicks), and 80% (190 chicks) in 2009, 2010, and 2011, respectively. This is lower than the results from a six-year (1977-82) study at Monterey Bay in Monterey County, California, that found at least 93% of the 124 chicks reaching 16 days of age fledged (Warriner et al. 1986).

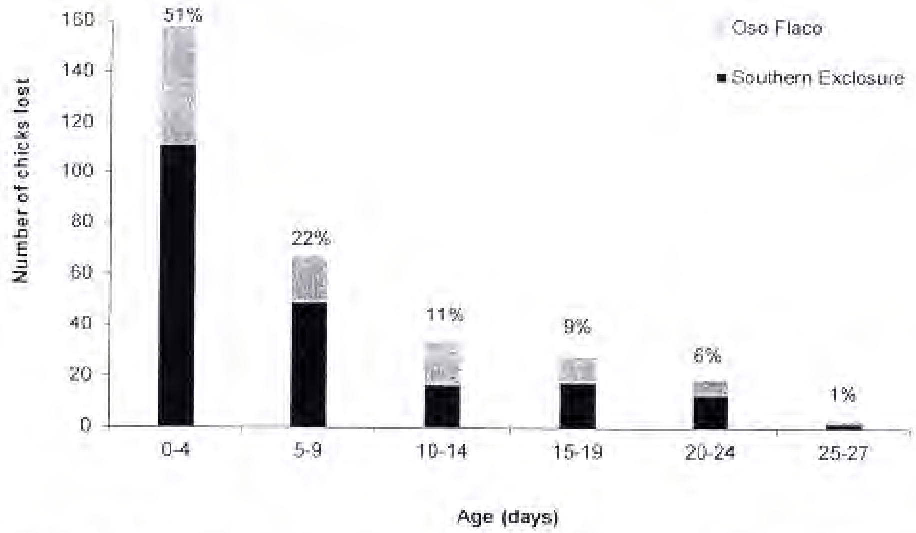


Figure 12. Loss of snowy plover chicks by age and location last seen in the Southern Exclosure and Oso Flaco at ODSVRA in 2012.

Number and percentage of total chicks lost shown for each age group. Of the 386 chicks whose fate was tracked, 290 were lost. Three live chicks were removed from site by monitors (Notes section). These chicks are considered lost on the day they were removed.

Table 15. Snowy plover brood movement at ODSVRA in 2012.

Three broods hatched from Boneyard exclosure are included in North Oso Flaco (Boneyard exclosure is located directly east of North Oso Flaco). The five broods from unknown location were very young when first observed and are included in area first seen (one in 7 exclosure, three in North Oso Flaco, and one in South Oso Flaco). Seven unassigned broods are included in the area where first seen (one in 6 exclosure, two in 8 exclosure, and four in North Oso Flaco). Eleven broods were known to cross back and forth over shoreline boundaries in area hatched and adjoining area; they are assigned to the area observed most frequently.

			Broods remaining in area hatched			Broods leaving area hatched		
Area	Shoreline length	Total no. broods	No. broods	No. broods that fledged at least one chick	No. chicks that fledged (chicks fledged per brood)	No. broods	No. broods that fledged at least one chick	No. chicks that fledged (chicks fledged per brood)
Southern Exclosure								
6 exclosure	0.52 mile	79	46	21	33 (0.72)	33	6	8 (0.24)
7 exclosure	0.42 mile	42	23	9	13 (0.57)	19	10	11 (0.58)
8 exclosure	0.45 mile	23	20	12	24 (1.20)	3	0	0 (0.00)
TOTAL SOUTHERN EXCLOSURE	1.39 miles	144	89	42	70 (0.79)	55	16	19 (0.35)
Oso Flaco								
North Oso Flaco	0.54 mile	15	14	4	5 (0.36)	1	0	0 (0.00)
South Oso Flaco	1.16 miles	5	3	1	2 (0.67)	2	0	0 (0.00)
TOTAL OSO FLACO	1.70 miles	20	17	5	7 (0.41)	3	0	0 (0.00)
GRAND TOTAL	3.09 miles	164	106	47	77 (0.73)	58	16	19 (0.33)

Productivity measured by number of fledglings produced per adult male

Based on a population viability analysis in the USFWS Pacific Coast western snowy plover recovery plan, a rate of 1.0 fledglings produced per male is believed necessary to prevent population decline with 1.2 allowing for moderate population growth (assuming approximately 75% annual adult survival and 50% juvenile survival) (USFWS 2007). In 2012, the number of chicks fledging per male was 0.91, the second lowest in the 11-year period 2002-12. During this same period, the number of fledglings produced per male has exceeded 1.2 in eight of the 11 years (Table 8). (Note that if the number of breeding males is underestimated, the number of chicks fledged per male is an overestimate.)

Mortality (other than eggs)

There was a minimum of 25 documented snowy plover mortalities (other than eggs) at ODSVRA in 2012. Fifteen of these were the result of depredation of chicks, adults, and a least one juvenile. Predation was observed or documented by prey remains (clipped wings of adults) or presence of bands in scats or regurgitated pellets (castings). Predators involved were coyote, gull, peregrine falcon, northern harrier, and unidentified avian predator (see section titled Predators and predator management on page 40 for additional information). Mortality other than predation included the intact and often desiccated carcasses of seven chicks and three adults (Appendix H).

Use of 10 foot by 10 foot exclosures, circulars, and mini-exclosures

In 2012, there were 196 nests from known locations and with known fate receiving one or more types of seasonal wire fence protection in the Southern Exclosure and Oso Flaco. Fates of an additional eight nests with only symbolic rope fence included six hatching nests, one abandoned pre- or post-term and one with unknown fate. The majority of nests from known location with known fate (154, 76%) were within the large seasonal exclosure, 21% of these received additional small exclosures in areas of high predation. Nests protected only by the seasonal exclosure had a 90% hatch rate, and nests in the seasonal exclosure with additional small exclosures had an 82% hatch rate. In 2012, 10 foot by 10 foot exclosures with a net top were used on nine nests (55% hatch rate), circulars were used on eight nests (38% hatch rate), and mini-exclosures were used on 52 nests (87% hatch rate). Compared to 2011, the use of 10 foot by 10 foot exclosures decreased and the use of mini-exclosures increased (CDPR 2010, 2011) (Appendix B and Table E.2 in Appendix E).

Banded snowy plovers breeding at ODSVRA in 2012

Monitoring efforts include identifying banded birds breeding at ODSVRA. In 2012, 90% (169/190) of documented breeding adults were checked for the presence or absence of bands. Of these, 50% (84/169) were banded, with the majority (89%, 75/84) representing recruitment from chicks banded and fledging from ODSVRA from 2003-11. One bird banded as a chick at Reservation Road, Monterey County, was the only breeding bird identified that hatched north of ODSVRA, and six birds were banded as chicks south of ODSVRA (one banded in 2002 at the adjoining Guadalupe-Nipomo Dunes NWR and five from Vandenberg Air Force Base, Santa Barbara County). An additional two birds were missing bands or tape and were from unknown locations and years. Monterey Bay is the closest site north of ODSVRA where banding occurs (almost all chicks are banded). To the south of ODSVRA, banding has not occurred at the Guadalupe-Nipomo Dunes NWR for several years, but occurs annually at Vandenberg Air Force

Base (varying percentage of chicks banded), and at several sites in San Diego County (Table D.3 in Appendix D).

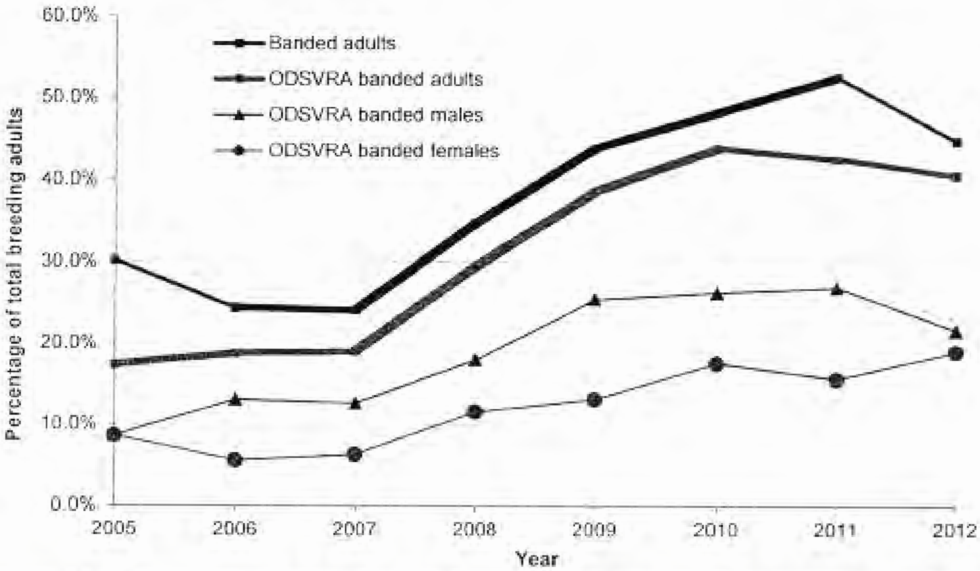


Figure 13. Percentages over the total calculated breeding population at ODSVRA of all verified banded adults and the sum of males and females originally banded at ODSVRA breeding from 2005-12.

Snowy plover surveys at ODSVRA during the nonbreeding season

Surveys for wintering plovers were conducted at weekly intervals (see Monitoring and Management Actions for survey details). Between October 2011 and February 2012, wintering snowy plover counts ranged from 104 to 247 (single day high count on 16 November 2011) at ODSVRA. Monthly averages were taken from three to five weekly surveys for each beach section. From 0.5 miles north of Pismo Pier to Grand Avenue, the monthly average ranged from five to 57 plovers (no plovers were observed north of Pismo Pier). The majority of plovers observed during the surveys were located between Grand Avenue and marker post 2, where off-highway vehicle use is prohibited, but street-legal vehicles are allowed. Within this area, the monthly average ranged from 50 to 129 plovers, with foraging birds and roosting flocks most often encountered on the relatively narrow beach between Grand and Pier Avenues. For the section of beach to the south (marker post 2 to marker post 6), the monthly average ranged from three to 26 plovers. Continuing south, the area from marker post 6 to the southern riding area boundary had a monthly average for of 11 to 47 plovers. For Oso Flaco, (southern riding area boundary to the southern property boundary), the monthly average ranged from 28 to 39 plovers (Figure 14).

Eighty banded snowy plovers were recorded during surveys from 1 October 2011 to 29 February 2012. These birds were banded at the following locations: 68 from ODSVRA; three from Vandenberg Air Force Base in Santa Barbara County; and nine from the Monterey Bay area in Monterey County, including Fort Ord (1), Reservation Road (1), Salinas River State Beach (1), Salinas River NWR (2), Moss Landing State Beach (3), and Pajaro Spit (1) (Table D.2 in Appendix D).

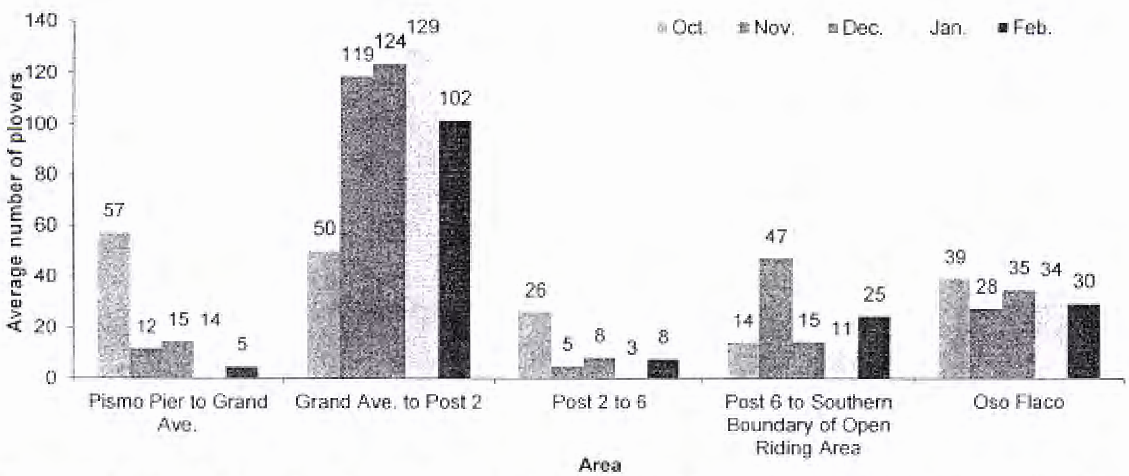


Figure 14. Monthly average number of snowy plovers observed during nonbreeding season surveys at ODSVRA from October 2011 to February 2012.

Surveys conducted three to five times a month.

Factors Influencing Least Tern and Snowy Plover Reproductive Success

The following is a discussion of some of the factors that influence reproductive success of terns and plovers at ODSVRA. The adequacy of any single factor alone is not sufficient to achieve and sustain recovery goals.

Size of protected habitat

Maintaining an adequate size of protected habitat at ODSVRA has been important in providing sufficient area for terns and plovers to roost, nest, and raise young. Protected breeding habitat of sufficient size allows nests and chicks to be dispersed which can reduce exposure and vulnerability to predators, as well as reduce adverse disturbance from human recreational activities. For plovers, it also improves opportunities for chicks to have access to adequate invertebrate food resources.

Quality of protected habitat

During the March through September least tern and snowy plover nesting season, habitat within the seasonal Southern Exclosure is protected and closed to public entry. Following the nesting season, and for the five-month period October through February, the area is open to public use, including camping, street-legal vehicles, and off-highway vehicles. This recreational use results in large areas of flattened terrain and barren sand with very limited scattered natural debris and vegetation. To offer more areas of disruptive cover the park staff places material in the 6, 7, and 8 exclosures. Materials added include surf-cast kelp (wrack), branches, driftwood, woodchips, seeds of coastal foredune plants, and a limited number of small container plants (see Appendix F for more detail).

Predators and predator management

Predators and predation can be an important factor limiting least tern and snowy plover reproductive success (Page et al. 1995; Thompson et al. 1997). Predators may impact terns and plovers directly by depredating eggs, chicks, juveniles, or adults. Indirect predator impacts, such as disturbance, can increase time spent by adults in vigilance or avoidance behavior, and may limit incubating and brooding behavior. Depredation of an adult tern or plover may result in egg abandonment or loss of dependent chicks. Predation can occur quickly, leaving little or no evidence, and it is likely that only a small percentage of events are documented during a season. There are many hours each day (including almost all night hours) when monitoring staff and/or predator management specialists are unable to observe predation. Even when monitors are present, there are limitations in the ability to detect predators, such as diurnal avian predators, that can travel quickly over large distances.

Species known to be predators of terns and plovers were documented by both number of days detected, as well as number of occurrences (mammalian) and sightings (avian). Number of days detected describes the total number of days predator presence was documented in the nesting area (Southern Exclosure and Oso Flaco) during the nesting season. Additional information was collected in order to estimate the extent of predator activity, both temporally and spatially, in the protected area. Occurrences and sightings were used for mammalian and avian predators, respectively, to reflect the difference in manner of detection; almost all mammalian predators were detected by tracks and scat whereas almost all avian predators were detected by direct observation (with the notable exception of nocturnal owls). Both occurrences and sightings are used to better describe the extent of predator activity on a single day by categorizing presence separately for the different areas of the Southern Exclosure (6, 7, 8, and Boneyard exclosures) and Oso Flaco (North and South). In addition, observations of an individual remaining in one area longer than one hour are counted as multiple sightings (one sighting per hour or portion thereof) in order to account for possible additional impacts. Information was more limited for mammalian predators and does not include details such as number of individuals, behavior, or duration of presence. The date range for all observations discussed is from 1 March to 10 September.

Selective live-trapping and relocation of avian predators was conducted by Ventana Wildlife Society and selective live-trapping and lethal removal of both mammalian and avian predators was conducted by USDA Wildlife Services. Eleven coyotes (*Canis latrans*), six raccoons (*Procyon lotor*), and one northern harrier (*Circus cyaneus*) were lethally removed. Three great horned owls (*Bubo virginianus*), two barn owls (*Tyto alba*), one northern harrier, two American kestrels (*Falco sparverius*), one peregrine falcon (*Falco peregrinus*), and nine loggerhead shrikes (*Lanius ludovicianus*) were live-trapped and relocated (Table G.2 in Appendix G).

Documented Predation
In 2012, no tern nests were known to be depredated. From 2002-12, 2.4% (12/499) of all tern nests were known to be lost to predators (6 mammalian, 1 avian, and 5 unidentified).

For snowy plovers, 19 of 203 (9.4%) nests with known fate and location were depredated (Table 16). Predators associated with nest loss included corvid (3), coyote (1), northern harrier (5), peregrine falcon (1), unidentified avian predator (6), and unidentified predator (3). From 2002-12, 8.7% (126/1454) of all plover nests were documented lost to predators (15 mammalian, 69 avian, and 42 unidentified).

Table 16. Snowy plover nest depredation rate in specific areas at ODSVRA in 2012.
Seven nests from unknown locations (known only by detection of brood) and five nests with unknown fate (hatch or fail) are not included in total number of nests with known location and known fate or in calculating percent nests depredated.

	6 exclosure	7 exclosure	8 exclosure	Boneyard exclosure	North Oso Flaco	South Oso Flaco	Open riding area	Total
No. nests depredated	5	8	3	2	0	0	1	19
Total no. nests with known location and fate	91	56	30	9	5	9	3	203
Percent depredated	5.5	14.3	10.0	22.2	0.0	0.0	33.3	9.4

In 2012, three least tern chicks, juveniles, or adults were documented as depredated by avian or mammalian predators. On 31 July, a peregrine falcon was observed with prey inside 6 exclosure. Feathers collected at this location were identified as belonging to a near-fledgling or fledgling least tern. On 9 August, coyote scat found in the Oso Flaco area contained an ODSVRA least tern band. On 11 August, feather remains of a juvenile least tern and an ODSVRA least tern band were found together in 6 exclosure.

In 2012, there was a minimum of 15 plover chicks, juveniles, or adults documented as depredated by avian or mammalian predators. On 9 May, an adult male northern harrier was observed landing and removing a recently hatched chick from a nest in 7 exclosure. On 23 May, a sub-adult female peregrine falcon was observed taking one chick and possibly a second on the shoreline border of 6 and 7 exclosures. This peregrine was trapped and a pellet removed from the transport carrier contained seven bands, representing a minimum of two plovers. On 3 July, an adult peregrine falcon was observed depredating a juvenile plover (48 days old). Examination of four separate coyote scats revealed eleven plover bands (including three bands with white-adhesive backed red tape, first used in 2012) representing a minimum of one chick and two unknown-aged plovers. On 18 July, a pair of adult-sized plover wings was found five feet west of a mini-exclosure on a nest inside 8 exclosure. On 22 August, an adult-sized wing of a plover was found half-buried in 8 exclosure. On 7 September, a regurgitated pellet from an unknown avian predator was found on 6 exclosure shoreline and contained eleven bands (including two with white-adhesive backed red tape first used in 2012), representing a minimum of one chick and two unknown-aged plovers. On 13 September, a gull pellet found on 6 exclosure shoreline contained nine bands, representing a minimum of three unknown-aged plovers (Appendix H).

Mammalian Predators

Red fox
In 2012, red fox tracks were documented near the Southern Exclosure and Oso Flaco nesting area for the first time. Tracks were present on seven days around Pavilion Hill (revegetation area near marker post 4), three days within the Pipeline revegetation area (adjacent to 8 exclosure), and one day within the Maidenform revegetation area (east of Boneyard exclosure). No red foxes were removed in 2012. In 2011, three red foxes were removed between Grand Avenue and Pier Avenue in an effort to control a nonnative invasive species and to prevent its spread into the plover and tern nesting area to the south.

Opossum
In 2012, no nests were identified as depredated by opossum. Tracks were primarily observed in 6, 7, and 8 exclosure. From 2007-12, the number of days opossum tracks were documented ranged from 5 to 25 days. From 2002-12, known nest loss to opossum was limited to one tern nest in the Southern Exclosure in 2010. In 2012, there was minimal occurrence of opossum tracks in tern and plover chick-rearing areas.

Skunk
In 2012, no nests were identified as depredated by skunk. Tracks were most often documented in 6, 7, and 8 exclosure. Documented skunk activity decreased from a range of 35 to 57 days for 2009-11 to 19 days in 2012 (Figure 15). From 2002-12, known nest loss to skunk was limited to five plover nests in Oso Flaco, occurring from 2009-11. In 2012, there was minimal occurrence of skunk tracks in tern and plover chick-rearing areas.

Raccoon
In 2012, no nests were identified as depredated by raccoon. Similar to 2010 and 2011, raccoon tracks were most commonly observed in North and South Oso Flaco, 8 exclosure, and the 7.5 revegetation area. Tracks and scat indicated that raccoons commonly traveled across the

exclosure to forage in the intertidal zone on prey that included mole crabs (*Emerita analoga*). Documented raccoon activity has increased from 47 and 68 days in 2007 and 2008, respectively, to a range of 108 to 141 days for 2009-12 (Figure 15). From 2002-12, known nest loss to raccoons was limited to two plover nests in Oso Flaco, occurring in 2010 and 2011. In 2012, six raccoons were lethally removed because they were interfering with coyote trapping. Raccoon tracks were common in some portions of the shore where plover chicks were present.

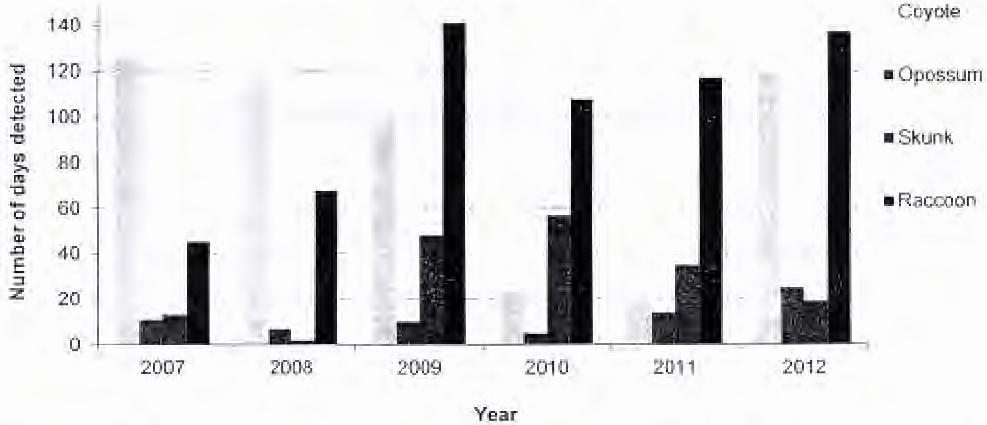


Figure 15. Number of days coyote, opossum, skunk, and raccoon were detected in the Southern Exclosure and Oso Flaco at ODSVRA from 2007-12.

Coyote

Live sightings of coyotes have rarely been documented inside the exclosure or along the shoreline during daytime hours. The lack of diurnal sightings, as well as timing of observed fresh tracks relative to windblown sand and tides, indicate that coyote activity is primarily nocturnal in these areas. As it is difficult to monitor the shoreline on foot due to potential disturbance to plover broods, predator tracks are documented opportunistically and counts are representative of a minimum level of activity that was likely much greater this season. In addition, shoreline accessibility may vary between years making direct comparison difficult. In 2012, there were 78 occurrences of coyote documented inside the predator fencing of the Southern Exclosure (Table 17). This compares to 15, 19, 5, and 10 occurrences in 2008-11, respectively. Number of days coyotes were detected inside the Southern Exclosure and Oso Flaco was 119 in 2012 compared to 20, 24, 99, 114, and 126 in 2011-07, respectively (Figure 15). Coyotes can enter the predator fenced portion of the exclosure by digging under, climbing, or jumping over the fence, as well as entering through areas in disrepair. In 2012, heavy equipment was not available to work on the fence from mid-June through the remainder of the nesting season, resulting in a less secure Boneyard exclosure interior fence. Coyote intrusion inside the Southern Exclosure at this location was high during this time. Tracks indicated that most coyote activity inside the predator fence was in Boneyard and 8 exclosures and not in 6 and 7 exclosures where the majority of nesting occurs. One plover nest was depredated by a coyote in Boneyard exclosure in 2012.

In 2012, there were 100 and 47 occurrences of coyote on the Southern Exclosure and North Oso Flaco shorelines, respectively, which compares to 17 and 20 occurrences in 2011, 24 and 23 occurrences in 2010, and 99 and 94 occurrences in 2009 (Table 17). In 2012, there were less documentations of coyote presence on South Oso Flaco shoreline due to decreased monitor presence in this area. Coyote tracks found on the Southern Exclosure shoreline were noted as having rapidly changing gaits, from walking to running, and changing direction, suggesting hunting behavior. As part of coyote monitoring at ODSVRA, coyote scat encountered by monitoring staff and contractors was checked in the field for plastic or aluminum bands used for banding least terns and snowy plovers. Eleven plastic bands used to band plovers and one bicolor aluminum band used to band terns were retrieved from four coyote scats found throughout the season in 2012, representing a minimum of one plover chick, two unknown-aged plovers, and one unknown-aged tern (Appendix H). There were nine plastic bands found in coyote scat in 2007; no bands were found in scat from 2008-11 (CDPR 2007). The protracted occurrence of coyote on the shoreline in 2012 coincided with a period of high snowy plover chick loss. As concerns of coyote impact on plover chick survival grew, coyotes were trapped in an attempt to decrease activity on the shoreline, however, shoreline activity continued throughout the season. In 2012, 11 coyotes were lethally removed (Table G.2 in Appendix G). This compares to four coyotes removed in 2011, nine in 2010, and five in 2009, 2008, and 2007.

Table 17. Coyote presence in the Southern Exclosure and Oso Flaco at ODSVRA from 2009-12.

Date range is from 1 March to 10 September (a 194-day period).

Year	Inside Southern Exclosure predator fencing	6, 7, 8 exclosure shoreline	North Oso Flaco shoreline	South Oso Flaco	Total no. occurrences (Total no. days detected)
2009	19	99	94	95	307 (147)
2010	5	24	23	47	99 (71)
2011	10	17	20	55	102 (83)
2012	92	100	47	35	274 (119)

Avian Predators

American kestrel, merlin, Cooper's hawk, and prairie falcon

The number of days American kestrel (*Falco sparverius*), merlin (*Falco columbarius*), and Cooper's hawk (*Accipiter cooperii*) were documented in the Southern Exclosure and Oso Flaco was limited (range 1-10 days). There was a single observation of a prairie falcon (*Falco mexicanus*) on 20 August in 7 exclosure feeding on a small shorebird.

Loggerhead shrike

Shrikes are known predators of plovers at ODSVRA and in 2005 five plover bands (likely from chicks) were found in regurgitated pellets. In 2012, a minimum of 10 loggerhead shrikes were observed in or adjacent to the nesting area. Shrikes were primarily observed in Oso Flaco and Boneyard exclosures, with fewer sightings in 8 exclosure. Nine shrikes were trapped, including one adult (16 February) and eight juveniles (29 June – 14 August). Additional sightings represent at least one other individual not trapped.

Owl

Owls are a known threat to plovers and terns and predation by owls has been suspected at ODSVRA. Owl activity, as evidenced by tracks, is difficult to estimate during daytime monitoring as there is limited entry into the nesting and chick-rearing areas to look for tracks. Owl tracks may be over a short distance and can be quickly covered by windblown sand. In addition, accessibility to areas where tracks have often been noted previously (e.g. North Oso Flaco, 8 exclosure, 7.5 revegetation area) may vary between years making direct comparison difficult. In 2012, despite there being fewer monitors on foot in areas where owl tracks are seen, there was an increase in detection (including near the west fence and on the shoreline in ODSVRA). In 2012, owl presence was detected on 53 days with 89 separate sightings (Figure 16, Table 18). In 2010-11, owl presence was detected less frequently on 30 days with 47 separate sightings and 10 days with 10 separate sightings respectively. Great horned owl is the primary species suspected and was the only species trapped and relocated prior to 2012. In 2012, three great horned owls were trapped and relocated between 18 April - 30 May. On 24 July, while attempting to trap a great horned owl, two barn owls were caught in the Pipeline revegetation area and were relocated (Table G.2 in Appendix G). Owl presence continued to be detected within the nesting and chick habitat after trapping. In 8 exclosure, Boneyard, and North Oso Flaco (including the west side), tracks were noted in abundance.

Red-tailed hawk

Red-tailed hawks are a documented or suspected predator of snowy plover eggs, chicks, juveniles, and adults and are documented as a predator of least tern chicks and juveniles (Page et al. 2009; Marschalek 2007). In 2012, red-tailed hawks were primarily observed perching in the North Oso Flaco foredunes, and less frequently in the South Oso Flaco foredunes and 7.5 revegetation area. There were 135 sightings over 74 days (Figure 16, Table 18). This compares with 85 sightings over 45 days in 2011, 48 sightings over 29 days in 2010, and less activity from 2007-09. On several occasions, red-tailed hawks were observed perched in the nesting area and were flushed by monitors when possible. Based on concurrent sightings and age, there was a minimum of four individuals observed in or near the nesting area in 2012: one adult male, one adult female, one sub-adult and one juvenile.

Northern harrier

Northern harriers are a known threat and are documented taking snowy plover eggs, least tern and plover chicks, and a tern fledgling at ODSVRA. From 2 May – 12 May, there were 40 sightings over 10 days of a male northern harrier hunting over the Southern Exclosure. During this same time frame, five nests were documented lost to an adult male northern harrier and five nests were depredated by an unknown avian predator (with northern harrier suspected). Additionally, three nests were depredated by an unknown predator during this same period of time with high northern harrier activity. An adult male northern harrier was also observed landing and grabbing a recently hatched chick near its nest bowl in 7 exclosure on 9 May. Attempts were made to determine the nesting status of the northern harrier and no active nests were located. After trapping efforts were unsuccessful, an adult male harrier was lethally removed on 12 May after it was observed depredating a plover nest in 6 exclosure. Yolk and eggshell fragments were found on the harrier's bill, in the esophagus and stomach, and small feathers were found in the stomach.

There were 132 sightings of northern harriers over 47 days in 2012 (Figure 16, Table 18). Based on age and sex, there was a minimum of seven individuals observed during this season: three adult males, two adult females, and two juveniles (one identified as female). In addition to the adult male lethally removed on 12 May, an adult male was trapped on 6 April at Oso Flaco Lake and relocated (Table G.2 in Appendix G).

Table 18. Sightings of large owl spp., northern harrier, peregrine falcon, and red-tailed hawk in specific areas of the Southern Exclosure and Oso Flaco at ODSVRA in 2012.
Date range is from 1 March to 10 September.

Location	Large owl spp.	Northern harrier	Peregrine falcon	Red-tailed hawk	Total
6 exclosure	4	21	41	2	68
7 exclosure	11	24	37	27	99
8 exclosure	27	21	31	20	99
Boneyard exclosure	19	4	9	6	38
North Oso Flaco	15	11	27	55	108
South Oso Flaco	13	51	11	25	100
TOTAL	89	132	156	135	512

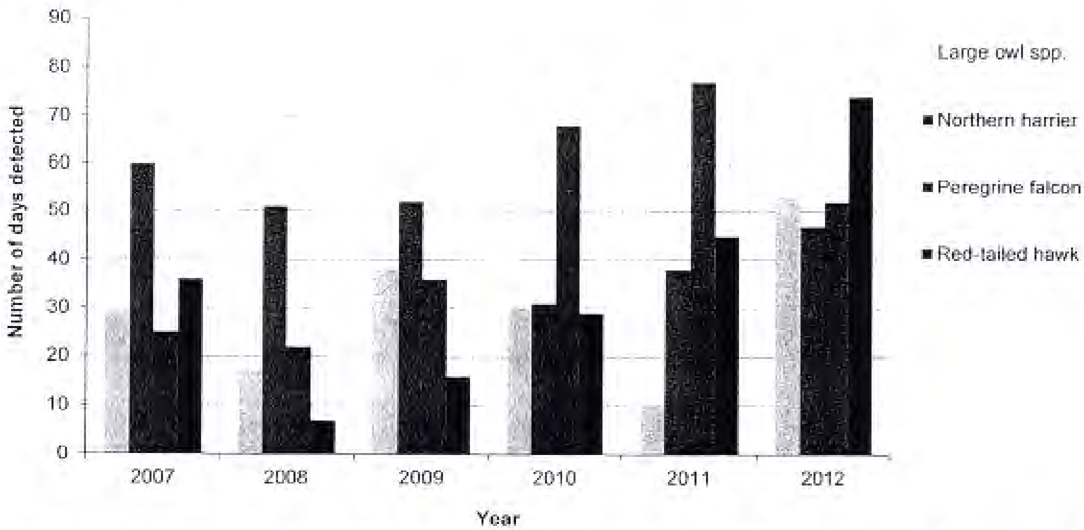


Figure 16. Number of days large owl spp., northern harrier, peregrine falcon, and red-tailed hawk were detected in the Southern Exclosure and Oso Flaco at ODSVRA in 2007-12.
Date range is from 1 March to 10 September (194-day period).

Peregrine falcon

Peregrine falcons (*Falco peregrinus*) are documented predators of plovers and terns (Table 19). In 2012, peregrine falcons were frequently observed actively hunting, perching, and eating prey in the Southern Exclosure and Oso Flaco. On multiple occasions, peregrines were perched in the nesting area for an extended period of time and were flushed by monitors when possible (sometimes requiring repeated efforts before the bird exited the exclosure). On 23 May, a sub-adult female peregrine falcon was observed hunting and eating at least one plover chick on the shoreline at the border of 6 and 7 exclosures (Appendix H). Monitors attempted to flush the falcon after it was observed eating the first chick but the falcon continued to hunt and appeared to catch and eat a second chick (unknown if from the same or a different brood). This same bird was later observed depredating eggs from a distant plover nest before it was live-trapped the same day. After relocating this bird, a regurgitated pellet containing seven plover bands was removed from the transport carrier, representing a minimum of two chicks. On 3 July, a peregrine was inside 6 exclosure with prey, later identified as a banded juvenile snowy plover from ODSVRA (48 days old). On 31 July, a peregrine was observed in 6 exclosure with prey. Feathers were collected from the prey site and confirmed to belong to a near-fledgling or fledgling least tern. Several other depredated remains of snowy plover, least tern, and other shorebirds may have been peregrine kills but could not be confirmed as such. In 2012, there was a minimum of six individual peregrine falcons identified at ODSVRA: one adult male, one adult female, one sub-adult male, one sub-adult female (trapped and relocated), and two juveniles.

Table 19. Sightings of peregrine falcon in specific areas of the Southern Exclosure and Oso Flaco at ODSVRA from 2008-12.

Date range is from 1 March to 10 September (a 194-day period). One, three, and one peregrines were trapped in 2009, 2010, and 2012 respectively; none were trapped in 2008 and 2011.

Location	2008	2009	2010	2011	2012
6 exclosure	11	13	37	39	41
7 exclosure	11	13	29	45	37
8 exclosure	5	13	25	40	31
Boneyard exclosure	6	6	11	32	9
North Oso Flaco	4	9	24	37	27
South Oso Flaco	1	20	18	12	11
Total no. sightings	38	74	144	205	156
No. days detected	22	36	68	77	52

Corvids (American crow and common raven)

American crows (*Corvus brachyrhynchos*) and common ravens (*Corvus corax*) are efficient predators at many tern and plover nesting sites and can have pronounced impacts over a short period of time. In 2012, crows and ravens were typically observed flying over South Oso Flaco, North Oso Flaco, Boneyard, and 8 exclosures (Table G.1 in Appendix G). Crow observations in 2012 were similar to 2008-11 in number of days detected, ranging from one to 10 days. From 2011-12, number of days ravens were detected ranged from 13 to 14 days and number of sightings ranged from 18 to 28. This compares to a range of 2 to 4 for number of days ravens were detected and 2 to 5 for number of sightings in 2007-10. The three nests depredated by corvid (in 7, 8, and Boneyard exclosures) were lost in June and there were crow and raven observations in the nesting area during this month. Due to potential overlap in track size for some individuals, it can, at times, be difficult to determine corvid species in absence of direct observation. From 2002-12, nine plover nests at ODSVRA were lost to raven (in 2003, 2004, and 2007) and eight were lost to corvid (in 2011 and 2012). In 2012, a number of nests were lost to raven at other plover and tern nesting sites within the Guadalupe-Nipomo dune complex. Ravens have been lethally removed periodically at Vandenberg Air Force Base, which may reduce the presence of some foraging individuals at other sites within the dune complex, including ODSVRA.

Gulls

Gulls are present year-round at ODSVRA with numbers fluctuating throughout the year. To document seasonal changes as well as long-term trends, daily surveys at specific locations are completed from March to October and weekly surveys of the entire park are completed year-round (see Monitoring and Management Actions section for more detail). In 2012, the number of gulls counted at ODSVRA reached a maximum of 2,898 in September (Figure 17). In 2012, as in previous years, a large gull flock was noted inside northern 6 exclosure during July and mini-exclosures were used to protect nests in this area. No nests were known depredated by gulls in 2012.

Although no gull predation events with plovers were observed in 2012, a gull pellet found on the 6 exclosure shoreline on 13 September contained nine bands, representing a minimum of three unknown-aged plovers taken by gulls (Appendix H). Events happen quickly and can easily go unobserved. In 2011, three gulls were documented taking a minimum of six chicks, three juveniles, one juvenile or adult, and five plovers of unknown age over a four-day period, from 28 July to 31 July. The chick loss rate during both these four days and the preceding two weeks was much higher than occurred prior to or after this period.

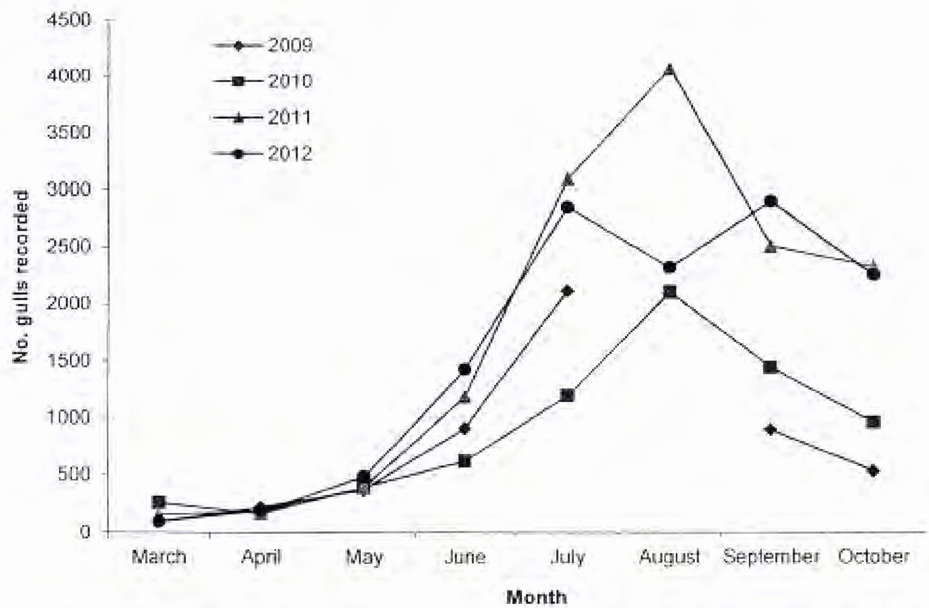


Figure 17. Monthly average number of gulls at ODSVRA for March to October, 2009-12. Information not available for August 2009. Weekly surveys were conducted between 6 am and 1 pm with 98% of surveys completed before 12 pm. Weekly survey data were only included if the entire park was covered. The number of surveys per month ranged from 1 to 5. See Monitoring and Management Actions section for "weekly gull survey" methodology.

RECOMMENDATIONS

Continue monitoring

Monitoring is critical for effective protection of nesting terns and plovers. As problems and threats arise for adult birds, nests, and chicks, timely information from monitoring can help guide appropriate management actions and evaluate their effectiveness. Monitoring efforts at ODSVRA should have adequate funding, resources, and flexibility to address anticipated problems (e.g., nesting failure, causes of chick loss, predator pressure) as well as unanticipated problems. Specific recommendations for monitoring are the following:

Continue banding least tern and snowy plover chicks

Continue banding least tern and snowy plover chicks to better understand chick behavior and factors promoting or threatening survival of chicks (e.g., feeding rates for tern chicks, foraging activity and movements of plover chicks, age and location of disappearance of different cohorts of chicks). Banding also provides a means to document fledging success. Without this information, the seasonal productivity of terns and plovers at ODSVRA would be unknown and management effectiveness could not be assessed. Additionally, bands provide an opportunity to gain insight into predator impacts on chicks and fledglings. Over time, banding of tern and plover chicks will provide information on natal site fidelity of terns and plovers fledged at ODSVRA, as well as migration to other sites.

Continue banding least tern chicks to individual

Beginning in 2006, least tern chicks were banded to allow individual chicks to be identified. This was done by placing one or two different colors of tape on the federal band, creating a unique combination for each chick. Banding to individual provides the opportunity to gain additional information that otherwise may not be obtainable, including:

1) providing the most accurate means to count the number of juveniles produced;
2) identifying if different areas within the colony are having different fledging success during a season;
3) identifying if broods hatching more than one chick are fledging more than one chick;
4) tracking individual chick and juvenile movement within the ODSVRA colony; and
5) providing information on the length of stay of individual juveniles at the colony site after fledging.

Banding to individual provides valuable information to assist in developing and assessing site management actions directed toward the recovery of the least tern.

Continue option to band adult snowy plovers

The occurrence of abandoned plover nests can raise concern about possible mortality of adult plovers. If elevated adult mortality rates occur or are suspected, it could prove beneficial to band various adults. This would allow monitors to verify if mortality was taking place and possibly identify the causes.

Continue use of motion detector cameras for nest monitoring

There are many hours each day when monitoring staff or predator management specialists are either not present or not in a position to observe nest predation. In addition, predators may leave little or no evidence behind or tracks may be quickly erased by wind-blown sand before nest fates can be investigated. Photo infrared digital cameras with passive motion detector triggers (Reconyx PC900) were purchased in the latter part of the 2010 season to help identify and document snowy plover nest predators. They were tested and, with permission from USFWS, placed near a small number of plover nests in 2010 and 2011 by staff members permitted by USFWS for this activity. Experimenting with the cameras continued in 2012. One of the challenges has been adapting the cameras that are normally used on large mammals to be sensitive enough to be triggered by movements of a small ground nesting bird. Because snowy plover movement was not triggering the cameras at certain settings, they were programmed to automatically take photos at regular intervals (one to five minutes) in addition to the motion detection setting. In 2012, stakes were used to position the cameras approximately eight to 12 inches above the ground to increase the camera's area of view. During the 2012 nesting season seven snowy plover nests were selected for camera use (to date cameras have only been used on plover nests at this site but the permit does allow for cameras to be placed near least tern nests). No predation events were recorded. However, the nest cameras documented nest fates and fate dates, nest exchanges between male and female, and adult band combinations. It is recommended for 2013 to continue to use motion detector cameras for nest monitoring, continue to experiment with camera settings and placement, and train and permit additional monitoring staff as needed.

Continue to use an anemometer with data logger to record daily wind speeds and direction
A wind tower with wind speed and direction collected at two, seven and 10 meters above the ground (Sonoma Technology, Inc.) has been located east of the 6 exclosure since June 2010. This station is intended to help record changes in wind speed and direction across a large area of the park and the Oso Flaco area and it has provided accurate data that matched the 2011 wind values collected from a smaller portable system owned by Parks (WindLog by RainWise Inc.). This portable system stopped working prior to the 2012 season and could not be repaired. On-site information for daily average and high gust wind speeds aids in understanding the role of wind in nest abandonment. For 2013, it is recommended to continue gathering data using the wind tower.

Continue to provide adequate-sized bumpouts and single nest exclosures to better protect least tern and snowy plover nests in or close to the open riding area
Least tern and snowy plover nests inside the Southern Exclosure and located close to the east fence receive temporary additional fencing to create a buffer from recreational activities in the open riding area. These bumpouts connect to the east fence adjacent to the nests and extend eastward into the open riding area. Prior to 2010, only nests found within 75 feet of the Southern Exclosure east fence were given a bumpout. Beginning in 2010, nests found within 100 feet of the Southern Exclosure fence bordering the open riding area received bumpouts. Nests more than 100 feet from the fence may also receive a bumpout if repeated disturbance from the open riding area is observed. Prior to 2012, nests found in the open riding area initially received an 82 foot radius circular single nest exclosure as per the previously existing protocol. It is our experience that these earlier identified minimums (75 feet and 82 feet) are not sufficient to adequately reduce disturbance from recreational activity and, in response to birds flushing from their nests, additional fence installation was often necessary to increase the size of the buffer.

In 2012, there were four snowy plover nests given bumpouts to increase the distance from the nest to the open riding area fence to a minimum of 100 feet. Of these nests, three hatched, and one was abandoned pre-term suspected due to wind. Three snowy plover nests were found in the open riding area and all received single nest exclosures with a minimum radius of 100 feet. One nest was approximately 330 feet east of 6 exclosure and was abandoned pre-term (SP1). Two nests were in the camperline to the north and distant from the 6 exclosure, one was 915 feet away and was abandoned pre-term with mortality of one member of the pair suspected (SP80) and the other nest was approximately 3,000 feet away and was depredated (SP81) (see Appendix B and Notes section for more nest fate details for SP1, SP80, and SP81).

For 2013, it is recommended to continue to install bumpouts for nests close to the east fence to create a buffer of at least 100 feet between the nest and the open riding area. Nests in the open riding area should receive a single nest exclosure with a minimum radius of 100 feet. Nests in the Southern Exclosure receiving adjacent bumpouts and nests in the open riding area receiving single nest exclosures will be monitored closely to assess the adequacy of protective fencing in reducing disturbance. If necessary, bumpouts or single nest exclosures may increase in size if disturbance to incubating birds is observed as a result of recreational activity. ODSVRA will continue to maintain a safe vehicle corridor adjacent to the east fence, any bumpouts, and single nest exclosures.

Continue option to use least tern chick fencing on the east side of the exclosure
Many sites in California use tern chick fencing to prevent least tern chicks from moving out of protected areas. This fencing is typically a low plastic fence with very small mesh size, often attached to the bottom of a larger and sturdy existing fence. In February 2010, tern chick fencing was installed on the north and east fence of the 6 exclosure and a portion of the east 7 exclosure. The tern chick fencing was monitored on a daily basis. After several periods of high winds there was a significant amount of sand deposition on the eastern side of the exclosure fence and a large portion of the tern chick fence was buried. Attempts to move the sand build-up with heavy equipment were not effective and it was determined that the fence could not be properly maintained throughout the season. The tern chick fencing was removed in March 2010 and not installed in 2011 or 2012. Windy site conditions at ODSVRA are inevitable and, therefore, a method to maintain the tern chick fencing should be further investigated to determine if such fencing may become an option to help prevent least tern chicks from moving into the open riding area.

Discontinue experiment of using four inch by four inch mesh fence size on the lower portion of small sections of the west exclosure fence
The prevailing northwest winds blow sand into the west exclosure fence and the fence causes localized decreased wind speed, resulting in increased sand deposition on the leeward side of the fence. The sand build-up immediately east of the fence can result in areas of bare sand and limited cover inside the exclosure. To exclude coyotes from the exclosure, the fence is a height of six feet with a mesh size of two inch by four inch on the lower portion and larger mesh for the upper layer. USDA Wildlife Services was consulted prior to the 2011 season and indicated that four inch by four inch mesh is the maximum size that is expected to deter coyotes from climbing or crawling through the fence. In 2011, four inch by four inch mesh was used in two 100 foot sections along the west fence of 6 and 7 exclosures as an experiment to see if the larger mesh would help reduce the buildup of sand east of the fence while still excluding coyotes. The experiment was repeated in 2012 with the fence length increased to two 500 foot sections of four inch by four inch fence. In both years, monitoring staff did not note differences in coyote or

other predator behavior in the two experimental areas during the breeding season. The fence was assessed during and at the end of each season and no noticeable difference in sand movement was observed in the experimental areas compared to the remainder of the western fence. The four by four inch fence could only be purchased in a four foot height and the two inch by four inch fence is five feet high; both were effective at excluding coyotes (with a second layer of fencing), but the five foot height is preferable because it would potentially require less maintenance throughout the season. It is recommended in 2013 to only use the two inch by four inch fence for the lower layer of the exclosure fencing.

Continue to position a large section of the shoreline exclosure fence further east to provide a wider functional shoreline habitat

The shoreline west of the exclosure west fence is important snowy plover habitat for rearing chicks. Past management practice has been to place the west fence as low as possible on the shoreline. This was to maximize the amount of nesting and brooding area inside the seasonal fence that is protected from coyotes. In 2011, two small experimental shoreline fence sections, located in 6 and 7 exclosures, were placed up to 100 feet further to the east and these areas appeared to have a broader and more functional shoreline when evaluated at the end of the season. In 2012, the shoreline fence was moved 100 feet east for the southern half of 6 exclosure and for the majority of 7 exclosure (except for the 7.5 revegetation area). The majority of the 8 exclosure shoreline fence was moved up to 50 feet east (Appendix C). The Southern Exclosure is seasonally open to off-highway vehicles during five months of the year between October and February. As a result of recreational activity during this time, the shoreline of the 6, 7, and 8 exclosures has almost no cover or topographic relief at the beginning of the breeding season and resource personnel distribute wood and wrack to provide some cover above and below the drift line. The shoreline is further altered with the installation of the west fence that results in substantial deposition of fine wind-blown sand on the leeward (east) side of the fence. A fence set low on the shore can result in a very narrow swath of shore with cover (west of the fence) bordered by limited cover over the majority of a strip of habitat (approximately 100 to 180 feet wide) immediately east of the fence (with deposited sand burying any existing or introduced cover).

Shifting the fence eastward allows for a wider area of shore with cover and wrack to be available as plover habitat. Adjusting the fence eastward also allows for the following benefits to the overall management goals for snowy plover productivity:

1) allow access from the shoreline for monitoring staff to maintain a wider swath of shore with habitat enhancement materials (including wrack) throughout the breeding season;
2) reduced chance of high tides and surf washing up and removing a low-set fence and habitat enhancement material;
3) provide better conditions for pioneering plants to grow in a wider area between the high tide line and the west fence (wind-blown sand deposited leeward of the fence can adversely impact seedling survival);
4) may increase foraging opportunities for plovers;
5) may reduce vulnerability to predators by providing more space and cover for chicks.

There was an increase in plover and tern nests on the shoreline in 2012 compared to 2011, likely as a result of moving the west fence eastward. In 2012, 18% of plover nests in 6 exclosure and 19% in 7 exclosure were west of the fence; this compares to 12% and 5% in 2011 (numbers exclude nests west of 7.5 exclosure). All least tern nests in 2012 were in 6 and 7 exclosures with eight of 46 nests on the shoreline. No least tern nests were found on the shoreline in the eight previous years that the exclosure was in the current general configuration. The hatch rate for the shoreline nests (west of the west fence) was comparable to the overall hatch rate for the entire exclosure area (both east and west of the west fence). The 6 and 7 exclosure had a plover nest hatch rate of 85% and 75%, respectively, compared to 86% and 100% hatch rate for the shoreline 6 and 7 exclosure plover nests. The overall least tern hatch rate for 2012 was the same as the shoreline hatch rate with known fate (75%) (there were four least tern nests on the shoreline with unknown fate and one was abandoned pre-term). Moving the west fence eastward did not appear to move nesting closer to the east fence or east of the exclosure into the open riding area. There was one nest found east of the exclosure in 2012 compared to two nests in 2011. In 2012, the number of bumpouts for nests found near the east fence was similar to previous years. There were four snowy plover nests and zero least tern nests near the fence bordering the ORA that received bumpouts. This compares to eight plover and tern nests that received bumpouts in 2011.

In 2012, snowy plover chick survival (25%) was lower than eight of the 10 previous years (2002-11, mean=37.9%). To assess if the increased shoreline width impacted chick survival, we analyzed multiple snowy plover broods totaling 135 chicks from various locations along the shoreline. We omitted chicks from broods that moved along the shoreline and any chick that did not survive for a minimum of 10 days. There were 19 ten-day-old or older chicks and 84% of them fledged in the narrower north side of 6 exclosure (500 to 1,000 feet south of marker post 6); there were 15 ten-day-old or older chicks and 80% fledged from south 6 exclosure where the fence was moved in 100 feet; there were 12 ten-day-old or older chicks and 67% fledged from 7 exclosure where the fence was moved in 100 feet; and 31 ten-day-old or older chicks and 81% fledged from 8 exclosure where the fence is mostly unchanged from previous locations. There is not enough information to determine if the increased shoreline left chicks more vulnerable to predation. Overall survival of chicks older than 10 days was high and the sample size was relatively small, especially on the 7 shoreline. We will analyze chick survival in future years to assess if chick survival is impacted in areas with a larger shoreline component.

Predation is believed to have played a large part in the low fledge rate recorded for 2012, with coyote and avian predators suspected for the chick loss; among other evidence, multiple snowy plover bands were found in coyote scat, a gull pellet, and an unidentified avian pellet. Moving the west fence 100 feet to the east improved the shoreline habitat characteristics for chick-rearing habitat. There was more topography and cover created by increased debris, woodchips, and wrack as well as greater foraging opportunities with the increased area of habitat enhancement. It is unclear if a slightly wider shoreline may make chicks more susceptible to coyote depredation (the west fence is not a barrier to avian and other mammalian predators). Although broods are observed moving east of the fence to take cover in foredune vegetation that is present in North Oso Flaco, parts of 8 exclosure, and 7.5 revegetation area, there is very little vegetation in 6 and 7 exclosures and broods are not often observed moving east of the fence. During early morning monitoring, broods are not observed east of the fence, including during cold, misty, and wet mornings when many young chicks are brooded for protracted periods and not feeding. Broods were observed on the shoreline at night during the few overnight shoreline surveys. Therefore, it is thought that the chicks are likely to be on the shoreline at night when coyotes are present. The reaction of chicks to coyote on the shoreline at night is unknown. The chicks may take cover in the closest wrack pile, plant, or other debris west or east of the fence which would support the idea that improving the shoreline habitat was valuable since the area immediately east of the fence is mostly bare. Or it is possible that instead of taking cover, the broods react to coyotes by running east of the fence and moving the fence 100 feet east may make the chicks more susceptible to coyote depredation.

It is recommended for 2013 to repeat the shoreline configuration as was present in 2012, with a large portion of the shoreline fence approximately 100 feet to the east of the typical shoreline fence location and to continue to gather further information. The northern section of 6 exclosure would not be moved east to avoid potential impacts to nests on the shoreline from trespassers and to reduce the possibility of pushing nesting activity further to the east side and closer to the riding area in this narrow portion of north 6 exclosure. The shoreline fence should continue to be installed last (after all other fencing is installed) and as close to 1 March as possible to lessen the chance of storm-driven high surf damaging the fence.

Continue to work to address water quality issues at Oso Flaco Lake

There is concern that activities occurring outside the park increase sediment and contaminants in Oso Flaco Lake, degrading water quality, which could impact least tern adults, chicks, and juveniles that consume fish from the lake. The Central Coast Regional Water Quality Control Board is currently considering a Total Maximum Daily Load (TMDL) regulation for a host of contaminants that impact water quality in Oso Flaco Lake. In 2010, fish tissue samples from the lake showed high levels of pesticides that exceed recommended human consumption levels. ODSVRA is currently working with the Coastal San Luis Resource Conservation District, regulatory agencies, and neighboring landowners to address water quality conditions in Oso Flaco Lake. If restored to a healthy system with available fish suitable for least terns, Oso Flaco Lake could be an important supplement to the near-shore ocean waters where prey availability may vary significantly within and between years. The number of least terns utilizing the lake varies from year to year. There was a single day high count of 13 least terns seen at Oso Flaco Lake for the 2012 season and there was a high of 29 and 10 terns seen in 2011 and 2010, respectively.

Continue to enhance habitat in the Southern Exclosure by distributing natural materials, seed, and plants and increase efficiency with the help of maintenance staff and heavy equipment

Natural materials such as driftwood, woodchips, and wrack (surf-cast kelp) should be distributed in large amounts within the exclosures (including the shoreline) to enhance habitat features. Since 2002, wrack has been gathered by hand and placed in the exclosure. Approximately 285 cubic yards of wrack were distributed on the exclosure shoreline throughout the 2012 season as habitat enhancement. Greater efficiencies can be achieved for this wrack distribution. Since 2008, OSDVRA monitoring staff has received assistance from available heavy equipment operators from park maintenance staff in loading woodchips to be distributed in the exclosure. In 2013, it is recommended that heavy equipment be available throughout the season to assist in loading large piles of wrack collected in the open riding area to then be distributed into the seasonal exclosure by permitted staff. This would increase staff efficiency and allow larger amounts of wrack to be dispersed on the shoreline, helping to maintain larger populations of invertebrate prey over a broader area for snowy plover chicks, fledglings, and adults. Broader distribution of wrack also provides shelter from wind and cover from predators. The use of heavy equipment needs to be balanced with other operational needs in the park.

Wrack and woodchip additions could also occur during the winter or prior to 1 March if materials and staff levels allow. Wrack collected from the riding area was experimentally distributed in a few large piles at the beginning of the 2011 and 2012 seasons in areas east of the shoreline fence. In both years, these piles persisted to the end of the season helping to create temporary hummocks within the exclosure and, in some cases, provided a favorable area for plants to grow. As time permits, it is recommended to continue to place large wrack piles in the winter or at the beginning of the season in the area where the seasonal exclosure will be located.

The addition of quick-growing annual dune vegetation should continue to be evaluated as habitat enhancement. Planting in early spring, with sufficient late rains, may allow enough time for plant growth to provide topographic features that could benefit plovers and terns. Seeding of the Southern Exclosure with sea rocket (*Cakile maritima*), beach bur (*Ambrosia chamissonis*), and other on-site available seed is recommended to continue in 2013. Planting of sea rocket or other appropriate available container stock (grown on-site) in test plots with areas of added materials (e.g., woody debris, wrack) should also continue to be evaluated in 2013. The seeding and planting would occur as soon as possible after the fence is installed on 1 March. Seeding or planting may be attempted prior to the fence installation in order to take advantage of rain events and moist sand. The goal of this planting is to provide areas of scattered vegetation for cover and to encourage the development of small hummocks. Management actions intended to reduce nesting near the east fence and north end of the seasonal exclosure adjoining the open riding area, including no substrate enhancement or distribution of seeds or container plants in the vicinity, will be continued in 2013 (Appendix F).

Continue to study the benefits of wrack addition to the Southern Exclosure shoreline and inoculation with wrack-associated invertebrates as a possible means to restore invertebrate species and biomass (these invertebrates are part of the prey base for snowy plover chicks, juveniles, and adults)

In 2007-12, Drs. Jenifer Dugan and Mark Page, researchers from the Marine Science Institute at the University of California Santa Barbara, examined the responses of invertebrate numbers and diversity in areas where wrack was added to the shoreline throughout the breeding season, with only limited sampling occurring at the beginning and end of the 2012 season. Results of the surveys suggested that the seven month seasonal closure (March through September) was not a sufficient period of time for invertebrates to effectively naturally recover species diversity and abundance on the Southern Exclosure shoreline. Preliminary analysis suggests that inoculating a large number of wrack-associated invertebrates into wrack over a wide area of the exclosure shoreline appeared to increase the estimated abundance of talitrids. If funding levels allow, experimental examination of wrack and invertebrate manipulation on the Southern Exclosure shore should continue in the 2013 season with the goal of identifying potential means to enhance the diversity and abundance of invertebrate species that are natural prey for plovers.

Continue to look for an appropriate design to cover trash dumpsters

The predator management strategy at ODSVRA includes methods to discourage attracting predators to the site. The large trash dumpsters (22 feet long, 20 cubic yard capacity) located near marker post 2 attract a large number of gulls landing on and foraging in the dumpsters. Four to six dumpsters are present during the busy summer months. An experimental cover was designed for one dumpster with fence material enclosed in an approximate 12 foot high metal frame with heavy 7.5 inch wide plastic strips hanging from the front of the frame. This design was intended to prohibit gulls from landing on the trash, allowed park visitors to easily discard their trash without lifting a lid, and allowed maintenance staff to lift the cover off and compact the trash with heavy equipment which is necessary before the dumpster can be pulled out and replaced each week. The cover was first installed in early April and high winds quickly destroyed the plastic strips, making the cover ineffective and the cover was removed in early July. For daily surveys at the dumpster area, the month of July had the highest daily average number of gulls (124) as well as the maximum number of gulls present at one time (492 on 11 July) (see section titled Predators and predator management on page 40 for more details). It is recommended for 2013 to cover the trash dumpsters in the marker post 2 area with lids designed to exclude gulls and meet the needs of the ODSVRA staff and visitors.

Continue to maintain option to salvage and rescue eggs, chicks, juveniles, and adults under very limited circumstances

In some circumstances the abandonment of least tern or snowy plover eggs and chicks can be directly attributed to human disturbance. The option to salvage such eggs and chicks to be raised in captivity by an approved facility and released in the wild is useful. Beginning in 2003, a limited number of abandoned but likely viable snowy plover eggs or chicks from ODSVRA were brought into captivity. Chicks were raised in a manner that they did not imprint on humans and were released into the wild when fledged. All fledglings were color-banded to individual to facilitate collecting information on movements, survival, and future reproductive success. Captive care should only be used selectively and not as a substitute for responding to the primary causes of elevated egg or chick abandonment rates.

Ongoing management actions that will continue in 2013

The following are part of our ongoing management actions and monitoring procedures for which a specific recommendation is no longer necessary (see Monitoring and Management Actions section for more detail). Background information and justifications for these management actions have been discussed in detail in previous annual reports.

- Oso Flaco area protection will continue at the same monitoring and management level as set in 2005 (Site Description).
- The Arroyo Grande Creek protected area will be clearly delineated as a closed area around the Arroyo Grande Creek and lagoon by using posts and signs as practiced since 2006 (Site Description).
- Night vision equipment will continue to be utilized for monitoring. The equipment has been used for monitoring since 2007.
- Continue monitoring least tern juveniles, night roost, and foraging activity at nearby freshwater lakes.
- Tern chick shelters will continue to be used (Appendix F).
- Predator monitoring and management actions that have been in place since 2003 and 2004 will continue.
- Gull surveys will continue as they have since 2008.
- The Southern Exclosure protected area will include the use of increased fence height as practiced since 2006 and use of aprons as used since 2007 to improve the effectiveness of the perimeter fence in protecting the breeding terns and plovers.
- The Southern Exclosure and North Oso Flaco shoreline will continue to be protected, this includes maintaining the posts and rope at marker post 6 and Oso Flaco boardwalk intertidal zones to minimize trespass, which has been part of the management actions in these locations since 2008.
- Continue use of 10 foot by 10 foot single nest exclosures with net tops and mini-exclosures as needed to protect nests from avian predators. These small exclosures are not without risks to incubating adults and we will continue to closely monitor and evaluate their use.
- Surveys for plovers will continue during the nonbreeding season. These surveys have been conducted since the winter of 2009-10.
- Continue to document impacts and, when possible, reduce disturbance caused by low-flying aircraft over the Southern Exclosure and Oso Flaco.
- Efforts to retain skilled monitors will continue at ODSVRA.

NOTES

Three snowy plover nests in the open riding area

In 2012, three of the 216 known snowy plover nesting attempts were in the open riding area. On 2 April, the first egg of nest SP1 was found approximately 300 feet east of 6 exclosure, and in an area where an unbanded pair had been scraping since 18 March. A circular single nest exclosure, approximately 200 feet in diameter, was constructed around the nest the same day. This nest was abandoned pre-term on 4 April and two eggs were collected on 26 April and held for later transfer to a scientific institution.

On 17 May, nest SP80, with three eggs, was found approximately 900 feet north of 6 exclosure. That same day, the first egg of nest SP81 was found approximately 3,000 feet north of 6 exclosure. Single nest exclosures, approximately 200 feet (SP80) and 250 feet (SP81) in diameter, were constructed the same day. Additionally, staff placed symbolic fencing (posts with a single rope) around each single nest exclosure, to delineate the area where parking and camping were not allowed (100 feet from the exclosure fence). On 24 May, SP81 was depredated by unknown avian predator (suspected to be gull sp.). On 2 June, SP80 was determined to be abandoned pre-term with adult mortality suspected. Two salvageable eggs from the nest were transported on 6 June to Monterey Bay Aquarium for captive rearing. One egg hatched and the fledgling was released at Moss Landing State Beach, Monterey County.

Snowy plover broods in the open riding area

In 2012, between 17 May and 7 June, a minimum of three different snowy plover broods were observed in the open riding area, three chicks from SP33 on two occasions, one large banded chick (likely SP19) on one occasion, and one chick from SP37 on one occasion.

On 17 May during the late morning, three chicks with two adults from SP33 were first observed on the shore 400 feet north of marker post 6 in the open riding area. Staff conducted traffic control until the chicks and adults returned to the 6 exclosure shoreline. The brood continued to be monitored throughout the day. On 18 May at 9:40 AM, three chicks and two adults from SP33 were observed halfway between marker post 5 and 6 in the open riding area. Staff implemented the same strategy as on 17 May, and the chicks entered the 6 exclosure shoreline at 12:21 PM. The brood was monitored continuously until 5 PM.

On 31 May at 9:21 PM, one large banded chick (likely SP19) with an adult was observed foraging on the shoreline of the open riding area approximately 1,200 feet north of marker post 6. Staff controlled traffic until the brood moved south into the 6 exclosure shoreline.

On 7 June at 6:27 AM, one chick from SP37 with an adult was observed just north of marker post 6 in the open riding area, and was directed into the exclosure.

Abandoned snowy plover eggs and chicks raised in captivity

On rare occasions, abandoned eggs or chicks are collected and transported to a facility to be raised in captivity and, if feasible, released into the wild.

On 24 May, one egg of SP80 was buried completely during high winds. This egg was unburied and all three eggs reset on the surface. On 24 and 25 May, during a period of sustained winds, the three-egg clutch was moved several times away from an encroaching sand bank. On 26 and 27 May, monitors on several occasions flushed roosting gulls out of the 200 foot diameter single nest exclosure. On 28 May, one of the eggs was found damaged twenty feet from the nest. The nest continued to be consistently incubated by the female until 30 May, after which only the male was seen on the nest and incubation was inconsistent. The nest was last seen with an incubating bird on 2 June. Over the next four days the nest was closely monitored, but no bird was seen at the nest, plover tracks at the nest were absent, and the eggs were partially buried. In addition, the eggs had been marked on 4 June and after two days their position was unchanged, indicating they were not being attended. The nest was determined to be abandoned pre-term and the two eggs were collected on 6 June and transported to the Monterey Bay Aquarium.

On 2 June, a mini-exclosure was installed on nest SP108 in South Oso Flaco. This was later replaced on 7 June with a 10 foot by 10 foot exclosure with a net top. On 28 June, the nest was determined to be abandoned and the three eggs were collected and transported to the Monterey Bay Aquarium. All three eggs hatched and three fledglings were released on 7 August at Moss Landing State Beach, Monterey County.

On 22 July, nest SP212 was found with one egg in Boneyard exclosure. This nest remained at one egg and was consistently incubated by the female. On 1 August, a 10 foot by 10 foot exclosure with net top was installed. On 7 August, the egg was noted with modest prehatching cracks. This nest was not incubated over a two-day period (8-9 August) and was determined to be abandoned. The egg was collected and transported to Monterey Bay Aquarium. This egg hatched and the fledgling was released on 10 September at Moss Landing State Beach, Monterey County.

On 10 August, nest SP205 in 7 exclosure had two recently hatched chicks and one egg. This nest was monitored (by spotting scope from a distant vehicle) for an extended period of time and was determined to be abandoned. The two chicks and one egg were transported to Monterey Bay Aquarium and the remaining egg hatched. Two fledglings were released on 10 September and one on 19 September at Moss Landing State Beach, Monterey County.

Capture and transfer to Monterey Bay Aquarium of injured snowy plover adult

On 2 October, an unbanded adult snowy plover with blood on its drooping left wing, and unable to fly, was captured north of Grand Avenue. This bird remained at Pacific Wildlife Care overnight and was transported to Monterey Bay Aquarium on 3 October. This injured adult was determined to be non-releasable. At the time of report completion, paperwork was in process for transfer of the live bird to the Long Beach Aquarium shorebird exhibit.

Necropsy of snowy plovers (see attached necropsy reports for more detail)
On 7 May, a mini-exclosure was installed on nest SP29 in 8 exclosure. On 22 May, a live unbanded chick from the third hatching egg was found three feet from the nest bowl and not moving. No adults or previously banded chicks were in the area. The chick was collected and transferred to Monterey Bay Aquarium. The chick was euthanized the following day after failing to feed. Necropsy results were unremarkable, and indicate nephrosis probably occurred due to dehydration.

On 18 August, the carcass of an unbanded adult snowy plover was found partially buried in faint tire tracks in the open riding area northeast of 6 exclosure. The carcass appeared fresh and had dried blood on the chest. Despite severe post-mortem changes, the necropsy results indicate hemorrhage in the lungs, mineralization of the kidneys and ventricular wall, and the presence of adult parasites in the intestines. Results were inconclusive as to cause of death.

Necropsy of least tern chick
On 2 July, the carcass of an unbanded least tern chick from LT16 was found dead in its nest bowl. This chick was approximately one day old and had been seen being brooded with its sibling earlier this same day. The carcass was sent for necropsy on 5 July to test for levels of DDT/DDE. Final results have yet to be received.

LITERATURE CITED

Bailey, J.P. and F.A. Servello. 2008. Chick survival, fledgling residency and evaluation of methods for estimating fledging success in least terns. Waterbirds 31(4):571-579.

CDPR. 2011. Nesting of the California least tern and western snowy plover at the Oceano Dunes State Vehicular Recreation Area, San Luis Obispo County, California 2011 Season. Unpublished Report, CDPR, Off-Highway Motor Vehicular Recreation Division.

CDPR. 2010. Nesting of the California least tern and western snowy plover at the Oceano Dunes State Vehicular Recreation Area, San Luis Obispo County, California 2010 Season. Unpublished Report, CDPR, Off-Highway Motor Vehicular Recreation Division.

CDPR. 2009. Nesting of the California least tern and western snowy plover at the Oceano Dunes State Vehicular Recreation Area, San Luis Obispo County, California 2009 Season. Unpublished Report, CDPR, Off-Highway Motor Vehicular Recreation Division.

CDPR. 2008. Nesting of the California least tern and western snowy plover at the Oceano Dunes State Vehicular Recreation Area, San Luis Obispo County, California 2008 Season. Unpublished Report, CDPR, Off-Highway Motor Vehicular Recreation Division.

CDPR. 2007. Nesting of the California least tern and western snowy plover at the Oceano Dunes State Vehicular Recreation Area, San Luis Obispo County, California 2007 Season. Unpublished Report, CDPR, Off-Highway Motor Vehicular Recreation Division.

Marschalek, D.A. 2012. California least tern breeding survey, 2011 season. California Department of Fish and Game. Sacramento, CA.

Marschalek, D.A. 2011. California least tern breeding survey, 2010 season. California Department of Fish and Game. Sacramento, CA.

Marschalek, D.A. 2010. California least tern breeding survey, 2009 season. California Department of Fish and Game. Sacramento, CA.

Marschalek, D.A. 2009. California least tern breeding survey, 2008 season. California Department of Fish and Game. Sacramento, CA.

Marschalek, D.A. 2008. California least tern breeding survey, 2007 season. California Department of Fish and Game. Sacramento, CA.

Marschalek, D.A. 2007. California least tern breeding survey, 2006 season. California Department of Fish and Game. Sacramento, CA.

Marschalek, D.A. 2006. California least tern breeding survey, 2005 season. California Department of Fish and Game. Sacramento, CA.

Page, G.A., J.S. and J.C. Warriner, and P.W.C. Paton. 1995. Snowy Plover (*Charadrius alexandrinus*). In The Birds of North America, No. 154, (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, PA, and The American Ornithologists' Union, Washington DC.

Thompson, B.C., J.A. Jackson, J. Burger, L.A. Hill, E.M. Kiroch, and J.L.Atwood. 1997. Least Tern (*Sterna antillarum*). In The Birds of North America, No. 290, (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, PA, and The American Ornithologists' Union, Washington, D.C.

USFWS. 2007. Recovery Plan for the Pacific Coast Population of the western Snowy Plover (*Charadrius alexandrinus nivosus*). In two volumes. Sacramento, CA. xiv+751pp.

USFWS. 2006. Five-Year Review Summary and Evaluation for the California Least Tern (*Sterna antillarum browni*). USFWS, Carlsbad, CA. September 2006.

USFWS. 1985. Recovery Plan for the California Least Tern (*Sterna antillarum browni*). USFWS, Portland, OR. 112 pp.

Warriner, J.S., J.C. Warriner, G.W. Page and L.E. Stenzel. 1986. Mating system and reproductive success of a small population of polygamous snowy plovers. Wilson Bulletin 98(1):15-37.

APPENDICES

Appendix A. California least tern nests at ODSVRA in 2012.

Least tern chicks were banded with blue over white vinyl tape on a size 1A blank aluminum band on the right leg and a size 1A numbered aluminum federal band on the left. Color tape was placed on the federal band to create combinations unique to individual. Chicks were weighed immediately prior to banding, typically at one to three days old. Five chicks from four known hatching nests were not banded. In addition, there were seven nests with unknown fate (unknown if hatched or failed). A total of six unbanded fledglings were seen in 6 exclosure on 4 August. The sixth fledgling is assumed to be from an unknown fate nest that did hatch. Band information on breeding adults is provided when known. Sex of banded adults is typically not known.

Location: 6 = 6 exclosure, 7 = 7 exclosure

Abandoned pre-term = nest abandoned before expected hatch date

Abandoned post-term = nest abandoned after expected hatch date

Unknown = unknown if nest hatched or failed

U = unbanded

na = Estimated date not available due to insufficient information

Nest	Location	Adult pair	Estimated initiation date	Nest fate	Estimated fate date	No. eggs	No. chicks (No. fledge)	Chick band combination (chick weight in grams)	Confirmed fledged	Notes
1	6		5/27	Hatch	6/22	2	2 (2)	R:B/W (8.9 g) W:B/W (7.4 g)	R/:B/W W:B/W	
2	7	-:A/G	6/2	Hatch	6/23	2	1 (1)	Y:B/W (8.3 g)	Y:B/W	One egg abandoned post-term on 5 July.
3	6		6/3	Hatch	6/29	3	1 (1)	Y/W:B/W (7.3 g)	Y/W:B/W	The two nonhatching eggs (both unnaturally light in weight) abandoned on 2 July.
4	7		na	Failed, unknown cause	6/6	1	0			Insufficient information to estimate initiation date.
5	7		6/4	Abandoned, unknown if pre- or post-term	6/26	2	0			Both eggs unnaturally light in weight and suspected to be nonviable.
6	7		na	Unknown	6/17	2				Nest found 6 June as two-egg nest. Seen consistently incubating for 12 consecutive days. Insufficient information to estimate initiation date.
7	7		6/8	Abandoned post-term	7/28	2	0			Nest consistently incubated for a minimum of 51 days prior to abandonment. Eggs nonviable.
8	7	U	6/7	Hatch	6/27	2	2 (2)	G:B/W (8.5 g) V:B/W (8.8 g)	G:B/W V:B/W	

Appendix A. California least tern nests at ODSVRA in 2012 (continued).

Nest	Location	Adult pair	Estimated initiation date	Nest fate	Estimated fate date	No. eggs	No. chicks (No. fledge)	Chick band combination (chick weight in grams)	Confirmed fledged	Notes
9	6		6/10	Hatch	7/2	1	1 (1)	G/Y:B/W (6.7 g)	G/Y:B/W	
10	6		6/4	Hatch	6/25	2	1 (1)	P:B/W (7.9 g)	P:B/W	Remaining egg last observed incubated 26 June. When examined on 27 June, egg had no pre-hatching cracks.
11	6		6/6	Hatch	6/27	2	2 (1)	L:B/W (4.6 g) O:B/W (4.8 g)	O:B/W	L:B/W chick last observed alive 27 June at time of banding on hatch day.
12	6		6/6	Hatch	6/28	2	1 (1)	R/W:B/W (8.3 g)	R/W:B/W	One egg abandoned post-term 29 June.
13	6	U	6/10	Hatch	7/1	1	1 (1)	G/R:B/W (5.6 g)	G/R:B/W	
14	7	Y/W/Y:-	6/1	Hatch	6/26	2	1 (1)	B:B/W (5.0 g)	B:B/W	
15	6		6/7	Hatch	6/28	2	2 (2)	O/W:B/W (7.6 g) G/W:B/W (9.4 g)	O/W:B/W G/W:B/W	
16	6	U	6/9	Hatch	6/30	2	2 (1)	W/R:B/W (6.6 g) U (dead at nest)	W/R:B/W	One chick dead at nest bowl.
17	6		6/3	Abandoned post-term	7/23	2	0			Nest active during a 51-day period 3 June to 23 July prior to abandonment.
18	6		6/3	Hatch	6/26	3	2 (0)	A:B/W (6.7 g) B/W:B/W (9.6 g)		Both chicks last observed alive 2 July at approximately 6 days old.
19	6	-:B/G/B U	6/4	Unknown	7/3	1				Nest active during a 29-day period 4 June to 2 July. No evidence of nest 3 July.
20	6		6/16	Hatch	7/9	2	2 (2)	A/R:B/W (5.8 g) O/A:B/W (14.8 g)	A/R:B/W O/A:B/W	
21	6		6/18	Hatch	7/10	1	1 (1)	A/Y:B/W (6.0 g)	A/Y:B/W	
22	6	U	6/15	Hatch	7/6	2	2 (2)	A/W:B/W (6.9 g) W/B:B/W (7.1 g)	A/W:B/W W/B:B/W	
23	6		6/8	Hatch	6/30	2	2 (2)	Y/G:B/W (8.6 g) O/G:B/W (7.3 g)	Y/G:B/W O/G:B/W	
24	6		6/17	Hatch	7/9	2	2 (?)	U U		Two chicks last observed alive 12 July at approximately 3 days old.
25	6	(light):W/B/W U	na	Unknown	7/4	1				Nest observed active during a 17-day period 18 June to 4 July with inconsistent incubation from 25 June to 4 July. Insufficient information to estimate initiation date.

Appendix A. California least tern nests at ODSVRA in 2012 (continued).

Nest	Location	Adult pair	Estimated initiation date	Nest fate	Estimated fate date	No. eggs	No. chicks (No. fledge)	Chick band combination (chick weight in grams)	Confirmed fledged	Notes
26	6	U	6/17	Hatch	7/9	2	2 (2)	A/B:B/W (8.4 g) A/O:B/W (7.8 g)	A/B:B/W A/O:B/W	
27	6	W/B:W/Y	6/20	Hatch	7/12	2	2 (2)	O/B:B/W (5.7 g) O/R:B/W (5.7 g)	O/R:B/W O/R:B/W	
28	6		na	Unknown	6/28	2				Nest observed active during a 11-day period 18 June to 28 June. Insufficient information to estimate initiation date.
29	6		na	Abandoned, unknown if pre- or post-term	7/4	2	0			Nest observed active during a 20-day period 15 June to 4 July. Two eggs found at nest after abandonment. Insufficient information to estimate initiation date.
30	6		na	Unknown	6/28	2				Nest observed active during a 9-day period 20 June to 28 June. Insufficient information to estimate initiation date.
31	6		na	Unknown	7/1	1				Nest observed active during a 3-day period 29 June to 1 July. Insufficient information to estimate initiation date.
32	6	U U	6/20	Hatch	7/11	2	2 (?)	U U		Two chicks last observed alive 22 July at approximately 11 days old.
33	6		na	Unknown	7/13	1				Nest active during a 14-day period 30 June to 13 July. Insufficient information to estimate initiation date.
34	6	-:W	6/28	Hatch	7/20	1	1 (1)	G/A:B/W (6.0 g)	G/A:B/W	
35	7		6/23	Hatch	7/15	2	2 (2)	B/G:B/W (6.2 g) B/R:B/W (6.1 g)	B/G:B/W B/R:B/W	
36	6		6/21	Hatch	7/23	2	2 (0)	G/O:B/W (4.8 g) Y/A:B/W (5.5 g)		Two chicks last observed alive 25 July at approximately 2 days old.
37	6		6/17	Hatch	7/8	2	2 (2)	W/A:B/W (5.3 g) W/O:B/W (5.9 g)	W/A:B/W W/O:B/W	
38	7	Y/W:W/B/W U	7/4	Hatch	7/27	2	2 (1)	Y/B:B/W (7.1 g) Y/O:B/W (6.0 g)	Y/B:B/W	Y/O:B/W chick last observed alive 2 August at approximately 6 days old.

Appendix A. California least tern nests at ODSVRA in 2012 (continued).

Nest	Location	Adult pair	Estimated initiation date	Nest fate	Estimated fate date	No. eggs	No. chicks (No. fledge)	Chick band combination (chick weight in grams)	Confirmed fledged	Notes
39	6		6/27	Hatch	7/18	2	2 (0)	B/Y:B/W (7.5 g) G/B:B/W (5.7 g)		G/B:B/W chick last observed alive 31 July at approximately 13 days old. B/Y:B/W chick last observed alive 2 August at approximately 15 days old.
40	6		na	Abandoned, unknown if pre- or post-term	6/28	2				Two-egg nest found 7 June and observed active during a 3-day period 7 June to 9 June. One egg found at nest after abandonment. Insufficient information to estimate initiation date.
41	7		6/24	Hatch	7/15	2	2 (1)	O/Y:B/W (4.8 g) B/A:B/W (5.1 g)	O/Y:B/W	B/A:B/W last observed alive 2 August at approximately 19 days old.
42	6	U	6/12	Hatch	7/3	1	1 (1)	W/G:B/W (7.21 g)	W/G:B/W	
43	6		6/22	Hatch	7/15	2	1 (1)	B/O:B/W (8.1 g)	B/O:B/W	One egg well pipped and chick's bill visible, but no movement. Portion of chick inside egg that is visible appears dry and chick appears dead.
44	6	U U	6/1	Hatch	6/22	≥1	1 (?)	U		Insufficient information to determine clutch size.
45	6	-:W W/B:W/A	7/12	Hatch	8/2	≥1	1 (1)	Y/R:B/W (10.3 g)	Y/R:B/W	Insufficient information to determine clutch size. Minimum of one egg.
46	6		na	Abandoned pre-term	6/28	2	0			Nest observed active during a 8-day period 21 June to 28 June. Two eggs found at nest after abandonment. Insufficient information to estimate initiation date.

Appendix B. Snowy plover nests at ODSVRA in 2012.

Split hatch noted for nests with eggs hatching on more than one day. Plover chicks were banded to brood.
Location: 6 = 6 exclosure, 7 = 7 exclosure, 8 = 8 exclosure, BY = Boneyard exclosure, NOF = North Oso Flaco, SOF = South Oso Flaco
Adult pair: M = male, F = female, U = unbanded
10'x10' exc. with top = 10 foot by 10 foot exclosure
na = Estimated date not available due to insufficient information

Nest	Location	Adult Pair	Est. Initiation Date	Nest Fate	Fate date (estimated)	No. eggs	No. chicks	No. chicks banded and combination	No. chicks fledged	Protection Type	Notes
1	Open riding area	F=U M=U	1 Apr	Abandoned pre-term	4 Apr	2				Single nest exclosure	Two eggs abandoned pre-term.
2	6	F=U M=U	1 Apr	Abandoned, suspected wind	27 Apr	3				Seasonal exclosure	Three eggs buried during period of high winds. One egg scavenged by a northern harrier on 10 May.
3	7	F=U M=U	29 Mar	Abandoned pre-term	3 Apr	1				Seasonal exclosure	One egg abandoned pre-term.
4	6	F=U M=PV:AG	1 Apr	Hatch	6 May	3	2	2 GG:OB		Seasonal exclosure	Split hatch. One egg (without cracks) abandoned post-term. On 14 May, one chick seen with injured right leg, not seen after 15 May. Band combination reused on SP151 (no chicks fledged).
5	6	F=VV:VW M=BB:-	1 Apr	Hatch	4 May	3	3	3 BB:BB	3	Seasonal exclosure	Split hatch. On 15 May, one chick observed favoring left leg slightly, seen subsequently without limp.
6	7	F=RR:AR M=PG:VY	5 Apr	Hatch	9 May	3	3	2 GA:AY 1 unbanded	1	Seasonal exclosure	On 9 May, one recently hatched chick depredated by male northern harrier near nest site.
7	8	F=BB:YG M=U	5 Apr	Hatch	10 May	3	3	3 GA:GB	1	Mini-exclosure Seasonal exclosure	
8	BY	F= M=	6 Apr	Abandoned, suspected wind	7 Apr	1				Seasonal exclosure	One egg buried during period of high winds.
9	6	F=VV:RB M=RR:PG	5 Apr	Hatch	10 May	3	1	1 GA:GR	1	Seasonal exclosure	Two eggs depredated by northern harrier.
10	6	F=U M=U	8 Apr	Hatch	12 May	3	3	3 GA:BY		Seasonal exclosure	Split hatch. Band combination reused on SP187 (two chicks fledged).
11	6	F=U M=U	2 Apr	Hatch	5 May	3	2	2 GG:BW	2	Seasonal exclosure	One egg (without cracks) abandoned post-term.
12	7	F=U M=RR:WR	8 Apr	Hatch	13 May	3	3	3 GA:WB	1	Mini-exclosure Seasonal exclosure	
13	6	F=U M=U	8 Apr	Hatch	12 May	3	3	3 VV:WG	1	Mini-exclosure Symbolic fence	

Appendix B. Snowy plover nests at ODSVRA in 2012 (continued).

Nest	Location	Adult Pair	Est. Initiation Date	Nest Fate	Fate date (estimated)	No. eggs	No. chicks	No. chicks banded and combination	No. chicks fledged	Protection Type	Notes
14	6	F=PV:BY M=U	10 Apr	Abandoned, suspected wind	12 Apr	1				Bumpout Seasonal exclosure	One egg buried during period of high winds.
15	8	F=U M=U	9 Apr	Hatch	13 May	3	3	3 GG:AW	2	Mini-exclosure Seasonal exclosure	Split hatch.
16	7	F= M=	8 Apr	Depredated, northern harrier	8 May	3				Seasonal exclosure	Three eggs depredated by northern harrier.
17	6	F=VV:VG M=PV:BR	7 Apr	Hatch	10 May	3	2	2 unbanded		Bumpout Seasonal exclosure	Chicks not banded due to predator disturbance in the area. One egg (without cracks) abandoned post-term.
18	7	F=U M=U	12 Apr	Depredated, avian	10 May	3				Seasonal exclosure	Three eggs depredated by unknown avian predator during period of northern harrier activity.
19	6	F=U M=U	6 Apr	Hatch	9 May	3	3	3 GG:RG	3	Seasonal exclosure	
20	7	F=U M=PV:AG	6 Apr	Hatch	9 May	3	3	3 BB:GR	1	Seasonal exclosure	
21	7	F= M=	12 Apr	Depredated	7 May	2				Seasonal exclosure	Two eggs depredated by unknown predator during period of northern harrier activity.
22	8	F=U M=BB:YY	9 Apr	Hatch	12 May	3	3	3 GA:AG	2	Mini-exclosure Seasonal exclosure	
23	8	F= M=U	10 Apr	Hatch	13 May	3	3	3 GA:WW	3	Mini-exclosure Seasonal exclosure	Split hatch. Band combination reused on SP72 (no chicks fledged).
24	8	F= M=	5 Apr	Abandoned pre-term	28 Apr	3				Seasonal exclosure	Three eggs abandoned pre-term.
25	8	F=VG:VY M=U	2 Apr	Hatch	5 May	3	3	3 GG:WW	3	Seasonal exclosure	
26	7	F=PV:YG M=U	6 Apr	Hatch	9 May	3	3	3 RR:RB	3	Mini-exclosure Symbolic fence	Split hatch.
27	7	F=U M=U	10 Apr	Hatch	13 May	3	2	2 GG:RR	1	Mini-exclosure Bumpout Seasonal exclosure	One egg (without cracks) abandoned post-term.
28	SOF	F=RR:BW M=	13 Apr	Abandoned pre-term	4 May	3				10'x10' excl. with top Symbolic fence	Three eggs abandoned pre-term.

Appendix B. Snowy plover nests at ODSVRA in 2012 (continued).

Nest	Location	Adult Pair	Est. Initiation Date	Nest Fate	Fate date (estimated)	No. eggs	No. chicks	No. chicks banded and combination	No. chicks fledged	Protection Type	Notes
29	8	F= M=	16 Apr	Hatch	19 May	3	3	1 VV:YG 1 -:YG 1 unbanded		Mini-exclosure Seasonal exclosure	Split hatch. On 19 May, one chick sprawled on back, not moving, skin missing and blood on tibiotarsal joint of left leg. On 22 May, live unbanded chick from third hatching egg is found three feet from nest bowl, not moving and no adults in area. Chick is collected and transferred to Monterey Bay Aquarium. Chick euthanized the following day after no response to feeding. See necropsy report. Band combination reused on SP158 (no chicks fledged). On 3 August, carcass of small, decomposed VV:YG chick found on surface of sand in North Oso Flaco.
30	8	F=U M=U	16 Apr	Hatch	19 May	3	3	3 VG:WB	2	Mini-exclosure Seasonal exclosure	
31	BY	F=RR:VW M=U	14 Apr	Hatch	18 May	3	2	2 GG:YR	1	10'x10' excl. with top Seasonal exclosure	Split hatch. One egg (without cracks) abandoned post-term.
32	6	F=U M=U	13 Apr	Hatch	16 May	3	2	2 GG:RY	1	Mini-exclosure Symbolic fence	One egg (without cracks) abandoned post-term.
33	6	F=PV:VY M=U	13 Apr	Hatch	16 May	3	3	3 VV:WY	2	Seasonal exclosure	On 3 July, intact carcass of a VV:WY 48-day-old fledge collected from the site of an observed peregrine falcon kill inside 6 exclosure.
34	7	F=banded M=U	19 Apr	Abandoned pre-term	22 Apr	1				Seasonal exclosure	One egg abandoned pre-term.
35	7	F=U M=	17 Apr	Hatch	20 May	2	1	1 VG:RW		Seasonal exclosure	One egg (with cracks and pips) abandoned post-term. Band combination reused on SP199 (no chicks fledged).
36	8	F= M=	21 Apr	Depredated	3 May	3				Seasonal exclosure	Three eggs depredated by unknown predator during period of northern harrier activity.
37	6	F=RR:PB M=U	17 Apr	Hatch	20 May	3	1	1 VV:RW	1	Seasonal exclosure	One egg missing pre-term. One egg (without cracks) abandoned post-term.
38	6	F= M=	13 Apr	Depredated	9 May	3				Seasonal exclosure	Three eggs depredated by unknown predator during period of northern harrier activity.
39	6	F=AY:AW M=U	16 Apr	Hatch	19 May	3	3	3 VV:YB	1	Seasonal exclosure	

Appendix B. Snowy plover nests at ODSVRA in 2012 (continued).

Nest	Location	Adult Pair	Est. Initiation Date	Nest Fate	Fate date (estimated)	No. eggs	No. chicks	No. chicks banded and combination	No. chicks fledged	Protection Type	Notes
40	7	F= M=	12 Apr	Depredated, northern harrier	9 May	3				Seasonal exclosure	Three eggs depredated by northern harrier.
41	6	F=U M=U	15 Apr	Hatch	18 May	3	2	2 VV:GR	2	Seasonal exclosure	One egg with unknown fate.
42	6	F=U M=U	22 Apr	Hatch	25 May	2	2	2 GG:WY	1	Seasonal exclosure	Split hatch.
43	6	F= M=GG:AB	17 Apr	Hatch	20 May	2	2	2 VV:AW		Seasonal exclosure	Band combination reused on SP UNK 7 (no chicks fledged).
44	BY	F=U M=U	22 Apr	Abandoned, suspected wind	7 May	3				Circular excl. with top Seasonal exclosure	One egg missing during period of high wind. Second egg missing during subsequent period of high wind. Nest camera records adult leaving nest for extended time periods during these high wind events but incubates consistently otherwise. Third egg abandoned pre-term.
45	7	F= M=	22 Apr	Depredated, avian	8 May	3				Seasonal exclosure	Three eggs depredated by unknown avian predator during period of northern harrier activity.
46	6	F=GG:VY M=U	20 Apr	Hatch	23 May	3	2	2 GA:GY		Seasonal exclosure	One egg (without cracks) abandoned post-term. Band combination reused on SP51 (two chicks fledged).
47	8	F= M=U	22 Apr	Abandoned pre-term	23 May	3				Mini-exclosure Seasonal exclosure	Three eggs (two with cracks) abandoned pre-term. On 22 August an adult-sized plover wing found half-buried near nest site.
48	6	F= M=	25 Apr	Depredated, avian	9 May	3				Seasonal exclosure	Three eggs depredated by unknown avian predator during period of northern harrier activity.
49	6	F=U M=BB:OR	23 Apr	Hatch	26 May	3	2	2 VG:GY		Seasonal exclosure	Split hatch. One egg missing pre-term. Band combination reused on SP204 (no chicks fledged).
50	8	F=RR:WR M=U	21 Apr	Hatch	24 May	3	2	2 VG:YR	2	Mini-exclosure Seasonal exclosure	One egg missing pre-term.
51	NOF	F=U? M=U	27 Apr	Hatch	30 May	3	3	3 GA:GY	2	Mini-exclosure Symbolic fence	Split hatch. Band combination previously used on SP46 (no chicks fledged).
52	7	F=VV:YW M=U	27 Apr	Abandoned, suspected wind	22 May	3				Seasonal exclosure	Three eggs buried during period of high winds.

Appendix B. Snowy plover nests at ODSVRA in 2012 (continued).

Nest	Location	Adult Pair	Est. Initiation Date	Nest Fate	Fate date (estimated)	No. eggs	No. chicks	No. chicks banded and combination	No. chicks fledged	Protection Type	Notes
53	6	F=GA:OB M=	22 Apr	Unknown	23 May	3				Mini-exclosure Symbolic fence	
54	7	F=U M=VG:YW	30 Apr	Hatch	2 Jun	3	3	3 VG:RY		Seasonal exclosure	Band combination reused on SP161 (no chicks fledged).
55	SOF	F=VG:VR M=	30 Apr	Abandoned, suspected wind	16 May	2				Circular excl. with top Symbolic fence	One egg buried during period of high winds.
56	7	F=GG:YG? M=RR:GG	26 Apr	Hatch	29 May	3	3	3 GA:GW		Mini-exclosure Symbolic fence	Split hatch. Band combination reused on SP162 (no chicks fledged).
57	BY	F=VG:AW M=	30 Apr	Abandoned pre-term	28 May	3				Circular excl. with top Seasonal exclosure	Three eggs abandoned pre-term.
58	8	F=U M=VG:PR	28 Apr	Hatch	31 May	3	2	2 GG:PR	2	Circular excl. with top Symbolic fence	One egg abandoned post-term.
59	8	F= M=	30 Apr	Depredated, avian	6 May	3				Seasonal exclosure	Three eggs depredated by avian predator during period of northern harrier activity.
60	BY	F= M=U	30 Apr	Hatch	5 Jun	2	2	2 GA:WY		Mini-exclosure Seasonal exclosure	Split hatch. Band combination reused on SP156 (no chicks fledged).
61	8	F= M=U	25 Apr	Hatch	28 May	3	2	2 VG:BY	1	Mini-exclosure Seasonal exclosure	One egg (without cracks) abandoned post-term.
62	7	F= M=	30 Apr	Failed, unknown cause	21 May	3				Seasonal exclosure	
63	7	F= M=	25 Apr	Depredated, northern harrier	11 May	3				Seasonal exclosure	Three eggs depredated by northern harrier.
64	7	F=U M=U	25 Apr	Hatch	28 May	3	2	2 VG:OY		Mini-exclosure Symbolic fence	Split hatch. One egg (without cracks) abandoned post-term. Band combination reused on SP174.
65	6	F=U M=U	1 May	Hatch	3 Jun	3	3	3 GA:OW		Seasonal exclosure	
66	6	F=U M=U	24 Apr	Hatch	27 May	3	3	3 GG:AY	1	Seasonal exclosure	On 13 June, desiccated carcass of one GG:AY chick approximately one-week-old found on 6 exclosure shoreline. Last observed alive on 4 June.
67	6	F= M=	na	Depredated, avian	9 May	3				Seasonal exclosure	Three eggs depredated by unknown avian predator during period of northern harrier activity. Insufficient information to estimate initiation date.

Appendix B. Snowy plover nests at ODSVRA in 2012 (continued).

Nest	Location	Adult Pair	Est. Initiation Date	Nest Fate	Fate date (estimated)	No. eggs	No. chicks	No. chicks banded and combination	No. chicks fledged	Protection Type	Notes
68	6	F= M=	na	Abandoned, unknown if pre- or post-term	25 May	3				Seasonal exclosure	Three eggs abandoned, unknown if abandoned pre- or post-term. Insufficient information to estimate initiation date.
69	6	F= M=	2 May	Abandoned pre-term	24 May	3				Seasonal exclosure	Three eggs abandoned pre-term.
70	6	F= M=	30 Apr	Hatch	2 Jun	3	3	3 GA:RG		Seasonal exclosure	Band combination reused on SP196 (no chicks fledged).
71	7	F=RR:OY M=S:-	25 Apr	Hatch	28 May	3	3	3 GA:VG	1	Circular excl. with top Symbolic fence	Band combination reused on SP173 (no chicks fledged).
72	8	F=VG:GW M=U	18 Apr	Hatch	21 May	3	3	3 GA:WW		Bumpout Seasonal exclosure	Band combination previously used on SP23 (three chicks fledged).
73	7	F=U M=BB:RG	22 Apr	Hatch	25 May	3	3	3 GA:VW		Seasonal exclosure	Split hatch. Band combination reused on SP178 (no chicks fledged).
74	6	F=GG:VY M=VG:YW	27 Apr	Hatch	30 May	3	3	2 GG:OG 1 unbanded		Mini-exclosure Symbolic fence	Split hatch. On 13 September, desiccated carcass of small GG:OG chick found on 6 exclosure shoreline possibly from SP74 or SP194. Band combination reused on SP194 (no chicks fledged).
75	7	F= M=	na	Depredated, northern harrier	9 May	2				Seasonal exclosure	Nest location known by observation of incubating adult. Minimum two eggs depredated by northern harrier (based on depredated eggshell fragments). Insufficient information to estimate initiation date.
76	6	F= M=	28 Apr	Hatch	31 May	3	3	3 GG:YW		Seasonal exclosure	Band combination reused on SP192 (no chicks fledged).
77	6	F=Banded M=	29 Apr	Depredated, northern harrier	12 May	3				Seasonal exclosure	Three eggs depredated by northern harrier.
78	NOF	F= M=RR:WR	9 May	Hatch	11 Jun	3	2	2 RR:RG		Mini-exclosure Seasonal exclosure	
79	6	F= M=	28 Apr	Depredated, peregrine falcon	23 May	2				Seasonal exclosure	Two eggs depredated by peregrine falcon.

Appendix B. Snowy plover nests at ODSVRA in 2012 (continued).

Nest	Location	Adult Pair	Est. Initiation Date	Nest Fate	Fate date (estimated)	No. eggs	No. chicks	No. chicks banded and combination	No. chicks fledged	Protection Type	Notes
80	Open riding area	F=U M=banded	30 Apr	Abandoned pre-term	2 Jun	3				Single nest exclosure	On 24 May, one egg is completely buried during high winds and replaced in bowl. Clutch of three eggs is moved away from encroaching sand bank multiple times on 24 and 25 May during sustained high winds. Gulls roosting in exclosure are flushed by monitors multiple times on 26 and 27 May.
81	Open riding area	F=PV:WW M=U	16 May	Depredated, avian	24 May	3				Single nest exclosure	Three eggs depredated by unknown avian predator.
82	6	F=U M=U	13 May	Hatch	15 Jun	3	1	1 RR:YW		Mini-exclosure Symbolic fence	Two eggs abandoned post-term.
83	6	F=U M=GA:YB	13 May	Hatch	15 Jun	3	3	3 GA:PW		Bumpout Seasonal exclosure	Band combination reused on SP215 (no chicks fledged).
84	7	F= M=	12 May	Failed, unknown cause	21 May	2				Seasonal exclosure	
85	7	F=U? M=U	16 May	Hatch	18 Jun	3	2	1 RR:YG 1 unbanded		Seasonal exclosure	One egg missing pre-term. One egg seen in process of hatching and egg or hatched chick not seen subsequently. Band combination reused on SP209.
86	7	F=U M=WS:WB	16 May	Hatch	18 Jun	3	3	2 VG:PG 1 VG:GP	1	Seasonal exclosure	One chick banded VG:PG fledged.
87	8	F= M=	15 May	na	24 May	3				Mini-exclosure Symbolic fence	Three eggs abandoned pre-term. Insufficient information to estimate initiation date.
88	SOF	F=U M=	11 May	Abandoned post-term	15 Jun	3				Circular excl. with top Symbolic fence	Three eggs abandoned post-term.
89	7	F=GA:RY M=U	18 May	Hatch	20 Jun	3	3	3 RR:AG		Seasonal exclosure	Split hatch. On 28 August, desiccated carcass of small RR:AG chick found partially buried west of 7.5 revegetation area. Last observed alive on 24 June.
90	SOF	F=VG:VY M=GA:PY	19 May	Hatch	21 Jun	3	3	3 VG:WR	2	Circular excl. with top Symbolic fence	Split hatch. On 29 May replaced existing mini-exclosure with circular exclosure.
91	6	F=VV:RB M=U	22 May	Hatch	24 Jun	3	3	3 PV:VR		Seasonal exclosure	Band combination reused on SP203 (no chicks fledged).

Appendix B. Snowy plover nests at ODSVRA in 2012 (continued).

Nest	Location	Adult Pair	Est. Initiation Date	Nest Fate	Fate date (estimated)	No. eggs	No. chicks	No. chicks banded and combination	No. chicks fledged	Protection Type	Notes
92	7	F=U M=U	11 May	Hatch	13 Jun	3	2	2 RR:OG	1	Mini-exclosure Symbolic fence	One egg (without cracks) abandoned post-term.
93	7	F=RR:AR M=U	14 May	Hatch	16 Jun	3	3	3 RR:BG		Seasonal exclosure	Band combination reused on SP183 (no chicks fledged).
94	7	F=U M=U	19 May	Hatch	21 Jun	3	2	2 GA:WR	2	Seasonal exclosure	One egg (without cracks) abandoned post-term.
95	7	F=B:PR M=VV:VR	17 May	Hatch	19 Jun	2	2	2 RR:RY		Mini-exclosure Symbolic fence	
96	6	F= M=	16 May	Flooded	2 Jun	3				Circular excl. with top Symbolic fence	Three eggs lost to tide.
97	7	F=U M=U	22 May	Hatch	24 Jun	3	3	3 RR:GW	1	Mini-exclosure Symbolic fence	Split hatch.
98	8	F=U M=U	12 May	Hatch	14 Jun	3	3	3 GA:OG		Seasonal exclosure	Split hatch. Band combination reused on SP171 (no chicks fledged).
99	BY	F= M=	21 May	Depredated, corvid	4 Jun	2				Seasonal exclosure	Two eggs depredated by corvid, likely common raven.
100	6	F=VV:VW M=VV:GB	17 May	Hatch	19 Jun	3	2	2 VG:PW	1	Symbolic fence	One egg abandoned post-term.
101	6	F=U M=U	24 May	Hatch	26 Jun	3	3	3 PV:OB		Seasonal exclosure	Split hatch.
102	6	F= M=	6 May	Hatch	8 Jun	3	3	3 BB:PG		Seasonal exclosure	Band combination reused on SP164 (no chicks fledged).
103	NOF	F=U M=VV:YY	19 May	Hatch	21 Jun	3	1	1 GA:OY		Mini-exclosure Seasonal exclosure	Two eggs (without cracks) abandoned post-term.
104	BY	F=GA:PB M=	28 May	Hatch	30 Jun	3	3	2 PV:WY 1 unbanded		10'x10' excl. with top Seasonal exclosure	Split hatch. Unbanded chick last seen with brood 5 July.
105	6	F=U M=NB:BY	8 May	Hatch	10 Jun	3	3	3 VG:PB		Seasonal exclosure	On 28 August, desiccated carcass of small VG:PB chick found in north portion of North Oso Flaco from SP105 or SP200. Band combination reused on SP200 (no chicks fledged).
106	6	F=U M=U	8 May	Hatch	10 Jun	3	3	3 GA:RR		Seasonal exclosure	Band combination reused on single unbanded chick (no chicks fledged).
107	7	F= M=U	17 May	Hatch	19 Jun	3	2	2 GG:PB	2	Mini-exclosure Symbolic fence	One egg abandoned post-term.

Appendix B. Snowy plover nests at ODSVRA in 2012 (continued).

Nest	Location	Adult Pair	Est. Initiation Date	Nest Fate	Fate date (estimated)	No. eggs	No. chicks	No. chicks banded and combination	No. chicks fledged	Protection Type	Notes
108	SOF	F=U M=U	24 May	Abandoned pre-term	25 Jun	3		1 AP:YL 1 AP:RL 1 WO:GG		10'x10' excl with top Symbolic fence	On 28 June, three eggs observed for an extended period of time without attending adult and eggs considered abandoned. Eggs collected and transported to Monterey Bay Aquarium. Eggs hatched. Three fledglings released 7 August.
109	7	F=U M=U	24 May	Hatch	26 Jun	3	3	3 PG:AB	1	Seasonal exclosure	
110	6	F=VV:AA M=GG:VY	31 May	Hatch	3 Jul	3	3	3 PG:GW	2	Seasonal exclosure	
111	6	F=(GG:?R)? M=	na	Abandoned post-term	18 Jul	2				Mini-exclosure Symbolic fence	One egg is unnaturally light with large clumps of sand stuck to egg where fluid possibly leaked. This egg goes missing pre-term. Second egg abandoned post-term. Insufficient information to estimate initiation date.
112	6	F=U M=GG:WB	28 May	Hatch	30 Jun	3	3	3 PV:BW	1	Symbolic fence	
113	6	F=BB:VG M=VV:GG	22 May	Hatch	24 Jun	3	1	1 GA:PR	1	Symbolic fence	Two eggs abandoned post-term.
114	7	F= M=	30 May	Depredated, corvid	20 Jun	3				Seasonal exclosure	Three eggs depredated by corvid.
115	6	F=U M=banded	25 May	Hatch	27 Jun	3	2	2 unbanded		Seasonal exclosure	Two chicks observed 27 June, not seen subsequently. One egg with unknown fate.
116	6	F=GG:VY M=U	4 Jun	Hatch	7 Jul	3	3	2 PG:YW 1 unbanded	1	Seasonal exclosure	Split hatch. Unbanded chick last seen with brood 5 August.
117	8	F= M=	6 Jun	Failed, unknown cause	19 Jun	1				Seasonal exclosure	
118	8	F= M=	3 Jun	Unknown	9 Jun	2				Seasonal exclosure	
119	Unknown	F= M=RR:OW	25 Apr	Hatch	(30 May)	2	2	2 unbanded	1		
120	7	F= M=	22 May	Abandoned, suspected wind	26 Jun	3				Seasonal exclosure	Three eggs buried during period of high winds.
121	7	F=VV:YW M=U	29 May	Hatch	1 Jul	3	3	2 RR:GY 1 unbanded	1	Seasonal exclosure	
122	7	F=U M=U	7 Jun	Hatch	7 Jul	3	2	2 PG:BR	1	Seasonal exclosure	Split hatch. One egg (without cracks) abandoned post-term.

Appendix B. Snowy plover nests at ODSVRA in 2012 (continued).

Nest	Location	Adult Pair	Est. Initiation Date	Nest Fate	Fate date (estimated)	No. eggs	No. chicks	No. chicks banded and combination	No. chicks fledged	Protection Type	Notes
123	7	F=AY:AW M=VG:YY	26 May	Hatch	28 Jun	3	3	1 GA:YR 2 unbanded		Seasonal exclosure	Unbanded chicks last seen with brood 2 July.
124	6	F=U M=GG:AR	26 May	Hatch	28 Jun	2	1	1 RR:AY	1	Symbolic fence	One egg (without cracks) abandoned post-term.
125	7	F= M=PG:OG	1 Jun	Hatch	4 Jul	3	2	2 PG:YY		Seasonal exclosure	
126	7	F=RR:AW M=U	2 Jun	Hatch	5 Jul	3	2	2 PG:OB	1	Seasonal exclosure	One egg (without cracks) abandoned post-term.
127	8	F=U M=	2 Jun	Abandoned pre-term	20 Jun	3				Mini-exclosure Seasonal exclosure	Three eggs abandoned pre-term.
128	6	F=GG:YG M=U	27 May	Hatch	29 Jun	3	1	1 GG:PY	1	Seasonal exclosure	Two eggs (without cracks) abandoned post-term.
129	6	F=GG:YG M=U	4 Jun	Hatch	7 Jul	3	3	3 PV:OY		Seasonal exclosure	Split hatch.
130	BY	F= M=	2 Jun	Depredated, coyote	17 Jun	3				Seasonal exclosure	Three eggs depredated by coyote.
131	6	F=VG:AW M=GG:AB	7 Jun	Hatch	10 Jul	3	3	3 PG:BY		Seasonal exclosure	
132	6	F=U M=U	4 Jun	Hatch	7 Jul	2	2	2 PV:GR		Seasonal exclosure	Split hatch.
133	6	F=U M=U	5 Jun	Hatch	8 Jul	3	3	3 PG:GG	2	Seasonal exclosure	
134	7	F=PV:BY M=U	27 May	Hatch	29 Jun	2	2	2 PV:WR	1	Seasonal exclosure	
135	7	F=VV:VW M=U	12 Jun	Hatch	15 Jul	3	3	3 PV:YR		Seasonal exclosure	
136	7	F= M=	20 May	Unknown	22 Jun	3				Seasonal exclosure	On 21 June, common raven is observed landing in area. No raven tracks are seen in the vicinity of the nest and two eggs remain. Last seen at three eggs on 14 June. On 22 June, nest location windswept. No evidence of hatch observed.
137	7	F= M=	27 May	Unknown	30 Jun	3				Seasonal exclosure	No evidence of hatch observed.
138	6	F=U M=PV:YY	3 Jun	Hatch	6 Jul	3	1	1 PG:GY	1	Seasonal exclosure	Two eggs (without cracks) abandoned post-term.
139	6	F= M=	30 May	Abandoned pre-term	27 Jun	3				Seasonal exclosure	Three eggs abandoned pre-term.
140	6	F=U M=U	1 Jun	Hatch	4 Jul	3	1	1 RR:GR		Seasonal exclosure	Two eggs (without cracks) abandoned post-term.

Appendix B. Snowy plover nests at ODSVRA in 2012 (continued).

Nest	Location	Adult Pair	Est. Initiation Date	Nest Fate	Fate date (estimated)	No. eggs	No. chicks	No. chicks banded and combination	No. chicks fledged	Protection Type	Notes
141	SOF	F=VG:GW M=U	11 Jun	Abandoned pre-term	22 Jun	3				10'x10' excl. with top Symbolic fence	Three eggs abandoned pre-term. One egg is small (approximately half the normal size).
142	8	F=U M=?	9 Jun	Hatch	12 Jul	3	3	3 PG:RB	1	Mini-exclosure Seasonal exclosure	
143	6	F=PV:YG M=U	28 May	Hatch	30 Jun	3	2	2 RR:WG	2	Seasonal exclosure	One egg abandoned post-term.
144	6	F=VG:AR M=U	29 May	Hatch	1 Jul	3	3	3 PV:GW	3	Seasonal exclosure	
145	8	F= M=	14 Jun	Depredated, corvid	18 Jun	2				Seasonal exclosure	Two eggs depredated by corvid.
146	7	F=U M=U	17 May	Hatch	19 Jun	3	2	2 GA:OR		Symbolic fence	One egg abandoned post-term.
147	7	F=U M=U	6 Jun	Hatch	9 Jul	3	2	2 unbanded	1	Mini-exclosure Symbolic fence	Chicks not banded to avoid disturbing other nearby young snowy plover broods. One egg abandoned post-term.
148	8	F=NB:OW M=U	10 Jun	Hatch	13 Jul	3	3	3 PG:RG		Mini-exclosure Symbolic fence	
149	6	F=GG:VY M=	13 Jun	Hatch	16 Jul	3	3	3 unbanded		Mini-exclosure Symbolic fence	Split hatch. Chicks not banded to avoid disturbing other nearby young snowy plover broods.
150	8	F=RR:WR M=U	9 Jun	Hatch	12 Jul	3	3	3 PG:OW		Mini-exclosure Seasonal exclosure	Split hatch.
151	8	F=U M=U	21 Jun	Hatch	24 Jul	3	1	1 GG:OB		Mini-exclosure Seasonal exclosure	Two eggs (without cracks and one noticeably smaller) abandoned post-term. Band combination previously used on SP4 (no chicks fledged).
152	NOF	F=U M=GG:AR	15 Jun	Hatch	18 Jul	3	2	2 PG:PR		Mini-exclosure Symbolic fence	Split hatch. One egg (without cracks) abandoned post-term.
153	7	F=U M=PG:VY	11 Jun	Hatch	14 Jul	3	3	3 PG:BW	2	Mini-exclosure Symbolic fence	
154	6	F=U M=PV:AG	19 Jun	Hatch	22 Jul	3	2	2 PG:OY		Seasonal exclosure	Split hatch. One egg (without cracks) abandoned post-term.
155	8	F=RR:OY M=U	18 Jun	Hatch	21 Jul	3	3	3 VV:LY		Mini-exclosure Symbolic fence	
156	7	F=U M=RR:WR	22 Jun	Hatch	25 Jul	3	2	2 GA:WY		Seasonal exclosure	Split hatch. One egg (without cracks) abandoned post-term. Band combination previously used on SP60 (no chicks fledged).
157	6	F= M=	16 Jun	Unknown	21 Jul	3				Seasonal exclosure	No evidence of hatch observed.

Appendix B. Snowy plover nests at ODSVRA in 2012 (continued).

Nest	Location	Adult Pair	Est. Initiation Date	Nest Fate	Fate date (estimated)	No. eggs	No. chicks	No. chicks banded and combination	No. chicks fledged	Protection Type	Notes
158	6	F= M=U	22 Jun	Hatch	25 Jul	3	3	3 VV:YG		Seasonal exclosure	On 3 August, carcass of small VV:YG decomposed chick found on surface of sand in North Oso Flaco from SP29 or SP158. Band combination previously used on SP29 (no chicks fledged).
159	8	F= M=	na	Abandoned pre-term	13 Jul	3				Mini-exclosure Symbolic fence	Three eggs abandoned pre-term. On 18 July a pair of adult-sized plover wings found five feet west of mini-exclosure. Insufficient information to estimate initiation date.
160	6	F=U M=U	15 Jun	Hatch	18 Jul	3	2	2 PG:PB		Seasonal exclosure	One egg (with cracks) abandoned post-term.
161	8	F=GA:RB M=BB:YY	24 Jun	Hatch	27 Jul	2	2	1 VG:RY 1 unbanded		Mini-exclosure Seasonal exclosure	Unbanded chick last seen with brood 1 August. Band combination previously used on SP54 (no chicks fledged).
162	8	F= M=U	20 Jun	Hatch	23 Jul	3	3	3 GA:GW		Mini-exclosure Seasonal exclosure	Band combination previously used on SP56 (no chicks fledged).
163	6	F=U M=U	19 Jun	Hatch	22 Jul	3	1	1 unbanded		Mini-exclosure Symbolic fence	Chick not banded to avoid disturbing other young snowy plover broods. Two eggs abandoned post-term.
164	NOF	F=(VG:VR)? M=BB:VR	19 Jun	Hatch	22 Jul	3	3	3 BB:PG		Mini-exclosure Symbolic fence	Band combination previously used on SP102 (no chicks fledged).
165	7	F=U M=U	19 Jun	Hatch	22 Jul	3	3	3 GG:LY	1	Seasonal exclosure	
166	6	F= M=	12 Jun	Hatch	15 Jul	3	3	3 PG:YG		Seasonal exclosure	
167	6	F= M=VG:YY	3 Jun	Hatch	6 Jul	3	3	3 PV:AW	1	Seasonal exclosure	Split hatch.
168	6	F= M=	17 Jun	Hatch	20 Jul	3	3	3 unbanded		Seasonal exclosure	Chicks not banded to avoid disturbing other young snowy plover broods.
169	6	F=BB:AW M=GG:VB	13 Jun	Hatch	16 Jul	3	2	3 PG:AY		Seasonal exclosure	One egg (without cracks and unnaturally weighted) abandoned post-term.
170	6	F=U M=U	19 Jun	Hatch	22 Jul	3	3	3 PG:PW	2	Seasonal exclosure	
171	7	F=U M=U	30 Jun	Hatch	2 Aug	3	2	2 GA:OG		Mini-exclosure Symbolic fence	One egg (peeping) abandoned post-term. Band combination previously used on SP98 (no chicks fledged).

Appendix B. Snowy plover nests at ODSVRA in 2012 (continued).

Nest	Location	Adult Pair	Est. Initiation Date	Nest Fate	Fate date (estimated)	No. eggs	No. chicks	No. chicks banded and combination	No. chicks fledged	Protection Type	Notes
172	6	F=U M=U	15 Jun	Hatch	18 Jul	3	3	3 PV:PG		Mini-exclosure Symbolic fence	
173	SOF	F=RR:VW M=U	23 Jun	Hatch	26 Jul	2	2	2 GA:VG		10'x10' excl. with top Symbolic fence	Band combination previously used on SP71 (one chick fledged).
174	6	F=U M=U	23 Jun	Hatch	26 Jul	3	2	2 VG:OY		Seasonal exclosure	One egg (without cracks) abandoned post-term. Band combination previously used on SP64 (no chicks fledged).
175	6	F=U M=GG:WB	18 May	Hatch	20 Jun	3	3	3 PG:AG	1	Seasonal exclosure	
176	6	F= M=	5 Jun	Unknown	4 Jul	3				Seasonal exclosure	Nest location known by multiple observations of incubating adult. Unable to walk to nest to avoid disturbing other young snowy plover broods. No evidence of hatch observed.
177	6	F=U M=U	9 Jun	Hatch	12 Jul	2	1	1 unbanded		Seasonal exclosure	Nest location known by multiple observations of incubating adult. Unable to walk to nest and band chick to avoid disturbing other nearby snowy plover broods. Minimum two eggs. One egg abandoned post-term.
178	7	F=U M=U	22 Jun	Hatch	25 Jul	2	2	2 GA:VW		Seasonal exclosure	Band combination previously used on SP73 (no chicks fledged).
179	6	F=U M=VG:YW	12 Jun	Hatch	19 Jul	3	3	3 unbanded		Seasonal exclosure	Split hatch. Chicks not banded to avoid disturbing other nearby young snowy plover broods.
180	6	F=U M=U	20 Jun	Hatch	23 Jul	3	3	3 VG:LY		Seasonal exclosure	
181	6	F=U M=U	15 Jun	Hatch	19 Jul	3	3	3 PV:PB		Seasonal exclosure	Split hatch.
182	6	F= M=	23 Jun	Unknown	4 Jul	1				Seasonal exclosure	Nest known by multiple observations of incubating adult. Unable to walk to nest to avoid disturbing other nearby young snowy plover broods. Minimum one egg.
183	6	F=U M=	22 Jun	Hatch	25 Jul	3	3	3 PV:RY		Seasonal exclosure	Band combination previously used on SP93 (no chicks fledged).
184	7	F=banded M=	28 Jun	Hatch	31 Jul	3	1	1 RR:BG		Seasonal exclosure	Two eggs abandoned post-term.

Appendix B. Snowy plover nests at ODSVRA in 2012 (continued).

Nest	Location	Adult Pair	Est. Initiation Date	Nest Fate	Fate date (estimated)	No. eggs	No. chicks	No. chicks banded and combination	No. chicks fledged	Protection Type	Notes
185	6	F=GA:OB M=Banded	1 Jul	Abandoned, unknown if pre- or post-term	29 Jul	3				Mini-exclosure Symbolic fence	Three eggs abandoned unknown if pre- or post-term.
186	8	F=U M=	30 Jun	Hatch	2 Aug	3	3	3 VV:VR		Mini-exclosure Symbolic fence	
187	6	F=U M=U	22 Jun	Hatch	25 Jul	3	2	1 GA:BY 1 unbanded	2	Seasonal exclosure	One banded and one unbanded chick fledged. Band combination previously used on SP10 (no chicks fledged).
188	6	F=U M=B:G/Y	22 Jun	Hatch	25 Jul	3	3	3 PG:WR		Seasonal exclosure	
189	6	F=U M=BB:RG	13 Jun	Hatch	16 Jul	3	3	3 PG:YR		Seasonal exclosure	
190	6	F=V:AB M=U	20 Jun	Hatch	23 Jul	3	3	3 PV:LY		Mini-exclosure Seasonal exclosure	
191	6	F=U M=	23 Jun	Hatch	26 Jul	3	2	2 PG:OR		Mini-exclosure Seasonal exclosure	
192	6	F= M=U	25 Jun	Hatch	28 Jul	3	3	3 GG:YW		Seasonal exclosure	Band combination previously used on SP76 (no chicks fledged)
193	7	F= M=U	3 Jul	Hatch	5 Aug	2	2	2 unbanded		Seasonal exclosure	Chicks not banded to avoid disturbing other snowy plover and least tern broods.
194	6	F= M=U	26 Jun	Hatch	29 Jul	3	2	2 GG:OG		Seasonal exclosure	One egg with unknown fate. On 13 September, desiccated carcass of small GG:OG chick found on 6 exclosure shoreline possibly from SP74 or SP194. Band combination previously used on SP74 (no chicks fledged).
195	6	F= M=U	24 Jun	Hatch	27 Jul	1	1	1 unbanded		Seasonal exclosure	Nest location known by multiple observations of incubating adult. Unable to walk to nest and band chick to avoid disturbing other young snowy plover and least tern broods. Minimum one egg.
196	6	F=U M=U?	25 Jun	Hatch	28 Jul	2	2	2 GA:RG		Seasonal exclosure	Band combination previously used on SP70 (no chicks fledged).
197	SOF	F=(BB:VG)? M=	30 Jun	Hatch	2 Aug	3	2	2 unbanded		10'x10' excl. with top Symbolic fence	One egg with unknown fate.
198	6	F= M=U	26 Jun	Hatch	29 Jul	3	3	3 unbanded		Symbolic fence	Chicks not banded to avoid disturbing other young snowy plover and least tern broods.

Nest	Location	Adult Pair	Est. Initiation Date	Nest Fate	Fate date (estimated)	No. eggs	No. chicks	No. chicks banded and combination	No. chicks fledged	Protection Type	Notes
199	6	F=BB:YG M=BB:OR	21 Jun	Hatch	24 Jul	3	2	2 VG:RW		Seasonal exclosure	Split hatch. One egg (without cracks) abandoned post-term. Band combination previously used on SP35 (no chicks fledged).
200	6	F= M=	2 Jul	Hatch	4 Aug	3	3	3 VG:PB		Seasonal exclosure	On 28 August, desiccated carcass of small VG:PB chick found in north portion of North Oso Flaco possibly from SP105 or SP200. Band combination previously used on SP105 (no chicks fledged).
201	6	F= M=	na	Abandoned, unknown if pre- or post-term	7 Aug	3				Symbolic fence	Nest identified by multiple observations of incubating adult. Three eggs abandoned unknown if pre- or post-term. Nest walked to on 21 August and three eggs collected. Not walked to when active to avoid disturbing other young snowy plover and least tern broods. Insufficient information to estimate initiation date.
202	6	F=U M=	2 Jul	Hatch	4 Aug	3	3	3 unbanded		Seasonal exclosure	Split hatch. Chicks not banded to avoid disturbing other young snowy plover and least tern broods.
203	6	F=(PV:WW)? M=U	2 Jul	Hatch	4 Aug	3	3	3 PV:VR		Mini-exclosure Seasonal exclosure	On 28 August, desiccated carcass of a 1-2 week-old PV:VR chick found partially buried on 7 shoreline. Chick last seen alive on 19 August at 15 days of age. Band combination previously used on SP91.
204	SOF	F=U M=VG:VY	26 Jun	Hatch	29 Jul	3	3	3 VG:GY		10'x10' excl. with top Symbolic fence	Band combination previously used on SP49 (no chicks fledged).
205	7	F= M=	8 Jul	Hatch	10 Aug	3	2	1 VV:RG 1 AP:YG 1 AP:WY		Seasonal exclosure	On 10 August, nest with two chicks and one egg observed for an extended period of time without an attending adult and considered abandoned. Chicks and egg collected and transported to Monterey Bay Aquarium. Egg hatched. Three fledglings released 10 and 19 September at Moss Landing State Beach, Monterey County.
206	6	F=U M=NB:BY	4 Jul	Hatch	6 Aug	3	3	2 VV:GB 1 unbanded		Seasonal exclosure	Split hatch. One unbanded chick last seen with brood on 9 August.

Appendix B. Snowy plover nests at ODSVRA in 2012 (continued).

Nest	Location	Adult Pair	Est. Initiation Date	Nest Fate	Fate date (estimated)	No. eggs	No. chicks	No. chicks banded and combination	No. chicks fledged	Protection Type	Notes
207	7	F= M=U	4 Jul	Hatch	6 Aug	3	3	3 GG:VW		Seasonal exclosure	
208	8	F= M=U	10 Jul	Hatch	12 Aug	3	3	3 GG:AB		Mini-exclosure Seasonal exclosure	
209	7	F= M=	5 Jul	Hatch	7 Aug	3	1	1 RR:YG		Seasonal exclosure	Two eggs (without cracks) abandoned post-term. Band combination previously used on SP85 (no chicks fledged).
210	6	F= M=	9 Jun	Unknown	22 Jun	1				Symbolic fence	Nest location known by multiple observations of incubating adult. Unable to walk to nest due to close proximity of young snowy plover and least tern broods. Minimum one egg. No evidence of hatch observed.
211	Unknown	F=VG:OG M=U	na	Hatch	22 Jul	2	2	2 PG:RY			Insufficient information to estimate initiation date.
212	BY	F=NY:RB M=	17 Jul	Abandoned pre-term	8 Aug	1		1 AP:WG		10'x10' excl. with top Seasonal exclosure	Egg noted with modest cracks 7 August. Nest not attended over a 2-day period (8-9 August) and considered abandoned. Egg collected and transported to Monterey Bay Aquarium. Egg hatched. Fledgling released 10 September at Moss Landing State Beach, Monterey County.
213	7	F=Banded M=GA:YB	na	Hatch	13 Aug	3	3	3 VV:RB		Seasonal exclosure	Split hatch. Insufficient information to estimate initiation date.
214	Unknown	F= M=RR:OR	12 Jul	Hatch	(14 Aug)	3	3	3 unbanded			Three chicks observed 15 August, not seen subsequently.
215	Unknown	F= M=RR:BB	na	Hatch	(22 Jul)	2	2	2 GA:PW			Band combination previously used on SP83 (no chicks fledged).v Insufficient information to estimate initiation date.
216	Unknown	F=NB:PG M=VG:BG	na	Hatch	(12 Jul)	3	3	3 PG:RW	1		Insufficient information to estimate initiation date.
UNK 1	Unknown	F=RR:PB M=U	na	Hatch	(22 Jun)	3	3	3 PV:YB	3		Insufficient information available to assign chicks to a specific nest with unknown fate or unbanded chicks. Insufficient information to estimate initiation date.

Appendix B. Snowy plover nests at ODSVRA in 2012 (continued).

Nest	Location	Adult Pair	Est. Initiation Date	Nest Fate	Fate date (estimated)	No. eggs	No. chicks	No. chicks banded and combination	No. chicks fledged	Protection Type	Notes
UNK 2	Unknown	F=unb? M=GA:PG	na	Hatch	na	2	2	2 VG:OR			Insufficient information available to assign chicks to a specific nest with unknown fate or unbanded chicks. Insufficient information to estimate initiation and fate date.
UNK 3	Unknown	F=U M=PV:WB	na	Hatch	(2 Jul)	3	3	3 PG:AW	2		Insufficient information available to assign chicks to a specific nest with unknown fate or unbanded chicks. Insufficient information to estimate initiation date.
UNK 4	Unknown	F=RR:PB M=VG:GW	na	Hatch	(7 Jul)	3	3	3 unbanded			Insufficient information available to assign chicks to a specific nest with unknown fate or unbanded chicks. Insufficient information to estimate initiation date.
UNK 5	Unknown	F=U M=U	na	Hatch	(17 Jul)	3	3	3 PG:PG			Insufficient information available to assign chicks to a specific nest with unknown fate or unbanded chicks. Insufficient information to estimate initiation date.
UNK 6	Unknown	F=U M=BB:--	na	Hatch	(21 Jul)	2	2	2 PG:AR			Insufficient information available to assign chicks to a specific nest with unknown fate or unbanded chicks. Insufficient information to estimate initiation date.
UNK 7	Unknown	F=U M=U	na	Hatch	(25 Jul)	3	3	3 VV:AW			Insufficient information available to assign chicks to a specific nest with unknown fate or unbanded chicks. Band combination previously used on SP43 (no chicks fledged). Insufficient information to estimate initiation date.

Appendix C. Maps of all California least tern and snowy plover nest locations at ODSVRA in 2012.

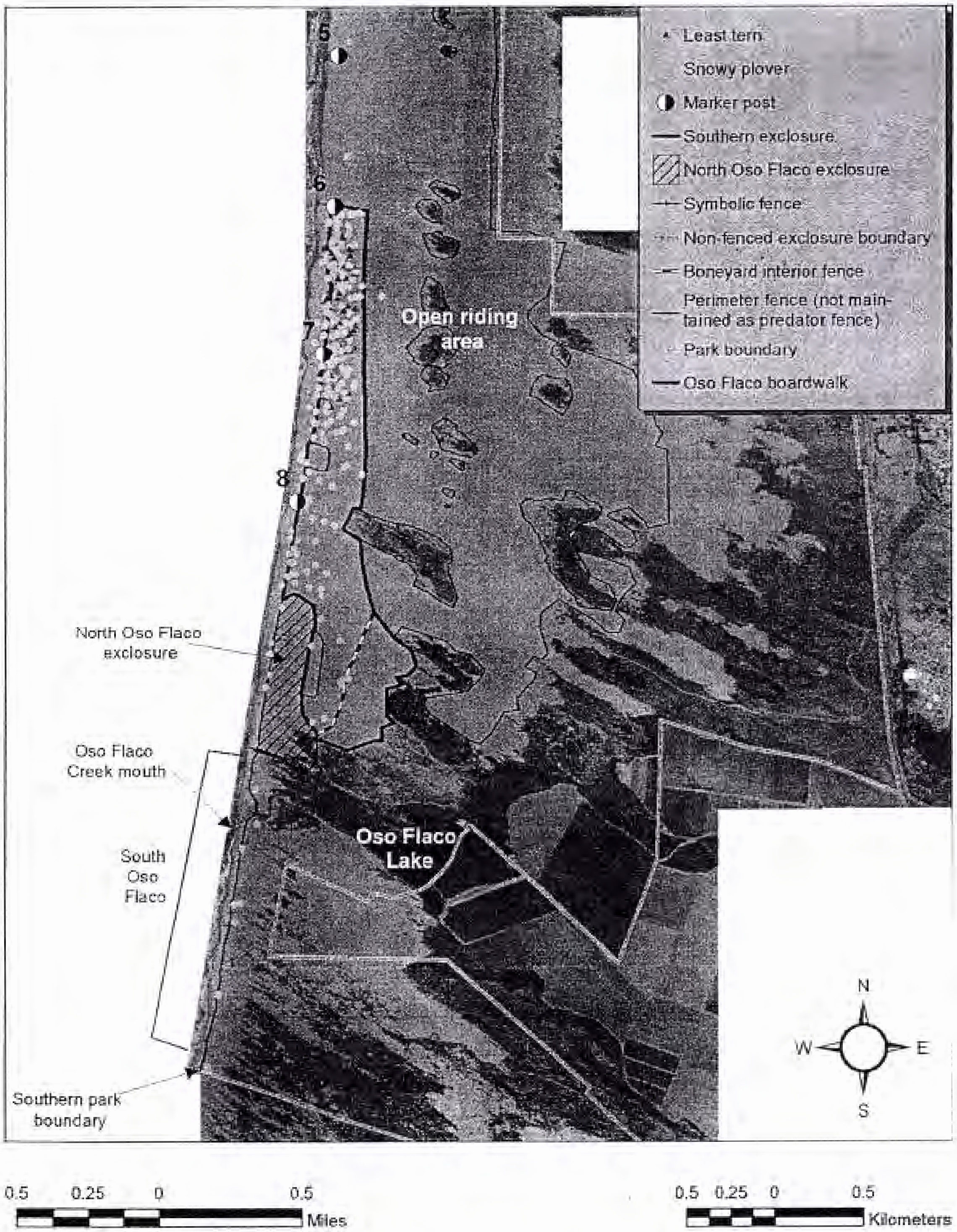


Figure C.1. All California least tern and snowy plover nest locations at ODSVRA in 2012.

Appendix C. Maps of all California least tern and snowy plover nest locations at ODSVRA in 2012 (continued).

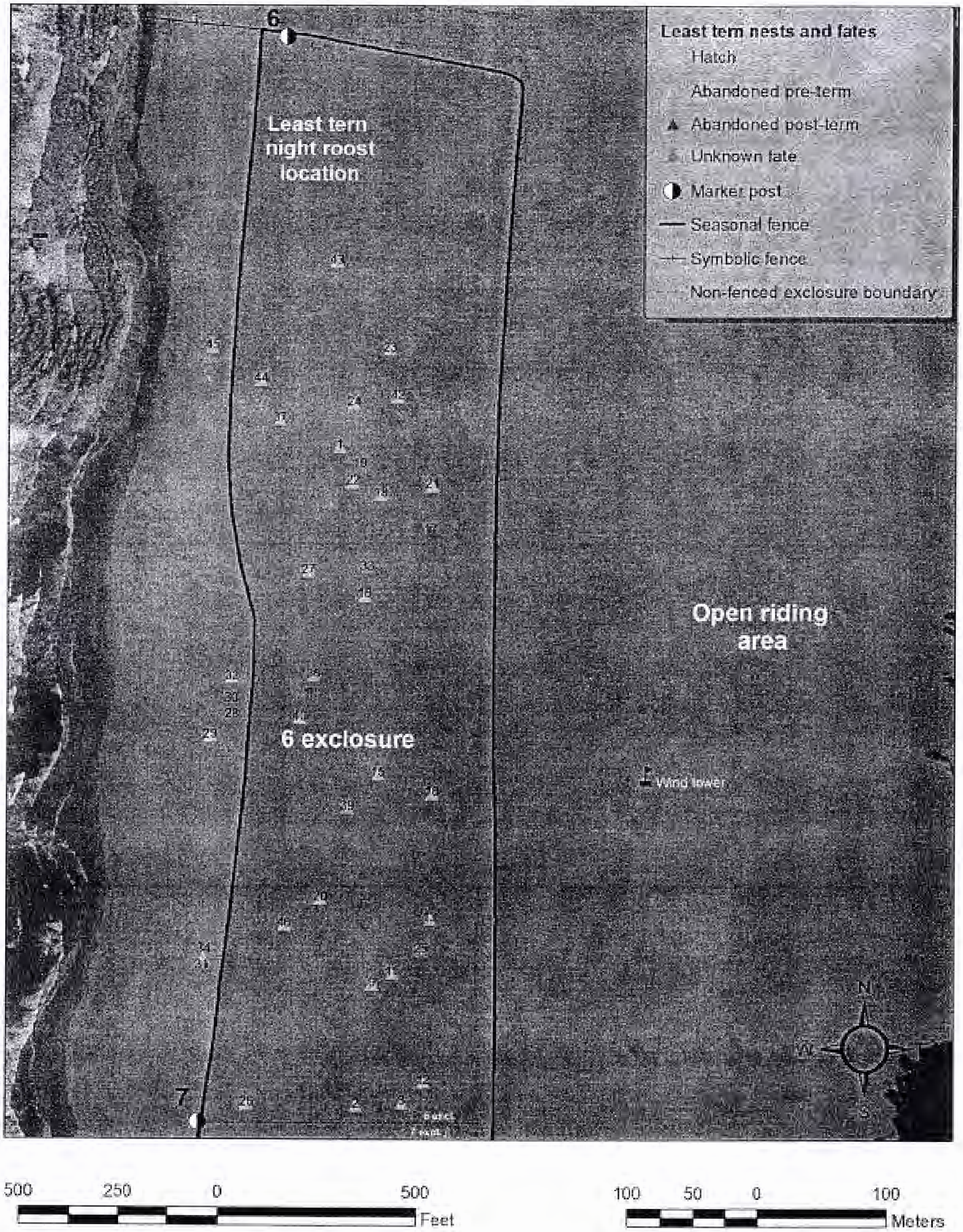


Figure C.2. California least tern nest locations at ODSVRA in 2012 (6 exclosure).

Appendix C. Maps of all California least tern and snowy plover nest locations at ODSVRA in 2012 (continued).

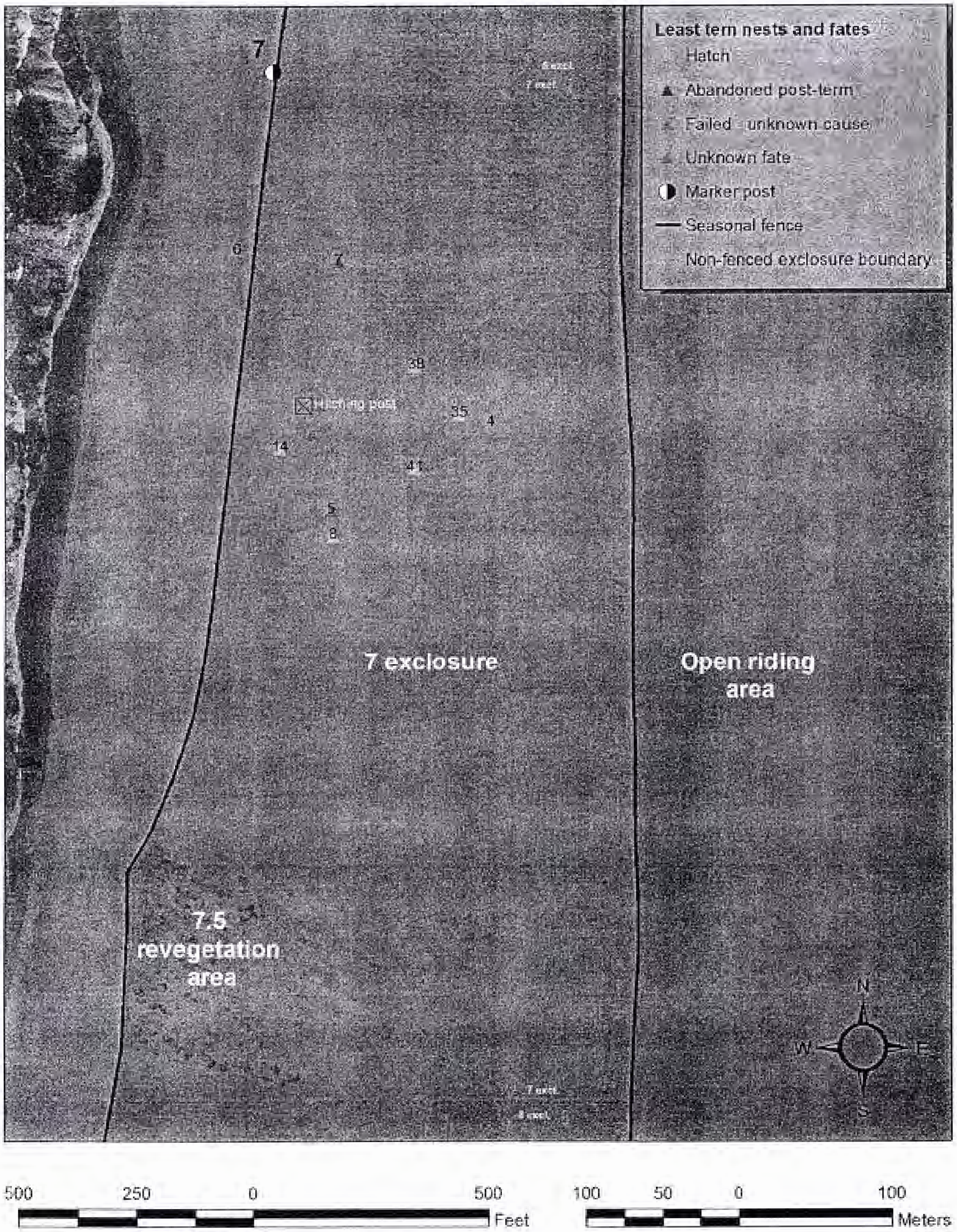


Figure C.3. California least tern nest locations at ODSVRA in 2012 (7 exclosure).

Appendix C. Maps of all California least tern and snowy plover nest locations at ODSVRA in 2012 (continued).

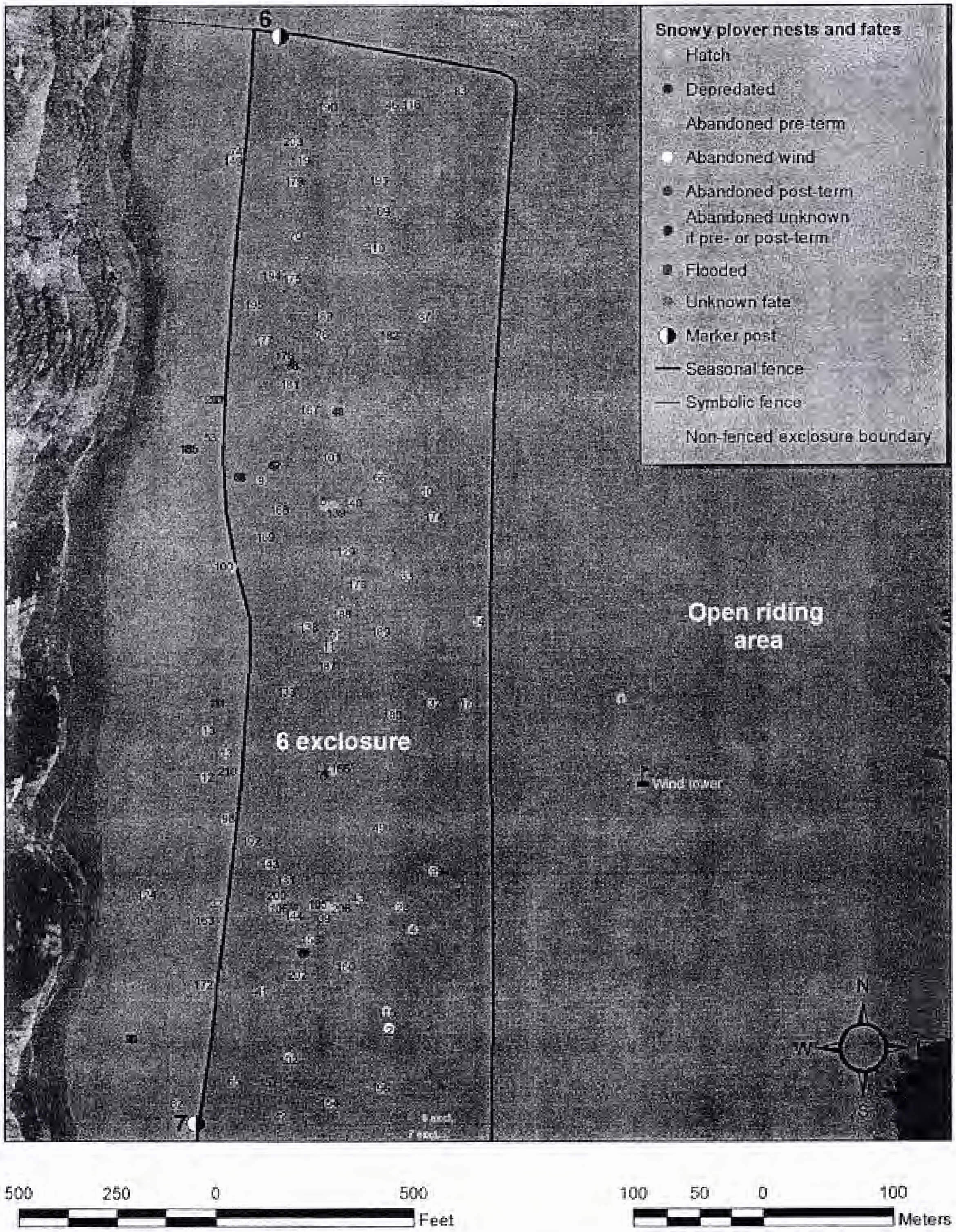


Figure C.4. Snowy plover nest locations at ODSVRA in 2012 (6 exclosure).

Appendix C. Maps of all California least tern and snowy plover nest locations at ODSVRA in 2012 (continued).

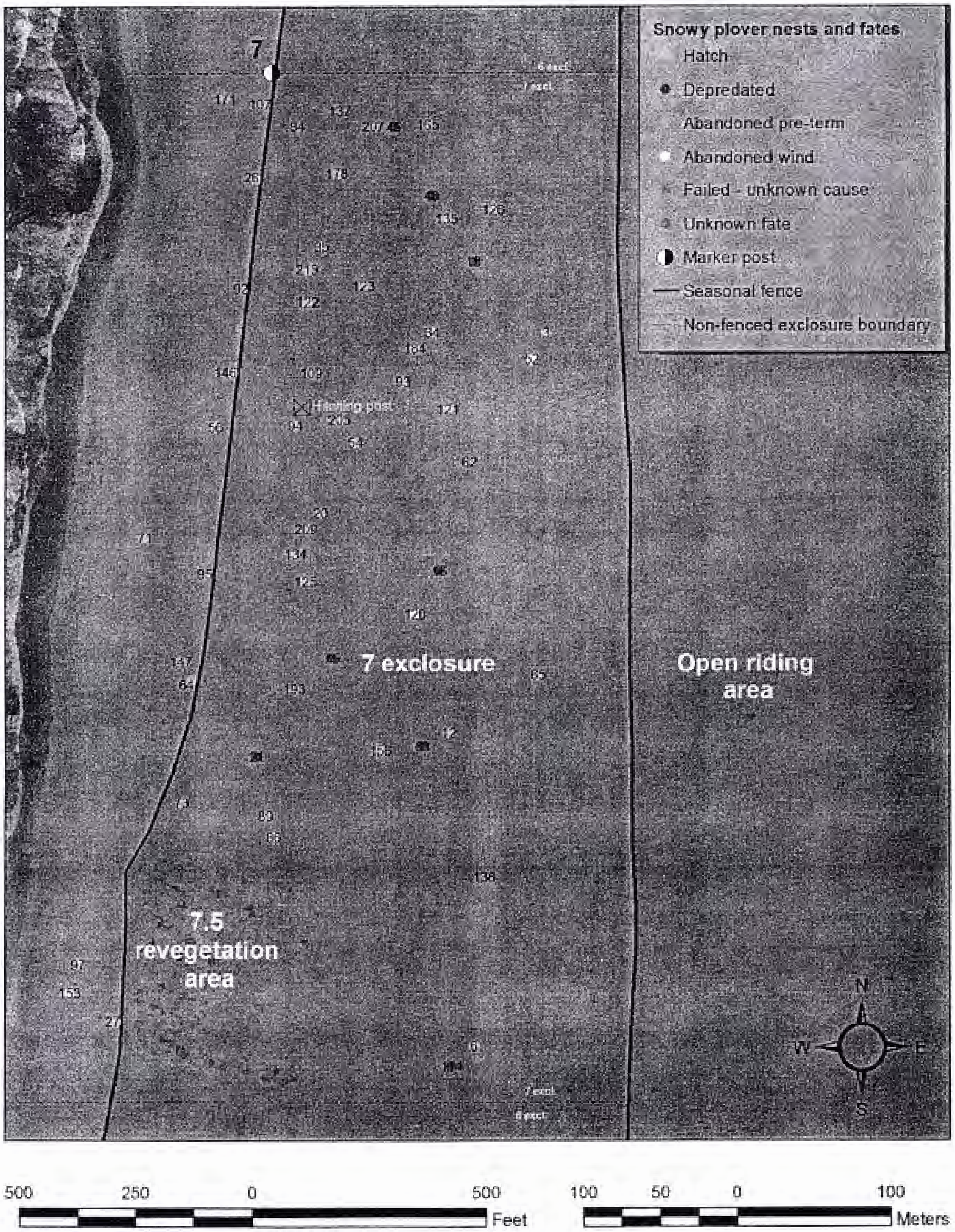


Figure C.5. Snowy plover nest locations at ODSVRA in 2012 (7 exclosure).

Appendix C. Maps of all California least tern and snowy plover nest locations at ODSVRA in 2012 (continued).

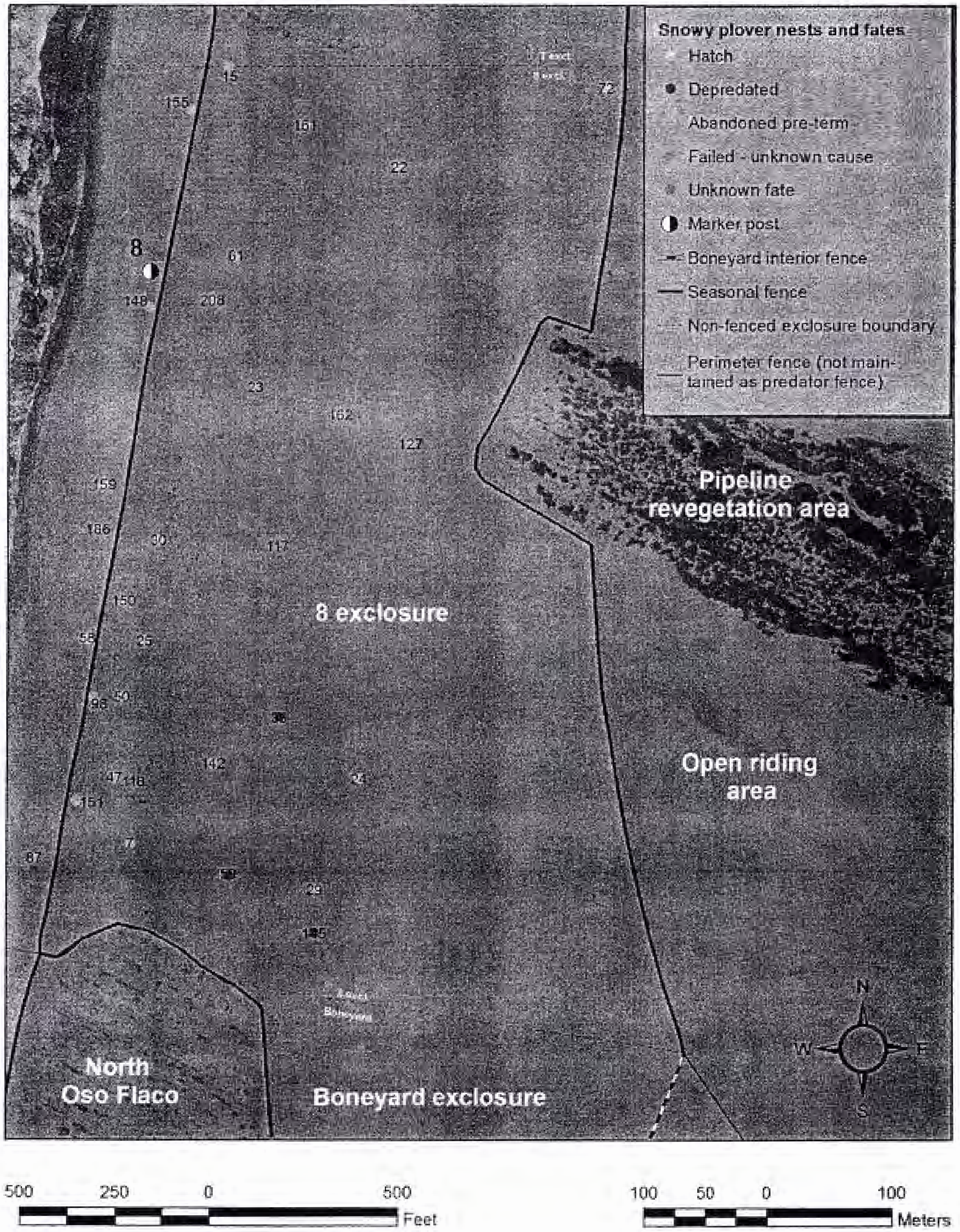


Figure C.6. Snowy plover nest locations at ODSVRA in 2012 (8 exclosure).

Appendix C. Maps of all California least tern and snowy plover nest locations at ODSVRA in 2012 (continued).

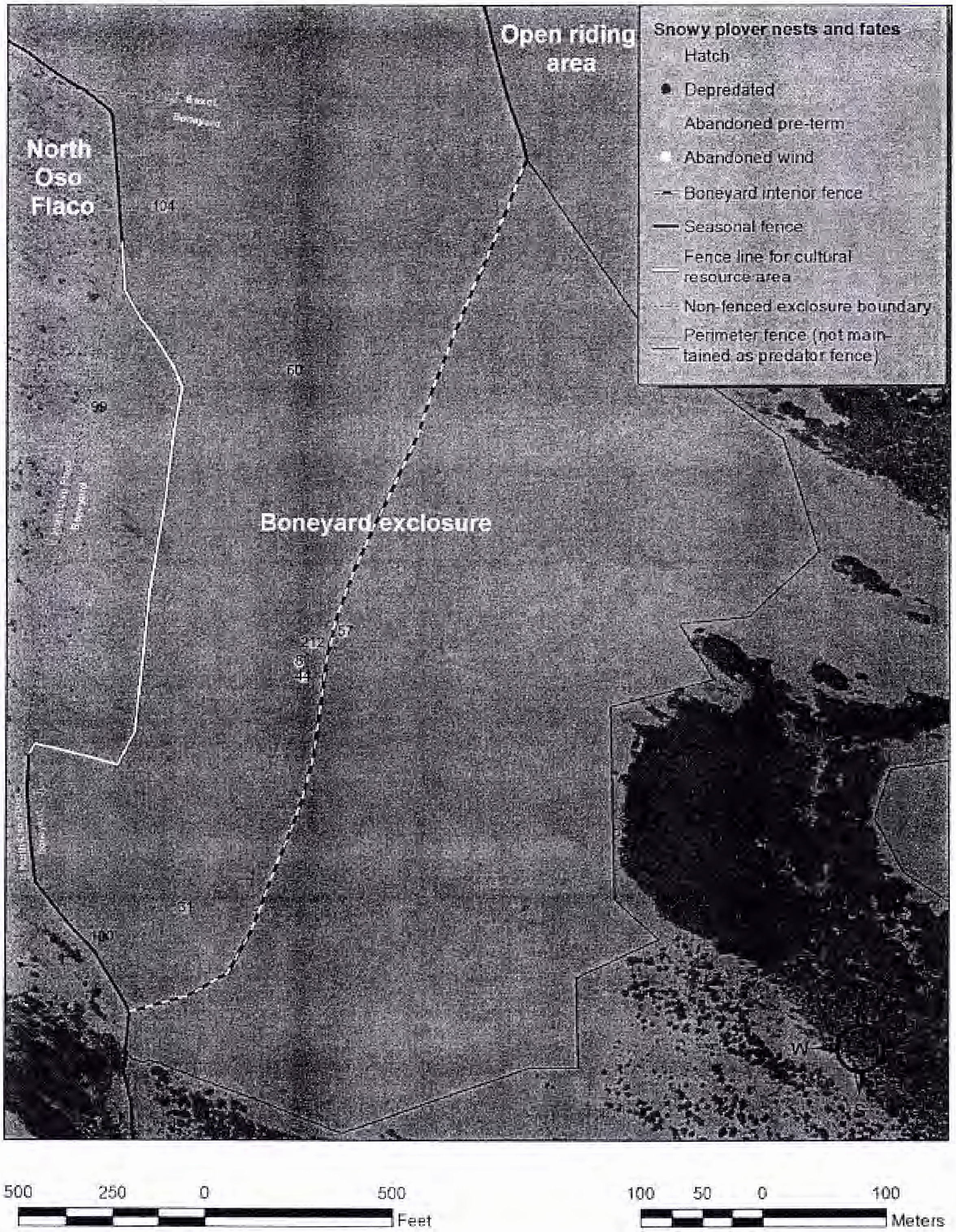


Figure C.7. Snowy plover nest locations at ODSVRA in 2012 (Boneyard exclosure).

Appendix C. Maps of all California least tern and snowy plover nest locations at ODSVRA in 2012 (continued).

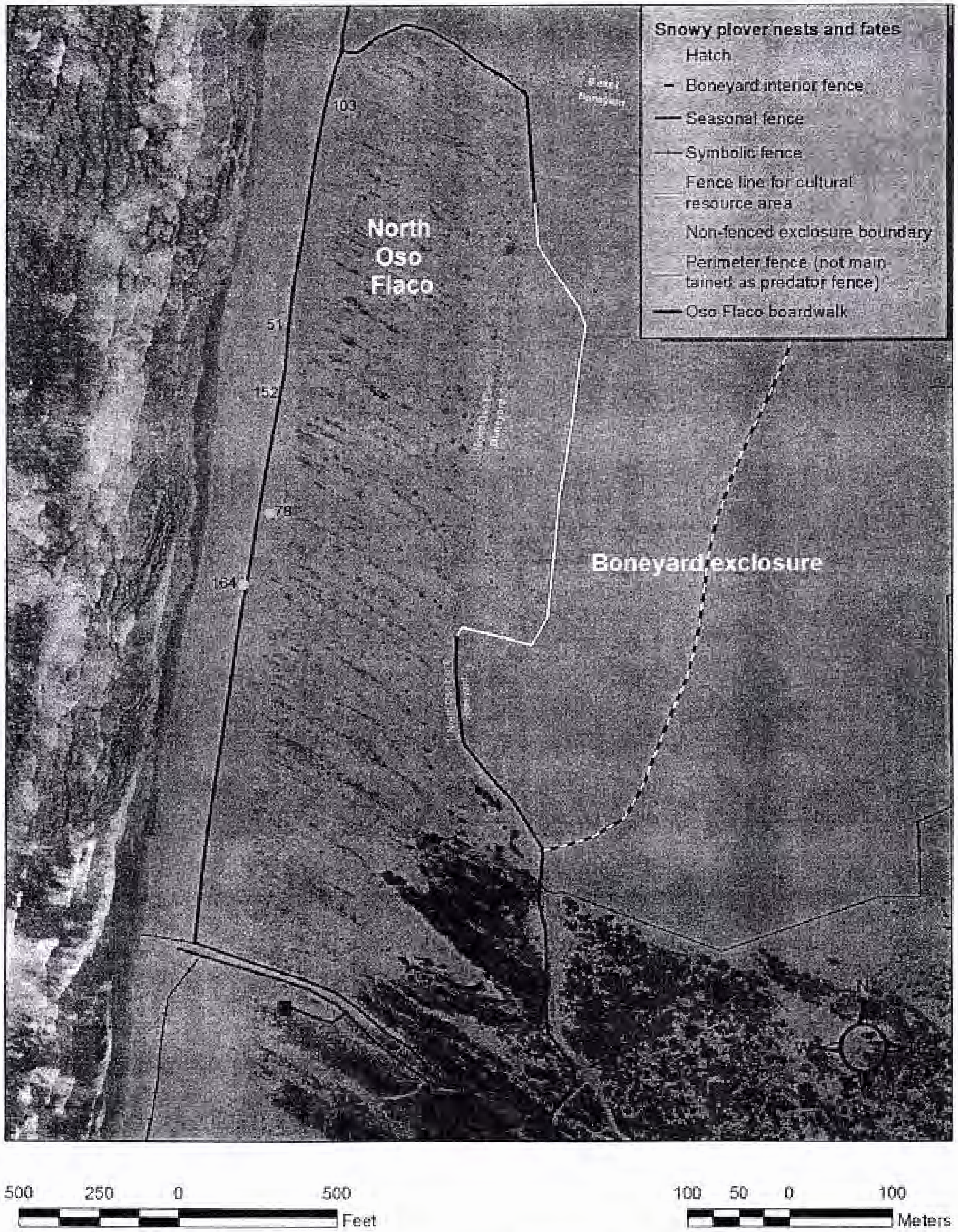


Figure C.8. Snowy plover nest locations at ODSVRA in 2012 (North Oso Flaco exclosure).

Appendix C. Maps of all California least tern and snowy plover nest locations at ODSVRA in 2012 (continued).

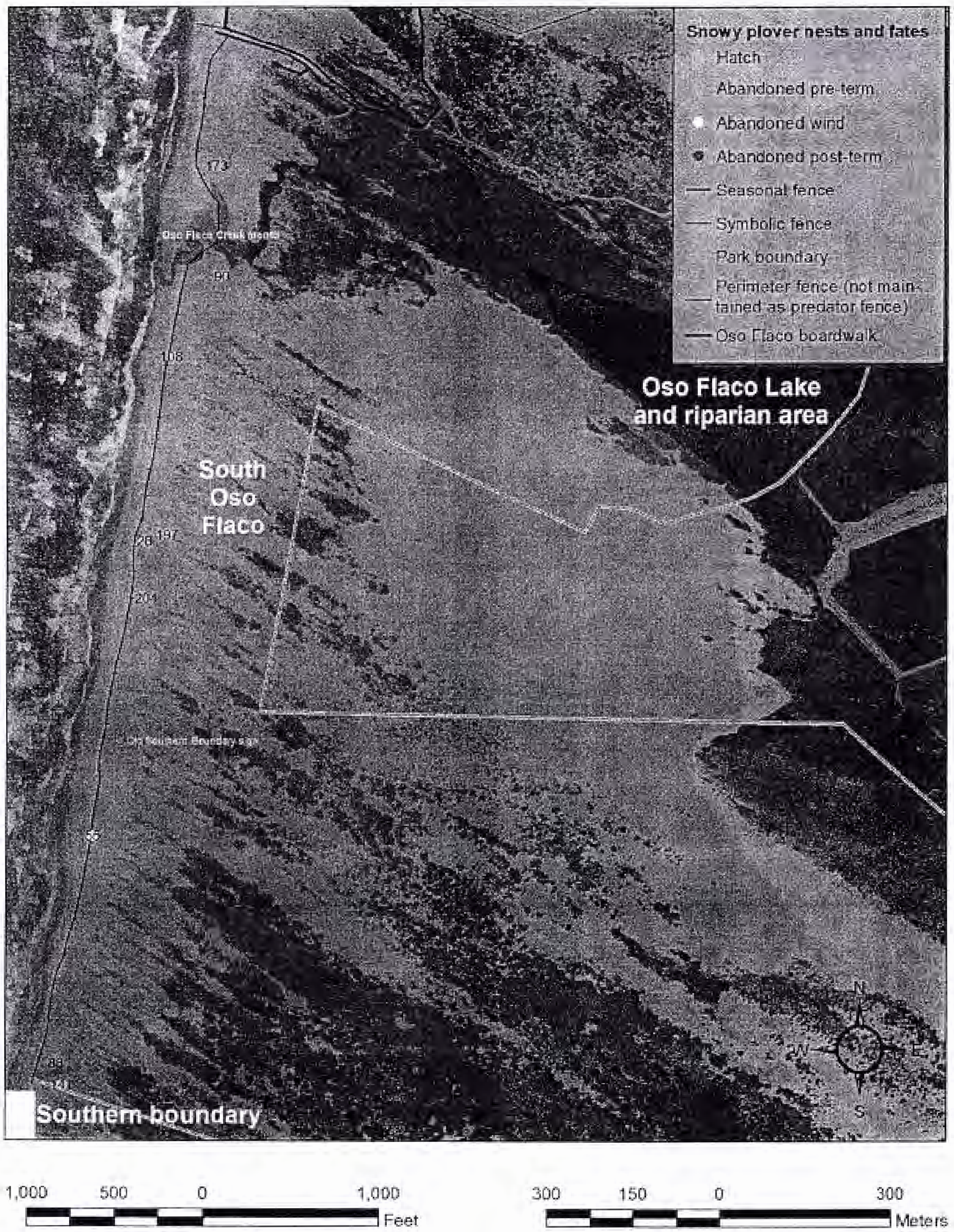


Figure C.9. Snowy plover nest locations at ODSVRA in 2012 (South Oso Flaco exclosure).

Appendix D. Banded least terns and snowy plovers.

Table D.1. Banded least terns recorded at ODSVRA in 2012.

Juveniles fledged from ODSVRA in 2012 are not included. All birds from ODSVRA were banded as chicks. Additional color-banded birds were recorded but combinations not confirmed. A number of birds had a band on only one leg. These birds may have been banded on only one leg or in many cases, lost a band.

Band	Dates Seen	Origin and Year Banded	Notes
-:A/G	5/17, 5/24, 7/30, 8/6	ODSVRA, either 2006 or 2008	**LT 2 breeding adult.** Y/G:A/G banded in 2006 or G/Y:A/G banded in 2008. There was one additional sighting as -:A on 30 July. It was noted that the G was faded and could easily be read as -:A.
-:B/G	7/28	ODSVRA 2006	Y/G:B/G banded in 2006.
-:B/G/B	5/15, 5/27, 6/20	likely ODSVRA 2008	**LT 19 breeding adult.** G/Y:B/G/B banded in 2008.
-:B/W	7/28	ODSVRA, either 2006, 2008, or 2010	Y/G:B/W banded in 2006, G/Y:B/W banded in 2008, W/B:B/W banded in 2010.
-:G/O	5/15, 5/16, 5/24, 5/27, 8/14	ODSVRA 2008	G/Y:G/O banded in 2008.
--:R/W	8/24	ODSVRA 2006	Y/G:R/W banded in 2006.
-:S	5/17, 5/22, 5/24, 5/25, 5/27, 5/28, 6/5, 8/11, 8/14	unknown	Two birds confirmed. Multiple sites may band in this way. Also may be any fledgling from 2004 when all banded G/Y:S
-:W	5/15, 5/31, 6/11, 6/27, 8/13, 8/14, 8/16, 8/29	ODSVRA, 2006, 2008, and 2010	**LT 34 breeding adult and LT45 breeding adult.** Y/G:W banded in 2006, G/Y:W banded in 2008, and W/B:W banded in 2010. Likely two different breeding adults.
-:W/B	5/14, 5/17, 5/22, 5/27, 5/28	likely ODSVRA , either 2006, 2008, 2009 or 2010	Y/G:W/B banded in 2006, G/Y:W/B banded in 2008, any fledgling from 2009 when all banded W/B on right leg, or W/B:W/B banded in 2010.
-:Y/G/Y	7/30	ODSVRA 2008	
-:Y/O	5/25	likely ODSVRA, either 2006 or 2008	Y/G:Y/O banded in 2006 or G/Y:Y/O banded in 2008
B/R:W/B	5/27	ODSVRA 2009	
B:W/B	7/25, 8/5	ODSVRA 2009	
G/O:-	8/17	ODSVRA 2007	
G/Y:-	5/27, 5/28	likely ODSVRA, either 2004 or 2008	Two birds confirmed. A fledgling from 2004 or 2008 when all banded with G/Y on left leg.
G/Y:A/B	5/16, 5/24, 5/25, 5/28	ODSVRA 2008	
G/Y:W/A	5/17, 5/27, 6/5	ODSVRA 2008	
G/Y:W/A/W	8/1	ODSVRA 2008	
O/A:W/B	5/14, 5/15, 5/17, 5/27, 8/15	ODSVRA 2009	
R/A:W/B	5/28	ODSVRA 2009	
R/W:W/B	5/15, 5/22, 5/24, 5/25, 5/27, 5/28, 6/5	ODSVRA 2009	
S:-	5/14, 5/15, 5/16, 5/17, 5/22, 5/24, 5/25, 5/27, 6/1	unknown	Two birds confirmed. Multiple sites may band in this way. Also may be a fledgling from 2003 when all banded S:G/Y
S:W	8/16	unknown	Multiple sites may band in this way.
V:W/B	5/27	ODSVRA 2009	
W/B:B	6/22	ODSVRA 2010	

Appendix D. Banded least terns and snowy plovers (continued).

Table D.1. Banded least terns recorded at ODSVRA in 2012 (continued).

Band	Dates Seen	Origin and Year Banded	Notes
W/B:W/A	6/5, 6/16, 8/11, 8/17, 8/21, 8/29	ODSVRA 2010	**LT 45 breeding adult.**
W/B:W/G	8/20	ODSVRA 2010	
W/B:W/Y	8/8, 8/9, 8/10, 8/11, 8/13, 8/14, 8/15	ODSVRA 2010	**LT 27 breeding adult.**
W/B:Y	8/3	ODSVRA 2010	
W/Y:W/B	8/1	ODSVRA 2009	
Y/O:W/B	5/14, 5/15, 5/25, 6/5, 7/19	ODSVRA 2009	
Y/W/Y:-	7/30, 8/6, 8/9, 8/10, 8/11, 8/14	ODSVRA 2007	**LT 14 breeding adult**
Y/W:W/B/W	8/24, 8/25	possibly ODSVRA 2008	**LT38 breeding adult.** Possibly faded from G/Y:W/B/W banded in 2008. Observed feeding Y/B:B/W juvenile (LT38) at Oso Flaco Lake on 24 and 25 August.
(light):W/B/W	5/25, 6/20	likely ODSVRA 2008	**LT 25 breeding adult.** Parental exchange observed at the nest site.

Table D.2. Banded snowy plovers with known origins seen at ODSVRA 1 October 2011 to 29 February 2012.
All birds were banded as chicks unless otherwise noted. Chicks banded outside of San Luis Obispo County are noted in order from north to south. Some sites band to brood and can have more than one bird with the same combination.
ODSVRA=Oceano Dunes SVRA, VAFB=Vandenberg Air Force Base, SB=State Beach, NWR=National Wildlife Refuge

Band	Origin and Year Banded	County Banded	Dates Seen	Notes
GL:AR	Pajaro Spit 2009	Monterey	11/11, 11/30, 12/12, 1/11	
AR:GO	Moss Landing SP 2011	Monterey	10/6, 10/7	
GB:PP	Moss Landing SB 2009	Monterey	10/7, 10/11, 10/22, 10/25, 11/9, 12/12, 1/11, 2/1, 2/8	
GB:YA	Moss Landing SB 2010	Monterey	10/22, 10/25, 11/30, 12/12	
BG:WA	Salinas River SB 2010	Monterey	10/8, 10/14, 10/20, 11/16, 12/12, 1/11	
YP:OL	Salinas River NWR 2008	Monterey	10/14, 10/26, 12/7, 12/12	
OL:GP	Salinas River NWR 2009	Monterey	10/11, 10/23, 11/28, 12/12, 2/8	
AY:AW	Reservation Road 2009	Monterey	10/11, 10/14, 12/12, 2/1	
YB:GW	Monterey Bay 2009	Monterey	10/11, 10/14, 10/15, 10/26, 12/12	Yellow band is above the joint, banded as an adult
BB:OG	ODSVRA 2010		10/23, 10/25, 10/26, 11/9, 11/16, 12/9, 12/12, 2/8	
BB:OR	ODSVRA 2010		10/14, 10/24, 10/25, 10/26, 11/9, 11/11, 11/28, 12/12, 12/22, 1/11	
BB:VR	ODSVRA 2011		10/4, 10/7, 10/20, 10/26, 11/2, 11/9, 11/30, 12/7, 12/12, 1/4, 2/23	
BB:WG	ODSVRA 2007 or 2010		10/26, 11/23, 11/30, 12/7, 12/12, 12/22, 1/4, 2/8, 2/15, 2/23	
BB:WR	ODSVRA 2010		10/25, 11/2, 11/9, 11/16, 12/7, 12/12	
BB:WW	ODSVRA 2010		10/5, 10/26, 11/9, 11/23, 11/30, 12/9, 12/12, 1/11, 2/8	
BB:YG	ODSVRA 2011		11/9, 11/16, 11/23, 11/30	
BB:YY	ODSVRA 2002 or 2010		10/7, 10/17, 11/9, 11/30, 12/7, 12/9, 12/12, 12/22, 1/4, 2/4, 2/8, 2/15	
GA:AR	ODSVRA 2011		10/15, 10/26, 11/23, 11/30, 12/12, 2/1, 2/4, 2/8	
GA:BB	ODSVRA 2010		11/16, 11/23, 2/4, 2/8	
GA:BG	ODSVRA 2011		10/26, 11/7, 11/30, 12/12	
GA:BW	ODSVRA 2011		10/5, 10/8, 10/10, 10/17, 11/30, 12/22, 2/8	
GA:PB	ODSVRA 2011		10/4, 10/14, 11/2, 11/9, 11/23, 11/30, 1/4, 2/8, 2/23	
GA:PG	ODSVRA 2011		10/15, 10/23, 10/26, 11/9, 11/23, 12/12, 1/4, 2/23	
GA:RB	ODSVRA 2004 or 2010		11/23, 12/12	
GA:RY	ODSVRA 2011		10/14, 10/17, 10/22, 10/23, 11/9, 11/11, 11/16, 11/28, 2/1	
GA:VB	ODSVRA 2008 or 2011		10/7, 10/26, 11/7, 11/11, 11/30, 12/7, 12/12	
GG:AB	ODSVRA 2007		10/12, 10/14, 11/16, 11/28, 11/30, 12/9, 12/12, 12/28, 1/4, 2/1, 2/8, 2/15	

Appendix D. Banded least terns and snowy plovers (continued.)

Table D.2. Banded snowy plovers with known origins seen at ODSVRA 1 October 2011 to 29 February 2012 (continued).

Band	Origin and Year Banded	County Banded	Dates Seen	Notes
GG:VY	ODSVRA 2008 or 2011		10/1, 10/5, 10/7, 10/14, 10/15, 10/16, 10/21, 10/23, 10/25, 11/7, 11/9, 11/16, 11/30, 12/4, 12/9, 12/12, 12/22, 12/28, 12/30, 2/1, 2/8, 2/15	2 birds confirmed.
GG:YG	ODSVRA 2011		10/4, 10/14, 10/17, 10/19, 10/23, 10/26, 11/2, 11/9, 12/1, 12/12, 2/8	
PG:BB	ODSVRA 2011		10/4, 10/8, 10/21, 10/26, 11/2, 11/30, 12/12	
PG:GR	ODSVRA 2011		11/30, 12/12	
PG:VW	ODSVRA 2011		10/8, 10/12, 10/16, 1/11	
PG:VY	ODSVRA 2008		10/7, 10/16, 10/17, 10/22, 10/23, 11/30, 12/12	
PV:AG	ODSVRA 2008		10/20, 11/2, 11/16, 1/17, 2/4	
PV:AY	ODSVRA 2007		10/12, 10/26, 11/9, 12/7	
PV:BA	ODSVRA 2009 or 2010		10/14, 10/25, 11/30, 12/12	
PV:BB	ODSVRA 2008 or 2010		10/7, 10/24, 11/9, 12/12	
PV:BG	ODSVRA 2011		10/9, 10/16	
PV:BR	ODSVRA 2007		10/7, 10/26, 11/2, 11/23, 12/12, 1/4, 1/11, 2/23	
PV:GB	ODSVRA 2008		10/16, 10/26, 11/2, 11/30, 12/7, 12/12, 1/4	
PV:GY	ODSVRA 2008		10/26, 1/4, 1/11, 1/17	
PV:WG	ODSVRA 2008		11/9, 11/30, 12/7, 12/12, 1/4, 1/11, 2/8	
PV:WW	ODSVRA 2008		10/8, 10/16, 10/19, 10/24, 10/25, 11/9, 11/30, 12/12, 12/28, 1/17, 2/1, 2/15	
PV:YG	ODSVRA 2009		10/7, 10/23, 10/25, 11/7, 11/9, 11/30, 12/7, 12/12, 12/30, 2/8	
RR:BW	ODSVRA 2010		10/12, 10/14, 11/2, 11/9, 12/12, 12/22, 1/4, 1/11	
RR:GG	ODSVRA 2011		10/7, 10/12, 11/9, 11/16, 12/9, 12/28, 2/4	
RR:OB	ODSVRA 2011		10/9, 10/12, 10/26, 12/12, 12/13, 1/4, 1/11, 2/8, 2/23	
RR:PB	OSVRA 2007 or 2010		10/20, 12/7, 2/3, 2/4	
RR:PG	ODSVRA 2009		10/7, 11/2, 11/15, 11/16, 12/7, 12/9, 1/11, 2/15, 2/23	
RR:VW	ODSVRA 2009 or 2011		12/7, 12/12, 12/22, 1/4, 1/11, 2/8	
RR:WR	ODSVRA 2010		10/11, 10/14, 10/22, 10/23, 11/16, 12/12, 1/4, 2/1, 2/4, 2/23	
RR:YR	ODSVRA 2010		10/6, 10/17, 10/19, 10/25, 11/16, 12/12, 1/11, 2/1	
VG:AB	ODSVRA 2011		10/12, 11/2, 11/23, 12/7, 12/12, 12/13, 1/11, 2/8, 2/23	
VG:AR	ODSVRA 2011		10/21, 10/25, 2/8, 2/15	
VG:AW	ODSVRA 2011		10/23, 10/25, 11/7, 11/9, 12/7, 12/12, 12/22, 1/11	
VG:BG	ODSVRA 2011		10/14, 10/16, 10/19, 10/26, 11/7, 11/23, 11/30, 12/12, 12/22, 12/28, 1/4, 1/11, 2/23	

Table D.2. Banded snowy plovers with known origins seen at ODSVRA 1 October 2011 to 29 February 2012 (continued).

Band	Origin and Year Banded	County Banded	Dates Seen	Notes
VG:BO	ODSVRA 2011		10/23, 11/30	
VG:GW	OSDVRA 2011		10/9, 10/12, 10/19, 10/23, 10/26, 11/11, 12/12, 1/17, 2/4, 2/15	
VG:OG	ODSVRA 2011		2/8, 2/15, 2/23	
VG:PR	ODSVRA 2011		10/20, 10/26, 11/9, 11/11, 2/23	2 birds confirmed.
VG:RB	ODSVRA 2011		10/16, 10/18, 10/26	
VG:VB	ODSVRA 2008 or 2011		11/2, 1/17, 2/4	
VG:VG	ODSVRA 2008 or 2011		10/8, 10/12, 10/26, 11/9, 12/12, 12/13	
VG:VR	ODSVRA 2009 or 2011		10/9, 10/26, 12/7, 12/12, 1/4, 2/8, 2/10, 2/23	
VG:VY	ODSVRA 2009		10/12, 10/26, 11/9, 11/16, 11/30, 12/12, 1/4	
VG:YW	ODSVRA 2011		10/5, 10/7, 10/9, 10/12, 10/17, 10/18, 10/19, 10/20, 10/23, 11/7, 11/9, 11/11, 11/23, 12/7, 12/12, 1/4, 1/11, 2/4, 2/8, 2/23	
VG:YY	ODSVRA 2011		10/16, 10/23, 10/25, 10/26, 11/7, 11/9, 11/16, 12/7, 12/12, 2/8, 2/15	
VO:BB	ODSVRA 2011		10/9, 10/12, 10/15, 10/17, 10/19, 10/20, 10/26, 11/2, 11/9, 11/11, 1/4, 2/8	
VS:BR	ODSVRA 2003		10/6, 10/11, 12/12, 1/17, 2/23	
VV:AA	ODSVRA 2011		10/5, 11/2, 2/15	
VV:BB	ODSVRA 2011		10/18, 1/11	
VV:RB	ODSVRA 2009		10/9, 12/7, 12/12, 1/11	
VV:VB	ODSVRA 2011		10/5, 10/6, 10/12, 10/14, 10/17, 10/26, 11/30, 12/7, 12/12, 1/4, 2/8, 2/23	
VV:VG	ODSVRA 2009 or 2011		12/12, 1/4	
VV:VW	ODSVRA 2008 or 2011		10/5, 10/12, 10/16, 10/17, 10/26, 11/9, 11/30, 12/4, 12/12, 12/13, 1/4, 1/17, 2/1, 2/15, 2/23	
VV:VY	ODSVRA 2011		10/5, 10/6, 10/14, 10/17, 10/20, 10/23, 10/26, 11/11, 11/23, 2/8, 2/23	
VV:YR	ODSVRA 2011		10/7, 10/14, 11/11, 11/28, 11/30, 12/1, 12/12	
VV:YY	ODSVRA 2011		10/11, 10/26, 11/2, 11/9, 11/30, 12/12, 12/22, 1/4, 2/8	
NB:PR	VAFB 2011	Santa Barbara	10/4, 10/15, 10/25, 12/12, 2/8	
NB:PY	VAFB 2011	Santa Barbara	10/8/2011	
NY:RB	VAFB 2008	Santa Barbara	10/21, 11/30, 2/15, 2/23	

Table D.3. Banded snowy plovers with known origins seen at ODSVRA 1 March to 30 September 2012.
Juveniles fledged from ODSVRA in 2012 are not included. All birds were banded as chicks unless otherwise noted. Chicks banded outside of San Luis Obispo. County are noted in order north to south. Some sites band to brood and can have more than one bird with the same combination.
The ULT, LLT, URT notation denotes chicks banded at ODSVRA from 2002 to 2004. Chicks were banded to brood during this time in a way to create combinations unique to each individual. This was done by alternating the leg (left or right) that received the federal band, as well as the location (upper or lower) on this band that remained exposed when color tape was applied. Due to viewing conditions, the exposed portion of the federal band was not always discernible, raising the possibility that two or more different birds were being recognized as the same band combination; these cases are noted below.
ODSVRA=Oceano Dunes SVRA, VAFB=Vandenberg Air Force Base, SB=State Beach, NWR=National Wildlife Refuge

Band	Sex (#)	Origin and Year Banded	County Banded	Dates Seen	Notes
--:Sb	J	Oregon 2012		9/9, 9/14	
BG:YY		Pajaro Spit 2007	Monterey	8/13, 8/23	
WO:OW	J	Pajaro Spit 2012	Monterey	9/3, 9/12, 9/27	
GB:PP		Moss Landing SB 2009	Monterey	3/3, 3/6, 8/16, 8/31, 9/3, 9/10, 9/12	
GO:OB		Moss Landing SB 2012	Monterey	8/21, 8/29, 8/30, 8/31, 9/4, 9/9, 9/17	
AB:AB		Marina SB 2011	Monterey	4/7, 4/11	
WB:WW	J	Marina SB 2012	Monterey	8/18, 8/20, 8/22, 8/23	
BG:WA		Salinas River SB 2010	Monterey	3/3, 3/11, 3/13, 3/21, 3/23, 9/13, 9/20, 9/27	
OA:WW	J	Salinas River NWR 2012	Monterey	9/12, 9/18, 9/27, 9/28	
OL:GP		Salinas River NWR 2009	Monterey	3/3, 3/16	
RP:WR		Salinas River SB (Molera Potrero) 2010	Monterey	8/29, 9/10	
YB:GW	F	Monterey Bay 2009	Monterey	3/3, 3/9, 3/24, 4/4, 4/5, 4/6, 4/7, 4/11, 4/13, 4/19, 8/16, 8/18, 8/20, 8/22, 8/23, 8/27, 8/28, 8/31, 9/5, 9/8, 9/9, 9/10, 9/11, 9/12, 9/13, 9/20	Yellow band is above the joint.
AY:AW	F	Reservation Road 2009	Monterey	3/3, 5/19, 6/28, 7/3, 9/7, 9/14, 9/15, 9/20, 9/29	ODSVRA breeding female.
B:PR	F	ODSVRA 2010		3/26, 3/30, 4/12, 5/22, 6/2, 6/21, 6/22, 7/6, 8/6, 8/13, 8/18	ODSVRA breeding female. Banded in 2010 as BB:PR.
BB:--	M	ODSVRA 2005		3/30, 3/31, 4/11, 5/6, 5/7, 5/8, 5/11, 5/15, 6/24	ODSVRA breeding male. Banded in 2005 as BB:WB.
BB:AW	F	ODSVRA 2010		3/23, 4/12, 6/1, 6/2, 7/17, 7/18, 8/11, 8/13, 8/21, 9/10, 9/17	ODSVRA breeding female.
BB:OR	M	ODSVRA 2010		3/2, 3/3, 3/13, 3/15, 3/16, 3/19, 3/26, 3/27, 3/30, 4/6, 4/12, 4/17, 5/1, 5/2, 5/3, 5/8, 5/9, 5/17, 5/22 5/25, 5/26, 5/27, 6/1, 6/24, 7/4, 7/5, 7/7, 7/8, 7/16, 7/30, 7/31, 8/16, 8/17, 8/22, 8/25, 8/28, 8/29, 9/1, 9/10, 9/17, 9/20, 9/29	ODSVRA breeding male.
BB:RG	M	ODSVRA 2007		4/12, 5/22, 6/1, 6/20	ODSVRA breeding male.
BB:RR		ODSVRA 2010		4/25, 7/22, 9/7, 9/19, 9/20	
BB:VG	F	ODSVRA 2008 or 2011		3/31, 4/12, 4/22, 6/7, 6/29, 7/1	ODSVRA breeding female.
BB:VR	M	ODSVRA 2011		3/4, 3/9, 3/10, 3/23, 3/26, 3/30, 4/25, 5/28, 7/24, 8/9, 8/13, 8/14, 8/27	ODSVRA breeding male.

Table D.3. Banded snowy plovers with known origins seen at ODSVRA 1 March to 30 September 2012 (continued).

Band	Sex (#)	Origin and Year Banded	County Banded	Dates Seen	Notes
BB:WG	M	ODSVRA 2007 or 2010		3/4, 3/15, 3/19, 3/26	
BB:WW		ODSVRA 2010		4/9, 4/25	
BB:YG	F	ODSVRA 2011		3/9, 5/20, 6/20, 6/23, 6/27, 7/23, 7/25	ODSVRA breeding female.
BB:YY	M	ODSVRA 2002 or 2010		3/11, 3/31, 4/18, 4/19, 4/25, 5/20, 6/13, 6/23, 7/30, 9/1, 9/18	ODSVRA breeding male.
GA:BB		ODSVRA 2010		3/9, 4/12	
GA:BW	F	ODSVRA 2011		3/24, 3/25	
GA:OB	F	ODSVRA 2010		4/15, 4/26, 6/7, 6/29, 7/18	ODSVRA breeding female.
GA:PB	F	ODSVRA 2011		3/1, 3/4, 3/26, 4/8, 4/12, 7/6, 7/11, 8/21, 9/1	ODSVRA breeding female.
GA:PG		ODSVRA 2011		3/4, 3/15, 4/12, 4/16, 4/20, 5/27, 6/27, 7/27, 8/10, 8/13, 8/14, 8/15, 8/17, 8/18, 8/20, 8/22, 8/28, 8/31, 9/2, 9/10, 9/12, 9/13, 9/28	
GA:PY	M	ODSVRA 2010		4/26, 7/13, 7/22	ODSVRA breeding male.
GA:RB	F	ODSVRA 2004 or 2010		6/1, 6/14, 8/1, 8/10, 8/11, 8/21, 8/27, 9/10, 9/18	ODSVRA breeding female.
GA:RY	F	ODSVRA 2011		3/3, 3/5, 3/16, 3/21, 3/30, 4/4, 4/6, 4/7, 4/11, 4/14, 6/22, 6/23, 8/13, 8/27, 9/10, 9/11, 9/14, 9/16, 9/20	ODSVRA breeding female
GA:YB	M	ODSVRA 2004		4/25, 5/7, 5/18, 5/31, 6/2, 6/5, 6/7, 6/13, 6/14, 6/15, 6/21, 6/22, 6/28, 7/27, 8/10, 8/20, 8/21, 8/22	ODSVRA breeding male
GA:YG		ODSVRA 2011		4/26, 6/30	
GG:AB	M	ODSVRA 2007		3/3, 3/12, 3/14, 3/15, 3/27, 3/30, 4/6, 4/17, 5/8, 5/9, 5/13, 5/20, 5/25, 6/19, 6/27, 6/29, 7/9, 7/11, 7/21, 7/22, 8/12, 8/14, 8/18, 8/20, 8/25, 8/28, 8/29, 9/8, 9/10, 9/22	ODSVRA breeding male.
GG:AR	M	ODSVRA 2011		3/16, 5/15, 5/17, 5/30, 5/31, 6/13, 6/27, 6/29, 7/1, 7/4, 7/5, 7/6, 7/18, 7/21, 8/1, 8/22	ODSVRA breeding males (2).
GG:GR		ODSVRA 2011		3/25, 3/30, 4/4, 4/7, 5/9	
GG:VB	M	ODSVRA 2008 or 2011		6/24, 6/29, 7/26	ODSVRA breeding male.
GG:VY	F(2) and M	ODSVRA 2008 or 2011		3/3, 3/10, 3/11, 3/12, 3/14, 3/15, 3/16, 3/17, 3/18, 3/19, 3/20, 3/22, 3/24, 3/27, 3/28, 3/30, 4/2, 4/6, 4/7, 4/11, 4/16, 4/23, 5/17, 5/19, 5/21, 5/22, 5/23, 5/24, 5/25, 5/30, 5/31, 6/1, 6/2, 6/4, 6/7, 6/10, 6/12, 6/14, 6/15, 6/16, 6/20, 6/21, 6/22, 6/24, 6/29, 6/30, 7/5, 7/9, 7/16, 7/18, 7/21, 7/22, 7/28, 7/29, 8/13, 8/16, 8/17, 8/18, 8/20, 8/21, 8/22, 8/24, 8/25, 8/27, 8/29, 8/31, 9/2, 9/3, 9/5, 9/10, 9/11, 9/14, 9/20, 9/22	ODSVRA breeding females (2) and ODSVRA breeding male.
GG:WB	M	ODSVRA 2011		4/18, 4/20, 5/2, 5/10, 5/22, 5/23, 5/24, 5/25, 5/27, 5/30, 5/31, 6/6, 6/7, 6/12, 6/13, 6/14, 6/24, 6/29, 7/1, 7/3, 7/5, 7/9, 7/10, 7/22, 8/9, 8/20, 8/24, 8/26, 8/27, 8/28, 9/1, 9/2, 9/3, 9/5, 9/8, 9/9, 9/14, 9/17, 9/18	ODSVRA breeding males (2).
GG:YG	F	ODSVRA 2011		3/3, 3/9, 3/11, 3/13, 3/19, 3/20, 3/26, 3/30, 4/12, 4/16, 4/19, 4/21, 6/27, 6/29, 7/1, 7/4, 7/5, 7/31, 8/11, 8/15, 8/21, 8/30, 9/1, 9/10, 9/11, 9/13, 9/28, 9/30	ODSVRA breeding females (2).
GG:YY		ODSVRA 2011		6/30, 9/29	

Appendix D. Banded least terns and snowy plovers (continued).

Table D.3. Banded snowy plovers with known origins seen at ODSVRA 1 March to 30 September 2012 (continued).

Band	Sex (#)	Origin and Year Banded	County Banded	Dates Seen	Notes
PG:GR	F	ODSVRA 2011		3/2, 3/16, 4/6, 4/7, 4/13, 4/14, 9/3, 9/20	
PG:OG	M	ODSVRA 2009		6/22, 7/4	ODSVRA breeding male.
PG:VY	M	ODSVRA 2008		3/3, 3/6, 3/10, 4/25, 5/11, 5/22, 6/1, 6/9, 6/13, 6/23, 7/4, 7/21, 8/1, 8/10, 8/14, 8/15, 8/22, 8/23	ODSVRA breeding male.
PV:AG	M	ODSVRA 2008		4/5, 4/26, 5/8, 5/9, 5/14, 5/17, 5/20, 5/22, 6/9, 7/16, 7/30, 7/31, 8/9, 8/27, 9/11, 9/30	ODSVRA breeding males (2).
PV:BA		ODSVRA 2009 and 2010		3/3, 3/13	
PV:BG	M	ODSVRA 2011		4/8, 4/11	
PV:BR	M	ODSVRA 2007		3/4, 3/11, 3/15, 3/27, 4/26, 5/14, 5/20, 5/31, 6/22, 7/16, 8/25, 8/29, 9/3, 9/11, 9/30	ODSVRA breeding male.
PV:BY	F	ODSVRA 2008		3/22, 4/7, 6/29, 7/4	ODSVRA breeding female.
PV:GY	M	ODSVRA 2008		3/9, 3/26, 5/3, 5/10, 6/1, 6/13, 6/14, 6/16, 6/21, 6/22, 6/29, 8/8, 8/10, 8/13, 8/15, 8/22, 8/27, 9/29	
PV:VY	F	ODSVRA 2009		3/23, 3/25, 4/8, 4/10, 4/11, 4/20, 4/23, 5/14, 5/18, 5/19, 5/20, 7/18, 7/22, 7/30, 8/12, 8/17, 8/22, 8/27, 8/29, 9/2, 9/3, 9/11, 9/12, 9/20, 9/21	ODSVRA breeding female.
PV:WB	F	ODSVRA 2007 or 2010		4/21, 5/11, 5/13, 6/1, 7/2, 7/3, 7/4, 7/21, 8/10, 8/14, 9/1, 9/2	ODSVRA breeding male
PV:WG	M	ODSVRA 2008		3/4, 3/27, 6/6, 8/20, 9/10, 9/14, 9/18	
PV:WW	F	ODSVRA 2008		5/10, 5/13, 5/14, 5/16, 5/17, 5/18, 5/19, 5/20, 5/26, 6/1, 6/7, 7/1, 7/4, 7/7, 7/8, 8/22, 9/2, 9/3, 9/6, 9/7, 9/8, 9/11, 9/20, 9/23	ODSVRA breeding female.
PV:YG	F	ODSVRA 2009		3/2, 3/3, 3/31, 5/11, 5/15, 5/20, 5/21, 5/30, 7/3, 7/19, 7/22, 7/30, 8/10, 8/13, 8/17, 8/18, 8/19, 8/22, 8/25, 8/29, 8/31, 9/1, 9/9, 9/14, 9/20, 9/21, 9/22	ODSVRA breeding female.
PV:YY	M	ODSVRA 2009		3/25, 3/28, 3/29, 3/30, 3/31, 4/6, 4/16, 5/7, 5/13, 5/15, 5/21, 5/25, 5/26, 5/27, 6/2, 6/12, 6/22, 6/28, 7/5, 7/8, 7/9, 7/11, 7/15, 7/18	ODSVRA breeding male.
RR:AR	F	ODSVRA 2010		3/9, 3/10, 3/11, 3/13, 3/30, 3/31, 4/1, 4/6, 6/21, 6/22, 6/24	ODSVRA breeding female.
RR:AW	F	ODSVRA 2011		5/5, 6/13, 6/20	ODSVRA breeding female.
RR:BB	M	ODSVRA 2010		6/16, 6/22, 6/28, 7/4, 7/5, 7/10, 7/11, 7/16, 7/28, 8/17, 8/18, 8/21, 8/24, 8/25, 9/3, 9/11, 9/14, 9/18	ODSVRA breeding male.
RR:BW	F	ODSVRA 2010		3/4, 4/20, 4/26, 5/31	ODSVRA breeding female.
RR:GG	M	ODSVRA 2011		3/4, 3/11, 3/19, 3/26, 3/30, 4/12, 4/16, 4/22, 5/15, 5/20, 5/21, 5/22, 5/24, 5/26, 5/27, 5/28, 5/29, 5/31, 6/2, 6/4, 6/5, 6/8, 6/10, 6/16, 6/20, 6/21, 6/24, 7/4, 7/22, 8/15, 8/23, 8/28, 8/30, 8/31, 9/1, 9/2, 9/3, 9/5, 9/9, 9/10, 9/13, 9/22, 9/29	ODSVRA breeding male.
RR:OB	F	ODSVRA 2011		3/26, 3/30, 4/4, 4/25, 6/13, 6/16, 7/23, 8/10, 8/12, 8/15, 8/22, 8/25, 8/27, 9/10, 9/18	
RR:OR	M	ODSVRA 2010		4/17, 4/26, 7/11, 7/16, 8/10, 8/16	ODSVRA breeding male.

Table D.3. Banded snowy plovers with known origins seen at ODSVRA 1 March to 30 September 2012 (continued).

Band	Sex (#)	Origin and Year Banded	County Banded	Dates Seen	Notes
RR:OW-ULT	M	ODSVRA 2003		6/29	ODSVRA breeding male. There were 11 additional sightings recorded as RR:OW between 11 March and 25 August.
RR:OY	F	ODSVRA 2010		3/19, 3/20, 3/21, 3/30, 3/31, 4/4, 4/12, 4/15, 4/19, 4/20, 4/21, 5/16, 6/13, 6/18, 7/7, 7/21, 8/14, 8/27, 8/30, 9/18, 9/19	ODSVRA breeding female.
RR:PB	F (2)	ODSVRA 2007 or 2010		3/14, 3/15, 3/22, 3/27, 3/28, 3/30, 3/31, 4/7, 4/8, 4/12, 4/17, 4/19, 5/7, 5/20, 6/6, 6/13, 6/15, 6/21, 6/23, 6/28, 7/4, 7/5, 7/9, 7/11, 7/12, 7/15, 7/18, 7/21, 7/22, 7/29, 8/13, 8/20, 8/24, 8/29, 8/30, 9/1, 9/2, 9/5, 9/18, 9/21, 9/22	ODSVRA breeding females (2).
RR:PG	M	ODSVRA 2009		3/3, 3/4, 3/11, 3/13, 3/14, 3/15, 3/18, 3/19, 3/31, 4/6, 4/10, 4/12, 4/21, 5/5, 5/6, 5/10, 5/11, 5/21, 6/1, 6/7, 6/29, 7/4, 7/5	ODSVRA breeding male.
RR:PY		ODSVRA 2007 or 2010		7/22, 8/25	
RR:VW	F	ODSVRA 2009 or 2011		3/4, 3/7, 3/23, 3/26, 4/12, 518, 5/19, 9/27, 9/29	ODSVRA breeding female.
RR:WB	M	ODSVRA 2011		5/20, 6/22, 7/4, 7/6, 7/11, 7/16	
RR:WR	F and M	ODSVRA 2011		3/1, 3/3, 3/4, 3/9, 3/10 ,3/13, 3/20, 3/24, 3/25, 3/30, 4/1, 4/12, 4/13, 5/15, 5/19, 5/29, 5/31, 6/13, 7/20, 7/26, 7/30, 8/1, 8/17, 8/21, 8/22, 9/1, 9/9, 9/10 ,9/11, 9/13, 9/16, 9/20,	ODSVRA breeding female and male.
RR:YB	M	ODSVRA 2011		4/3, 4/6, 4/11, 4/13, 4/26	
RR:YR		ODSVRA 2010		3/10, 3/13, 3/17, 3/21, 3/23, 3/30, 3/31, 4/2, 4/4, 4/5, 4/6, 4/7, 8/13, 8/16, 8/18, 8/19, 8/22, 8/24, 8/25, 8/27, 8/28, 8/29, 9/8, 9/10, 9/13, 9/16, 9/20, 9/21	
RR:YY	M	ODSVRA 2010		5/21, 5/24, 6/6, 6/7, 6/9, 6/12, 6/13, 6/20, 6/22, 6/29, 7/4, 7/8, 7/20, 7/21	
VG:AB	M	ODSVRA 2011		3/4, 3/15, 3/26, 3/31, 4/12, 4/26, 6/13, 7/12, 8/10, 8/13, 8/20, 9/18, 9/27	
VG:AR	F	ODSVRA 2011		3/3, 3/11, 3/17, 3/26, 3/27, 3/30 ,3/31, 7/3, 7/4, 7/5, 7/21, 7/22, 8/11, 8/13, 8/17, 8/24, 8/25, 8/27, 8/28, 8/30, 9/1, 9/5, 9/10, 9/11, 9/14, 9/17, 9/18, 9/30	ODSVRA breeding female.
VG:AW	F	ODSVRA 2011		4/12, 4/13, 4/25, 4/26, 5/9, 5/28, 6/27, 8/13	ODSVRA breeding female.
VG:AY		ODSVRA 2011		6/15, 6/28, 6/29, 7/4, 7/11, 8/13, 8/17, 8/22, 8/27, 8/29, 8/31, 9/3, 9/5, 9/8, 9/10, 9/21, 9/28	
VG:BG	M	ODSVRA 2011		3/1, 3/7, 3/15, 3/27, 3/30, 4/16, 4/19, 6/28, 7/11, 8/8, 8/9, 8/17	ODSVRA breeding male.
VG:BR	F	ODSVRA 2003		4/26, 5/9, 7/5, 8/18, 8/19, 8/21, 8/31, 9/29	
VG:GW	F and M	ODSVRA 2011		3/4, 3/10, 3/14, 3/31, 4/2, 4/25, 5/5, 5/11, 5/17, 5/20, 6/2, 6/4, 6/6, 6/10, 6/12, 6/14, 6/15, 6/16, 6/19, 6/21, 6/29, 7/11, 7/13, 8/13, 8/18, 8/28, 8/29, 9/12, 9/18, 9/28, 9/30	ODSVRA breeding female and male.
VG:OG	F	ODSVRA 2011		3/4, 3/30, 6/1, 6/14, 8/24, 8/28, 8/29, 8/31, 9/3, 9/6, 9/9, 9/12, 9/13, 9/21, 9/27	ODSVRA breeding female.
VG:PR	M	ODSVRA 2011		4/1, 4/12, 5/2, 5/7, 6/2, 6/14, 6/21, 7/4, 7/26, 8/9, 8/13, 8/14, 8/15, 8/21, 8/22, 8/25, 8/27, 9/1, 9/10, 9/18	ODSVRA breeding male.

Appendix D. Banded least terns and snowy plovers (continued).

Table D.3. Banded snowy plovers with known origins seen at ODSVRA 1 March to 30 September 2012 (continued).

Band	Sex (#)	Origin and Year Banded	County Banded	Dates Seen	Notes
VG:VR	F	ODSVRA 2009 or 2011		3/4, 3/7, 3/15, 4/9, 4/25, 5/15, 5/20, 5/31, 6/14, 6/15, 6/20, 7/16, 8/10, 8/21, 8/31, 9/2, 9/3, 9/5	ODSVRA breeding female.
VG:VW	F	ODSVRA 2011		3/31, 4/12, 6/1, 6/9	
VG:VY	F and M	ODSVRA 2009		3/10, 3/11, 3/30, 5/9, 6/4	ODSVRA breeding female and male.
VG:YW	M (2)	ODSVRA 2011		3/11, 3/15, 3/19, 3/20, 3/22, 3/23, 3/26, 3/27, 3/29, 4/1, 4/4, 4/5, 4/7, 4/12, 4/16, 4/26, 5/1, 5/2, 5/7, 5/9, 5/11, 5/13, 5/16, 5/17, 5/18, 5/20, 5/25, 5/26, 5/27, 5/28, 5/29, 5/30, 5/31, 6/1, 6/1, 6/2, 6/4, 6/15, 6/16, 6/19, 6/24, 6/28, 7/5, 7/8, 7/22, 7/26, 7/30, 8/10, 8/11, 8/13, 8/15, 8/17, 8/20, 8/25, 8/27, 8/29, 8/30, 9/1, 9/2, 9/3, 9/7, 9/10, 9/11, 9/18, 9/21, 9/22, 9/29	ODSVRA breeding males (2).
VG:YY	M (2)	ODSVRA 2011		3/13, 3/14, 3/20, 3/25, 3/27, 3/30, 3/31, 4/1, 4/3, 4/11, 4/16, 4/17, 4/21, 5/8, 5/19, 5/22, 6/1, 6/7, 6/14, 6/22, 6/24, 7/7, 7/9, 7/21, 7/22, 7/30, 8/9, 812, 8/14, 8/25, 8/29, 9/1, 9/4, 9/5, 9/9, 9/11, 9/12, 9/14, 9/20, 9/21, 9/22	ODSVRA breeding males (2).
VS:BR	F	ODSVRA 2003		5/10, 8/30	
VV:AA	F	ODSVRA 2011		3/2, 3/3, 3/14, 3/26, 3/30, 4/1, 4/8, 4/12, 4/16, 4/20, 5/24, 5/25, 5/30, 5/31, 6/1, 6/2, 6/15, 6/28, 7/5, 7/9, 8/13, 8/22, 8/29, 8/30, 9/2, 9/9, 9/10, 9/14, 9/21	ODSVRA breeding female.
VV:BY	M	ODSVRA 2007		8/27/2012	
VV:GB	M	ODSVRA 2009		4/13, 4/15, 5/17, 6/12, 6/20, 6/29, 7/1, 7/5, 7/22, 9/21	ODSVRA breeding male.
VV:GG	M	ODSVRA 2009		4/7, 4/10, 4/21, 5/20, 5/30, 6/1, 6/6, 6/12, 6/24, 6/29, 7/15, 7/18, 7/21	ODSVRA breeding male.
VV:GW	M	ODSVRA 2009		3/3, 3/25, 3/30, 4/12, 5/7, 5/8, 5/11, 5/22, 5/26, 6/6, 6/9, 6/12, 6/13, 6/18, 6/22, 6/28, 7/3, 8/12, 8/13, 8/18, 8/19, 8/25, 8/27, 8/28, 9/2, 9/3, 9/5, 9/7, 9/10, 9/11, 9/12, 9/13, 9/17, 9/21	
VV:OO	M	ODSVRA 2009 or 2010		3/24, 3/30, 3/31, 4/12, 4/21, 5/7, 5/8, 5/9, 5/13, 6/7, 6/24, 7/5	
VV:OY	M	ODSVRA 2007		3/11, 3/15, 3/27, 4/9, 4/13, 4/26	
VV:RB	F	ODSVRA 2009		3/3, 3/4, 3/12, 3/13, 3/14, 3/15, 3/19, 3/31, 5/11, 5/19, 6/13, 6/19, 6/24, 8/15, 8/18, 8/20, 8/28, 9/2, 9/3, 9/4, 9/8, 9/10	ODSVRA breeding female.
VV:VB	M	ODSVRA 2011		3/4, 3/31, 4/13, 4/26, 6/13	
VV:VG	F	ODSVRA 2009 or 2011		3/4, 3/11, 3/22, 3/28, 4/8, 4/23, 5/20, 5/31, 8/10, 9/11, 9/29	ODSVRA breeding female.
VV:VR	M	ODSVRA 2008		3/31, 4/12, 6/2, 6/21, 6/22	ODSVRA breeding male.
VV:VW	F	ODSVRA 2008 or 2011		3/2, 3/14, 3/16, 3/17, 3/18, 4/1, 4/25, 5/7, 6/6, 6/20, 6/29, 7/7, 7/18, 8/12, 8/14, 8/17, 8/19, 9/3, 9/9, 9/10, 9/20, 9/22, 9/23, 9/27	ODSVRA breeding female.
VV:VY	F	ODSVRA 2011		3/4, 3/7, 3/10, 3/30, 4/12, 6/4, 6/22, 6/29, 8/12, 9/2, 9/3, 9/18, 9/28	
VV:YW	F	ODSVRA 2011		4/11, 4/19, 4/21, 4/25, 5/25, 7/4	ODSVRA breeding female.

Appendix D. Banded least terns and snowy plovers (continued).

Table D.3. Banded snowy plovers with known origins seen at ODSVRA 1 March to 30 September 2012 (continued).

Band	Sex (#)	Origin and Year Banded	County Banded	Dates Seen	Notes
VV:YY	M	ODSVRA 2011		3/4, 3/10, 4/25, 4/30, 5/13, 5/28, 6/2, 6/22, 7/5, 7/6, 7/21, 7/22, 8/10, 8/17, 8/20, 8/21, 9/11, 9/18	ODSVRA breeding male.
WS:WB	M	Guadalupe NWR 2002		6/20, 6/23, 7/4, 7/5, 7/6, 7/16, 8/12	ODSVRA breeding male.
Y:GO	M	VAFB unknown year	Santa Barbara	4/2, 4/4, 4/7, 4/8, 4/16, 4/17, 4/18, 5/15, 5/20, 5/22, 5/24, 5/31, 7/1	
B:G/Y	M	VAFB 2002	Santa Barbara	8/1, 8/10, 8/15	ODSVRA breeding male.
B:GW		VAFB 2009	Santa Barbara	3/1, 3/18, 9/3	
NB:BY	M	VAFB 2011	Santa Barbara	5/9, 7/4	ODSVRA breeding male. There was one additional sighting as RB:BY on 10 August
NB:OW	F	VAFB 2011	Santa Barbara	6/12, 7/16, 7/30, 8/10, 8/13, 8/27, 9/10	ODSVRA breeding female. There was one additional sighting as RB:OW on 25 August.
NB:PG	F	VAFB 2011	Santa Barbara	9/10	ODSVRA breeding female. There were 14 additional sightings as RB:PG between 16 July and 14 September.
NB:PR		VAFB 2011	Santa Barbara	3/16, 3/31, 4/5, 4/13	
NB:RW		VAFB 2011	Santa Barbara	6/1, 7/4	Both sightings recorded as RB:RW.
NW:AB	J	VAFB 2012	Santa Barbara	8/27/2012	
NY:OR	J	VAFB 2012	Santa Barbara	8/27/2012	
NY:RB	F	VAFB 2008	Santa Barbara	3/4, 3/15, 3/19, 3/26, 3/30, 4/17, 4/26, 8/13, 8/17, 8/19, 8/22, 9/21, 9/22	ODSVRA breeding female.
NY:RW		VAFB 2008	Santa Barbara	9/10, 9/20, 9/21, 9/22	

Table D.4. Snowy plovers banded as chicks at ODSVRA seen at other sites from 1 October 2011 to 29 February 2012.
This is a partial list based on information received from PRBO Conservation Science (pers. comm. F. Bidstrup), Morro Bay State Park (pers. comm. R. Orr), and Channel Coast District of State Parks (pers. comm. A. Frangis) and from sightings by staff at ODSVRA at nearby sites.
Notes: for multiple dates seen in 2012, the first date will have the year and all days following will be of the same year; ODSVRA is banding chicks to brood and some bands have been used multiple years so it is possible to have more than one bird with the same combination.
SB = State Beach, SP = State Park, NWR = National Wildlife Refuge, VAFB=Vandenberg Air Force Base

Band Combination	Year Banded	Location Seen	County	Dates Seen
VG:OG	2011	Arroyo de la Cruz	San Luis Obispo	2/5
BB:YB	2011	San Simeon Beach SP	San Luis Obispo	12/8, 2/5
VG:YB	2011	San Simeon Beach SP	San Luis Obispo	2/5
GA:OB	2010	Villa Creek, Estero Bluffs SP	San Luis Obispo	12/21, 12/27, 1/17
P:AG	2008	Villa Creek, Estero Bluffs SP	San Luis Obispo	12/21, 12/27, 1/15/12, 1/17, 2/21
B:PR	2010	Morro Bay Sandspit	San Luis Obispo	12/28, 2/21
BB:OB	2010	Morro Bay Sandspit	San Luis Obispo	12/28
BB:YG	2011	Morro Bay Sandspit	San Luis Obispo	12/28, 2/21
GA:VR	2009	Morro Bay Sandspit	San Luis Obispo	12/28
PV:PW	2008	Morro Bay Sandspit	San Luis Obispo	12/28
RR:BB	2010	Morro Bay Sandspit	San Luis Obispo	12/21, 12/28
RR:WW	2010	Morro Bay Sandspit	San Luis Obispo	12/21, 2/21
RR:YB	2011	Morro Bay Sandspit	San Luis Obispo	12/28
VG:PR	2011	Morro Bay Sandspit	San Luis Obispo	12/28, 2/21
VG:VR	2009 or 2011	Morro Bay Sandspit	San Luis Obispo	2/21
VG:VW	2011	Morro Bay Sandspit	San Luis Obispo	12/28
B:PR	2010	Morro Strand SB	San Luis Obispo	12/25
BB:OB	2010	Morro Strand SB	San Luis Obispo	12/21, 12/25
RR:YB	2011	Morro Strand SB	San Luis Obispo	12/21, 12/25, 1/13
R:YB	2011	Morro Strand SB	San Luis Obispo	12/8
PV:PW	2008	Morro Strand SB	San Luis Obispo	12/21, 12/25, 1/5
VG:VR	2009 or 2011	Morro Strand SB	San Luis Obispo	12/21, 12/25
VG:VW	2011	Morro Strand SB	San Luis Obispo	12/21, 12/25, 1/13
VG:YW	2011	Morro Strand SB	San Luis Obispo	12/21, 12/25, 1/11
BB:YY	2002 or 2010	Guadalupe-Nipomo Dunes NWR	San Luis Obispo	2/4
GA:AR	2011	Guadalupe-Nipomo Dunes NWR	San Luis Obispo	2/4
GA:BB	2010	Guadalupe-Nipomo Dunes NWR	San Luis Obispo	2/4
GA:RB	2004 or 2010	Guadalupe-Nipomo Dunes NWR	San Luis Obispo	2/4
PV:AG	2008	Guadalupe-Nipomo Dunes NWR	San Luis Obispo	2/4

Appendix D. Banded least terns and snowy plovers (continued).

Table D.4. Snowy plovers banded as chicks at ODSVRA seen at other sites from 1 October 2011 to 29 February 2012 (continued).

Band Combination	Year Banded	Location Seen	County	Dates Seen
RR:GG	2011	Guadalupe-Nipomo Dunes NWR	San Luis Obispo	2/4
RR:PB	2007 or 2010	Guadalupe-Nipomo Dunes NWR	San Luis Obispo	2/4
RR:VY	2008	Guadalupe-Nipomo Dunes NWR	San Luis Obispo	2/4
RR:WR	2010	Guadalupe-Nipomo Dunes NWR	San Luis Obispo	2/4
VG:GW	2011	Guadalupe-Nipomo Dunes NWR	San Luis Obispo	2/4
VG:VB	2008 or 2011	Guadalupe-Nipomo Dunes NWR	San Luis Obispo	2/4
VG:YW	2011	Guadalupe-Nipomo Dunes NWR	San Luis Obispo	2/4
VV:BY	2007	Guadalupe-Nipomo Dunes NWR	San Luis Obispo	2/4
BB:RY	2010	Chevron Property	San Luis Obispo	1/15
GG:YG	2011	Chevron Property	San Luis Obispo	1/15
PV:VG	2008	Chevron Property	San Luis Obispo	1/15
PV:YG	2009	Chevron Property	San Luis Obispo	1/15
VG:PR	2011	Chevron Property	San Luis Obispo	1/15
BB:BR	2010	Rancho Guadalupe Dunes County Park	Santa Barbara	1/15
BB:OR	2010	Rancho Guadalupe Dunes County Park	Santa Barbara	1/15
BB:VG	2008 or 2011	Rancho Guadalupe Dunes County Park	Santa Barbara	1/15
BB:VR	2011	Rancho Guadalupe Dunes County Park	Santa Barbara	1/15
BB:WG	2007 or 2010	Rancho Guadalupe Dunes County Park	Santa Barbara	1/15
BB:WY	2007 or 2010	Rancho Guadalupe Dunes County Park	Santa Barbara	1/15
GA:RB	2004 or 2010	Rancho Guadalupe Dunes County Park	Santa Barbara	1/15
GA:VB	2008 or 2011	Rancho Guadalupe Dunes County Park	Santa Barbara	1/15
GA:VV		Rancho Guadalupe Dunes County Park	Santa Barbara	1/15
PG:VW	2011	Rancho Guadalupe Dunes County Park	Santa Barbara	1/15
RR:PY	2007 or 2010	Rancho Guadalupe Dunes County Park	Santa Barbara	1/15
VG:RB	2011	Rancho Guadalupe Dunes County Park	Santa Barbara	1/15
VV:BY	2007	Rancho Guadalupe Dunes County Park	Santa Barbara	1/15
VV:GG	2009	Rancho Guadalupe Dunes County Park	Santa Barbara	1/15
RR:LY	2010	VAFB	Santa Barbara	2/10
RR:WW	2010	VAFB	Santa Barbara	1/30
VG:VR	2009 or 2011	VAFB	Santa Barbara	2/10
VV:OA	2011	VAFB	Santa Barbara	1/30
VV:YW	2011	VAFB	Santa Barbara	2/10

Table D.4. Snowy plovers banded as chicks at ODSVRA seen at other sites from 1 October 2011 to 29 February 2012 (continued).

Band Combination	Year Banded	Location Seen	County	Dates Seen
BB:AW	2010	Jalama Beach	Santa Barbara	11/13, 2/3
GA:PB	2011	Jalama Beach	Santa Barbara	11/13
PV:OG	2011	Jalama Beach	Santa Barbara	2/3
RR:PB	2007 or 2010	Jalama Beach	Santa Barbara	11/13, 2/3
VV:YW	2011	Jalama Beach	Santa Barbara	11/13, 2/3
VG:AW	2011	San Buenaventura Beach	Ventura	11/17, 12/19
PV:OG	2011	McGrath SB	Ventura	11/17
VG:AW	2011	McGrath SB	Ventura	10/4
VV:OO	2010	McGrath SB	Ventura	11/17, 12/19
BB:BG	2011	Mandalay SB	Ventura	10/4, 12/19
RR:AW	2011	Mandalay SB	Ventura	10/4, 12/19
RR:OR	2010	Hollywood Beach	Ventura	10/1
RR:AR	2010	Mugu Lagoon Beach	Ventura	11/14
RR:GG	2011	Cabrillo SB	Los Angeles	10/24
GG:AR	2011	Malibu Lagoon SB	Los Angeles	11/11, 12/6, 12/25
GG:BY	2007	Naval Air Station and North Island Peninsula	San Diego	10/19, 11/23, 11/28
GA:VB	2008 or 2011	Silver Strand SB	San Diego	12/11
GG:YY	2011	Tijuana River Beach	San Diego	11/14

Table D.5. Snowy plovers banded as chicks at ODSVRA seen at other sites from 1 March to 30 September 2012.
This is a partial list based on information received from PRBO Conservation Science (pers. comm. F. Bidstrup), Morro Bay State Park (pers. comm. R. Orr), Chevron property in Guadalupe-Nipomo Dune Complex (pers. comm. K. Paradis), Guadalupe-Nipomo Dunes National Wildlife Refuge (pers. comm. G. Greenwald; pers. comm. T. Applegate), Channel Coast District of State Parks (pers. comm. A. Frangis) and from sightings by staff of ODSVRA at nearby sites.
Note: ODSVRA is banding chicks to brood so it is possible to have more than one bird with the same combination.
Guadalupe NWR = Guadalupe-Nipomo Dunes National Wildlife Refuge, SB = State Beach, SP = State Park;
J = juvenile, M = male, F = female.

Band Combination	Year Banded	Sex or Age	Location Seen	County	Dates Seen
GG:AR	2011	M	Gazos Creek Beach	San Mateo	4/24, 5/22
BB:GR	2012	J	Villa Creek, Estero Bluffs SP	San Luis Obispo	8/2, 8/4
GA:OB	2010	F	Villa Creek, Estero Bluffs SP	San Luis Obispo	8/7, 8/8, 8/9, 9/19
GG:AR	2011		Villa Creek, Estero Bluffs SP	San Luis Obispo	4/5
GG:YR	2012		Villa Creek, Estero Bluffs SP	San Luis Obispo	7/13
P:AG	2008	F	Villa Creek, Estero Bluffs SP	San Luis Obispo	3/6, 3/8, 3/14, 3/15, 3/16, 3/23, 3/29, 3/30, 4/4, 4/5, 4/6, 4/9, 4/13, 4/17, 4/19, 4/20, 4/23, 4/24, 4/27, 5/2, 5/3, 5/8, 5/9, 5/15, 5/17, 5/18, 5/22, 5/23, 5/24, 5/25, 5/28, 5/29, 5/31, 6/5, 6/6, 6/7, 6/8, 6/9, 6/12, 6/14, 6/15, 6/16, 6/19, 6/21, 6/26, 6/30, 7/10, 7/16, 7/19, 7/28, 7/31, 8/1, 8/2, 8/3, 8/4, 8/6, 8/7, 8/9, 8/10, 8/13, 8/15, 8/16, 8/18, 8/20, 8/24, 8/25, 8/27, 8/29, 8/31, 9/3, 9/5, 9/12, 9/14, 9/19, 9/21
PG:B?		M	Villa Creek, Estero Bluffs SP	San Luis Obispo	3/26
B:PR	2010	F	Morro Bay Sandspit	San Luis Obispo	8/6, 8/13, 8/18, 8/31, 9/12, 9/21
BB:GR	2012	J	Morro Bay Sandspit	San Luis Obispo	8/9, 8/14
BB:YG	2011		Morro Bay Sandspit	San Luis Obispo	9/12
GA:OB	2010	M	Morro Bay Sandspit	San Luis Obispo	8/14, 8/16, 8/21, 8/24, 8/29, 9/3, 9/12, 9/14
GA:VR	2009	F	Morro Bay Sandspit	San Luis Obispo	3/6, 3/7, 3/9, 3/14, 3/16, 3/19, 3/20, 3/23, 3/27, 3/29, 4/4, 4/11, 4/12, 4/17, 4/18, 4/19, 4/30, 5/24, 5/30, 6/6, 6/14, 6/15, 6/19, 6/25, 6/26, 6/28, 7/4, 7/12, 7/17, 8/1, 8/2, 8/8, 8/14, 8/15, 8/16, 8/18, 8/21, 8/24, 8/27, 8/29, 8/31, 9/14, 9/21
GG:BW	2012	J	Morro Bay Sandspit	San Luis Obispo	8/1, 8/18, 8/31
GG:YR	2012	J	Morro Bay Sandspit	San Luis Obispo	7/10
PG:AB	2012	J	Morro Bay Sandspit	San Luis Obispo	9/12
PV:PW	2008	M	Morro Bay Sandspit	San Luis Obispo	5/3, 5/7, 5/8, 5/24, 9/14
RR:AW	2011	M	Morro Bay Sandspit	San Luis Obispo	5/3, 5/21, 5/22, 6/8
RR:BB	2010		Morro Bay Sandspit	San Luis Obispo	8/8
RR:BW	2010		Morro Bay Sandspit	San Luis Obispo	5/3, 5/8, 5/10, 5/16
RR:VB	2008 or 2010		Morro Bay Sandspit	San Luis Obispo	8/6, 8/18, 8/12, 8/29, 8/31, 9/3
RR:WG	2012	J	Morro Bay Sandspit	San Luis Obispo	9/14

Appendix D. Banded least terns and snowy plovers (continued).

Table D.5. Snowy plovers banded as chicks at ODSVRA seen at other sites from 1 March to 30 September 2012 (continued).

Band Combination	Year Banded	Sex or Age	Location Seen	County	Dates Seen
RR:WW	2010	M	Morro Bay Sandspit	San Luis Obispo	3/8, 3/15, 3/23, 3/26, 3/29, 3/30, 4/16, 4/18, 4/19, 5/4, 5/7, 5/10, 5/18, 5/21, 5/24, 5/31, 6/1, 6/14, 6/15, 6/18, 6/19, 6/22, 6/27, 6/28, 6/29, 7/2, 7/3, 7/4, 7/5, 7/6, 7/9, 7/10, 7/11, 7/12, 7/13, 7/16, 7/17, 7/19, 7/20, 8/1, 8/4, 8/6, 8/8, 8/9, 8/10, 8/13, 8/14, 8/15, 8/16, 8/17, 8/18, 8/20, 8/21, 8/29, 9/3, 9/12, 9/18, 9/21
RR:YB	2011		Morro Bay Sandspit	San Luis Obispo	3/9
VG:PR	2011	F	Morro Bay Sandspit	San Luis Obispo	3/8, 3/12, 3/15, 3/16, 3/19, 3/26
VG:VR	2009 or 2011	F	Morro Bay Sandspit	San Luis Obispo	3/6, 3/7, 3/8, 3/12, 3/15, 9/12, 9/18, 9/21
VG:VW	2011	F	Morro Bay Sandspit	San Luis Obispo	3/7, 3/12, 3/14, 3/19, 4/4, 4/5, 4/10, 4/11, 4/12, 4/17, 4/18, 5/10
VV:GR	2007 or 2012		Morro Bay Sandspit	San Luis Obispo	8/2
B:PR	2010	F	Morro Strand SB	San Luis Obispo	3/6, 3/7
GA:OB	2010	F	Morro Strand SB	San Luis Obispo	3/9, 3/15
PV:PW	2008	M	Morro Strand SB	San Luis Obispo	3/8, 3/9, 3/19, 3/30, 4/6, 4/17, 6/1, 6/6, 6/8, 6/14, 6/16, 6/19, 6/20, 6/22, 6/26, 6/27, 6/28, 7/6, 8/5, 8/6, 8/7, 8/9, 8/10, 8/15, 8/27
RR:YB	2011	F	Morro Strand SB	San Luis Obispo	3/6, 3/19, 3/20
VG:VR	2009 or 2011	M	Morro Strand SB	San Luis Obispo	3/20, 4/5, 4/17
GG:BY	2007		Chevron	San Luis Obispo	8/15
PG:OB	2012		Chevron	San Luis Obispo	8/22
PV:YB	2007 or 2012		Chevron	San Luis Obispo	8/22
RR:WG	2012		Chevron	San Luis Obispo	8/22
VG:AB	2011		Chevron	San Luis Obispo	8/22
VG:PW	2012		Chevron	San Luis Obispo	8/20
VV:BY	2007		Chevron	San Luis Obispo	7/13
BB:RB	2007 or 2010	M	Rancho Guadalupe Dunes County Park	Santa Barbara	5/29
GA:VB	2008 or 2011	M	Rancho Guadalupe Dunes County Park	Santa Barbara	5/29
VG:WB		M	Rancho Guadalupe Dunes County Park	Santa Barbara	5/29
VV:OO	2009 or 2010		McGrath SB	Ventura	7/30, 8/2
VV:YB	2012		McGrath SB	Ventura	8/2
BB:BG	2011		Mandalay SB	Ventura	4/10, 5/4
GG:YY	2011	F	Mandalay SB	Ventura	4/10
RR:AW	2011	F	Mandalay SB	Ventura	4/10, 5/4
GG:RG	2012		Hollywood Beach	Ventura	8/17
RR:AW	2011		Hollywood Beach	Ventura	8/17
RR:GG	2011	M	Hollywood Beach	Ventura	8/3
VV:GG	2009	M	Hollywood Beach	Ventura	4/8

Appendix D. Banded least terns and snowy plovers (continued).

Table D.5. Snowy plovers banded as chicks at ODSVRA seen at other sites from 1 March to 30 September 2012 (continued).

Band Combination	Year Banded	Sex or Age	Location Seen	County	Dates Seen
BB:RB	2007 or 2010		Point Mugu	Ventura	7/12, 7/30
RR:AR	2010		Point Mugu	Ventura	7/16, 7/23, 7/30
PV:YB	2007 or 2012		Malibu Lagoon SB	Los Angeles	9/27
RR:RB	2012		Bolsa Chica Ecological Preserve	Orange	8/8
RR:YY	2010		Silver Strand SB	San Diego	4/6
GG:YY	2011		Salt Works	San Diego	7/24
GG:YY	2011	F	Tijuana River Mouth	San Diego	4/19, 5/11, 6/14

Appendix E. Addendums to snowy plover nesting success.

Table E.1. Nesting success of snowy plovers at ODSVRA from 2001-12.

For calculation of percent nests hatching, nests with unknown fate or detected only by the presence of brood are excluded. Nests from unknown locations were detected as broods inside the seasonally protected habitat in Southern Exclosure or Oso Flaco. Between 1998-2003, the amount of riding area seasonally closed increased; size has been relatively stable since 2004. In 2003 and 2005, East Boneyard (part of the seasonally closed riding area) was included in the Riding Area category. Beginning in 2006, an additional 0.4 mile of shoreline at the southern end of park has been monitored by ODSVRA (a survey conducted by the Guadalupe-Nipomo Dunes NWR in 2005 determined this area was part of ODSVRA and not the NWR, as was previously thought). In 2012, insufficient information existed to assign seven broods to specific known nests. Unassigned broods are not included in nest, egg, hatching, or chick totals and percentages. Fledglings from unassigned broods are included in totals and percentages, as they likely represent known existing nests. For corrections made to data presented in previous reports, see Appendix H in the 2009 report (CDPR 2009).

Year	Area	No. nests	No. nests with known fate and known location	No. nests hatching	% nests hatching	No. chicks	No. banded or known fate chicks	No. chicks fledged	% known fledged
	Arroyo Grande Creek	3	3	3	100	9	9	0	0
	Riding Area	26	25	22	88	65-68	54	1	2
	Oso Flaco	4	2	2	100	6	6	1	17
2001	Total	33	30	27	90	71-74	69	2	3
	Riding Area	33	33	25	76	62	62	35	56
	Oso Flaco	2	2	0	0	0	-	-	-
2002	Total	35	35	25	71	62	62	35	56
	Dune Preserve	1	1	1	100	3	3	0	0
	Riding Area	77	76	55	72	139	138	97	70
	Oso Flaco	13	13	5	38	11	11	7	64
	Pipeline Revegetation	3	3	2	67	4	4	2	50
	Unknown location	1		1	-	2	2	2	100
2003	Total	95	93	63	67	162	159	108	67
	Riding Area	114	112	87	78	208	208	59	29
	Oso Flaco	27	27	17	63	40	39	7	18
	Pipeline Revegetation	1	1	1	100	3	3	0	0
	Unknown location	5	-	5	-	12	12	0	0
2004	Total	147	140	110	75	263	263	66	25
	Riding Area	81	81	62	77	148	148	59	40
	Oso Flaco	22	22	18	82	49	49	23	47
	Unknown location	4	-	4	-	7	7	0	0
2005	Total	107	103	84	78	204	204	82	40
	Riding Area	88	85	65	76	173	173	8	5
	Oso Flaco	29	29	22	76	57	57	9	16
2006	Total	117	114	87	76	230	230	17	7
	Riding Area	76	76	61	80	159	157	58	37
	Oso Flaco	15	15	9	60	20	20	4	20
	Unknown location	8	-	8	-	21	21	4	19
2007	Total	99	91	78	77	200	198	66	33
	Riding Area	100	100	73	73	172	172	64	37
	Oso Flaco	19	19	8	42	15	19	5	26
	Unknown location	2	-	2	-	8	6	3	50
2008	Total	121	119	83	68	197	197	72	37
	Pismo Lagoon	1	1	0	0	0	-	-	-
	Riding Area	125	124	86	69	221	221	79	36
	Oso Flaco	23	22	8	36	22	22	2	9
	Unknown location	1	-	1	-	2	2	0	0
2009	Total	150	147	95	64	245	245	81	33
	Carpenter Creek	1	1	0	0	0	0	0	-
	Arroyo Grande Creek	3	3	0	0	0	0	0	-
	Riding Area	127	124	96	77	236	236	88	37
	Oso Flaco	22	22	13	59	33	33	15	45
	Unknown location	2	-	2	-	6	6	4	67
2010	Total	155	150	111	73	275	275	107	39
	Riding Area	142	137	115	84	305	305	130	43
	Oso Flaco	23	23	16	70	40	40	18	45
	Unknown location	7	-	7	-	20	20	4	20
2011	Total	172	160	138	82	364	365	152	42
	Riding Area	197	189	143	76	353	353	85	24
	Oso Flaco	14	14	9	64	21	21	4	19
	Unknown location	5	-	5	-	12	12	2	17
	Unassigned broods	7	-	7	-	19	19	5	26
2012	Total	216	203	157	75	386	386	96	25

Appendix E. Addendums to snowy plover nesting success (continued).

Table E.2. Nest protection used at ODSVRA in 2012.

Nest protection used at ODSVRA in 2012. Nests with unknown location and unknown fate nests are excluded. Mini, circular and 10 foot by 10 foot exclosures (10x10) outside of the large seasonal exclosure (shoreline of 6, 7, 8 exclosures, North Oso Flaco and South Oso Flaco) were used in conjunction with symbolic fence. One mini-exclosure in 7 exclosure also received a bumpout. un=unknown predator, av=unknown avian predator, cor=corvid, no=northern harrier, pf=peregrine falcon, coy=coyote, pre=abandoned pre-term, pos=abandoned post-term, ukp=abandoned unknown if pre- or post-term, win=abandoned, suspected wind, fld=flooded, unk=failed, cause unknown.

	Large seasonal exclosure					Symbolic fencing				
Area	No additional fencing	Bumpout	10x10	Circular	Mini	No additional fencing	10x10	Circular	Mini	Single nest exclosure
6 exclosure	70	3	0	0	3	6	0	1	9	
Nests hatched	61 (88%)	2 (67%)			3 (100%)	5 (84%)			7 (78%)	
Nests depredated	5 (1 un, 2 av, 1 no, 1 pf, 1 coy)									
Nests failed other causes	4 (2 pre, 1 ukp, 1 win)	1 (1 win)				1 (1 ukp)		1 (1 fld)	2 (1 pos, 1 ukp)	
7 exclosure	41	0	0	0	2	1	0	1	10	
Nests hatched	27 (66%)				2 (100%)	1 (100%)		1 (100%)	10 (100%)	
Nests depredated	8 (1 un, 2 av, 1 cor, 4 no)									
Nests failed other causes	6 (2 pre, 2 win, 2 unk)									
8 exclosure	7	1	0	0	16	0	0	1	5	
Nests hatched	2 (29%)	1 (100%)			14 (88%)			1 (100%)	3 (60%)	
Nests depredated	3 (1 un, 1 av, 1 cor)									
Nests failed other causes	2 (1 pre, 1 unk)				2 (2 pre)				2 (2 pre)	
Boneyard	3	0	3	2	1	0	0	0	0	
Nests hatched			2 (67%)		1 (100%)					
Nests depredated	2 (1 cor, 1 coy)									
Nests failed other causes	1 (1 win)		1 (1 pre)	2 (1 pre, 1 win)						
SOUTHERN EXCLOSURE TOTALS	121	4	3	2	22	7	0	3	24	
Nests hatched	90 (75%)	3 (75%)	2 (67%)		20 (91%)	6 (86%)		2 (67%)	20 (84%)	
Nests depredated	18 (3 un, 5 av, 3 cor, 5 no, 1 pf, 1 coy)									
Nests failed other causes	13 (5 pre, 1 ukp, 4 win, 3 unk)	1 (1 win)	1 (1 pre)	2 (1 pre, 1 win)	2 (2 pre)	1 (1 ukp)		1 (1 fld)	4 (2 pre, 1 pos, 1 ukp)	
North Oso Flaco	0	0	0	0	2	0	0	0	3	
Nests hatched					2 (100%)				3 (100%)	
Nests depredated										
Nests failed other causes										
South Oso Flaco										
Nests hatched										
Nests depredated										
Nests failed other causes										
OSO FLACO TOTALS	0	0	0	0	2	0	6	3	3	
Nests hatched					2 (100%)		3 (50%)	1 (34%)	3 (100%)	
Nests depredated										
Nests failed other causes							3 (3 pre)	2 (1 pos, 1 win)		
Open riding area										3
Nests hatched										
Nests depredated										1 (1 av)
Nests failed other causes										2 (2 pre)
GRAND TOTAL	121	4	3	2	24	7	6	6	27	3
Nests hatched	90 (75%)	3 (75%)	2 (67%)		22 (92%)	6 (86%)	3 (50%)	3 (50%)	23 (86%)	
Nests depredated	18 (3 un, 5 av, 3 cor, 5 no, 1 pf, 1 coy)									1 (1 av)
Nests failed other causes	13 (5 pre, 1 ukp, 4 win, 3 unk)	1 (1 win)	1 (1 pre)	2 (1 pre, 1 win)	2 (2 pre)	1 (1 ukp)	3 (3 pre)	3 (1 pos, 1 win, 1 fld)	4 (2 pre, 1 pos, 1 ukp)	2 (2 pre)

Appendix F. Habitat enhancement actions in 6, 7, and 8 exclosures at ODSVRA and subsequent substrate use by nesting least terns and snowy plovers and their success.

Wrack

From 29 February to 25 September 2012, approximately 285 cubic yards of wrack were distributed on the exclosure shoreline throughout the season as habitat enhancement. In the winter prior to, and at the beginning of, the 2012 nesting season, wrack was collected from the riding area and distributed in a few large piles in areas east of the shoreline fence to create temporary hummocks within the exclosure.

In 2012, a total of approximately 34,400 wrack-associated invertebrates collected from north of Grand Avenue were inoculated into wrack over a wide area as was done in previous years. The inoculations took place from late March to early May. Late season September 2012 observations indicated the invertebrates were present under fresh wrack throughout the exclosure, similar to last year.

Least tern chick shelters

There were 223 tern chick shelters placed in the 6 and 7 exclosures in 2012 to provide chicks and juveniles with cover from predators and the elements (sun, wind, wind-blown sand).

Plants and seed

Experimental seed plots and planting areas (seeds and plants were not intermixed) were established in the closed exclosure at the start of the 2012 breeding season in an effort to provide areas of scattered vegetation for cover, and to encourage the development of small hummocks that can benefit plovers and terns during the breeding season. The focus of the experiment was within 6 and 7 exclosures because these areas have the least amount of vegetative cover during the nesting season compared to other areas of the seasonal exclosure. A total of 255 pounds of unprocessed seed from native dune species was distributed and raked into the plots prior to expected rains. Seed included 115 pounds of sea rocket (*Cakile maritima*), 65 pounds of beach bur (*Ambrosia chamissonis*) and sand verbena (*Abronia maritima*) mixture, 50 pounds of beach bur, 20 pounds of sand verbena, and five pounds of beach saltbush (*Atriplex leucophylla*). The plots were generally square to rectangular shaped, 4,000 to 18,000 square feet in size, and were completely bare of plants at the time of seeding. Seventeen total seed plots were installed from January to March 2012. Of those, eleven were on the shoreline (west of the west fence) (eight in 6 exclosure and three in 7 exclosure) and six were east of the west fence (three in each 6 and 7 exclosures) (Figure F.1). The seed plots were evaluated in September 2012 and, overall, 11 plots had good vegetative growth, with approximately five to 10% vegetative cover, and were considered successful. The shoreline had nine plots with good plant growth, while only two plots had good plant growth east of the west fence. All the eight plots with wrack present had good plant growth, including two plots east of the west fence. Although putting seed out prior to the exclosure closing on 1 March helped to increase the amount of seed that could be distributed, the March seed plots generally had greater success; six of the seven March plots had good plant growth compared to five of 10 of the January and February plots. Plants from all of the species of seed distributed were observed at the end of the season, except beach saltbush plants; however, only a small amount of this seed was distributed in three of the plots. Six rectangular shaped control plots of approximately 560 square feet were not seeded or planted. Three plots

Appendix F. Habitat enhancement actions in 6, 7, and 8 exclosures at ODSVRA (continued).

(one on shoreline and two east of the west fence) were located in each of 6 and 7 exclosures. All of the control plots either had no plants at the end of the season or small seedlings providing less than one percent cover (Figure F.2).

Approximately 600 potted container plants were installed in three large experimental areas and were separate from the seeding plots. The planting areas were located on the mid-6 exclosure shoreline, east of the west fence within 6 exclosure, and east of the west fence within 7 exclosure (Figure G.1). Plants were dispersed in clusters within the approximately 1,000 to 1,500 square foot planting areas. The planting areas were bare of plants, except the two areas east of the west fence had a few scattered sea rocket plants growing. The shoreline planting area received 24 beach saltbush plants, 11 beach bur plants, and 200 sea rocket plants. Fresh wrack was piled at the west side of planting areas as part of the experiment. The 6 exclosure area received 116 beach evening primrose (*Camissonia cheiranthifolia*) plants and 83 dune mint (*Monardella crispa*) plants, with plants placed on the east side of wood logs or wrack. The 7 exclosure planting area received 114 beach evening primrose, 47 dune mint, and six beach bur plants, with plants placed east of wood logs or sea rocket plants already present in the planting area. The majority of the plant pots were small (2.25 inches square and five inches deep) and the plants were in the seedling stage (less than three inch tall). The beach bur and beach saltbush plants were slightly larger and in five inch square pots. Plants were installed prior to a rain event in mid-March. Within a week, most of the larger sized beach bur and saltbush plants were alive and had grown in size, but the smaller sized sea rocket, dune mint, and beach evening primrose were dry and did not survive. By the end of the season, a large number of the beach saltbush and beach bur planted on the shoreline had formed large hummocks of approximately one foot in height and plants were from two to four foot wide (Figure F.3). The beach bur planted within the 7 exclosure were also large and had formed hummocks. Only a few beach evening primrose planted within the exclosure survived but were still small in size with very little root system development and no dune mint survived.

Appendix F. Habitat enhancement actions in 6, 7, and 8 exclosures at ODSVRA (continued).

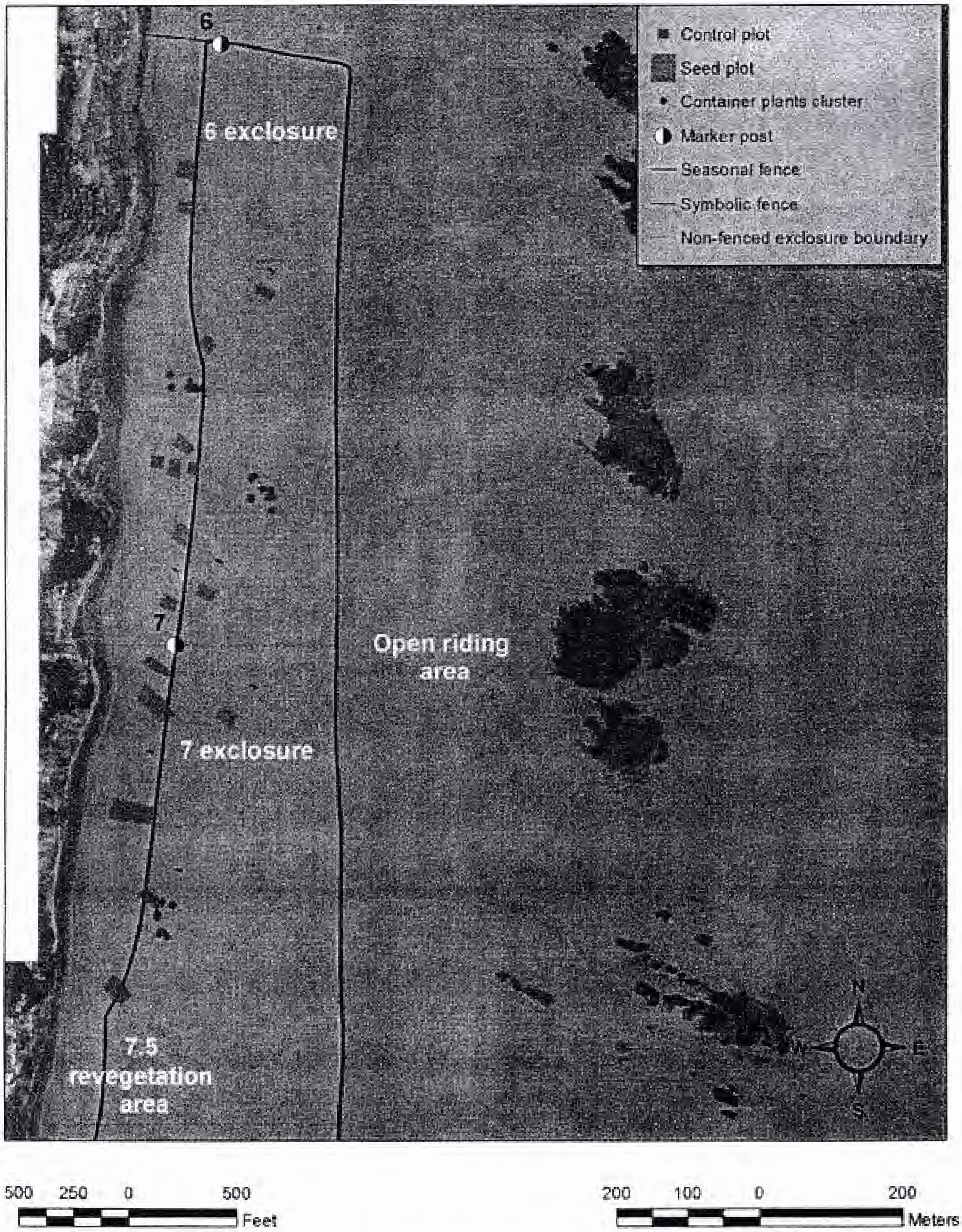


Figure F.1. Map of seeding and planting locations for 2012.

Appendix F. Habitat enhancement actions in 6, 7, and 8 exclosures at ODSVRA (continued).

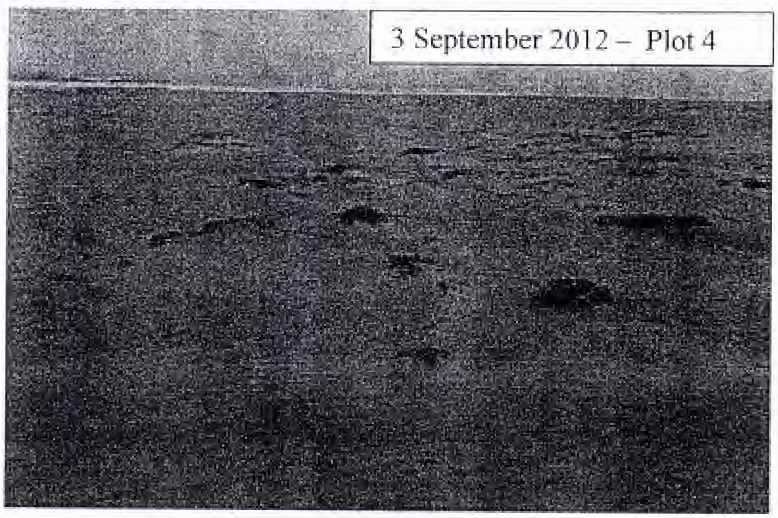
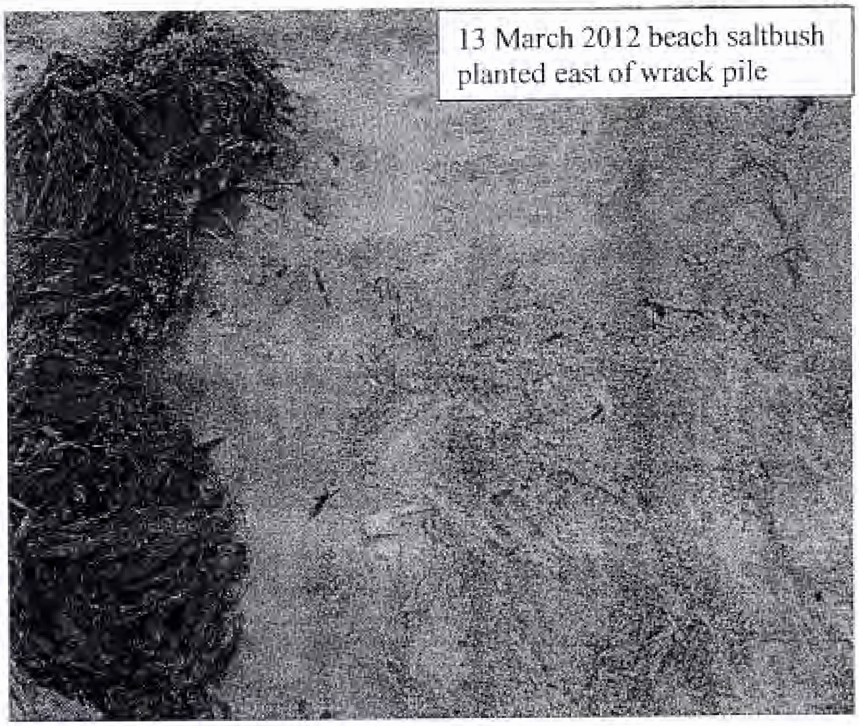


Figure F.2. Photos taken at the beginning and at the end of the 2012 breeding season of an experimental seed plot located on the shoreline of southern 6 exclosure.

Appendix F. Habitat enhancement actions in 6, 7, and 8 exclosures at ODSVRA (continued).



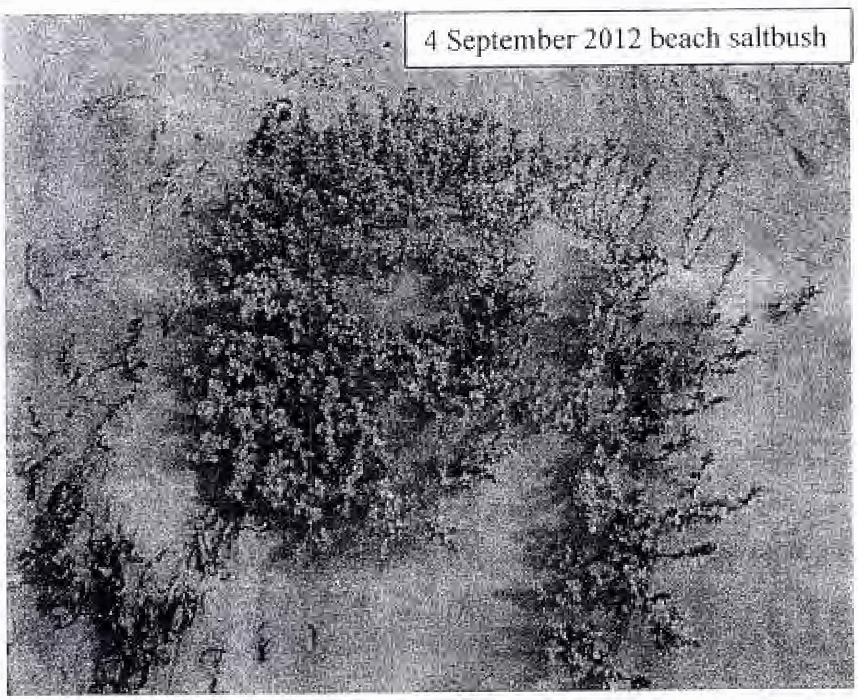


Figure F.3. Photos taken at the beginning and at the end of the 2012 breeding season of an experimental plant plot located on the shoreline of 6 exclosure.

Appendix F. Habitat enhancement actions in 6, 7, and 8 exclosures at ODSVRA (continued).

Woodchips

Wind and shifting sand altered the amount and composition of surface substrates over the course of the season, exposing and covering debris and woodchip patches from this and earlier years. The amount of woodchip coverage was estimated quantitatively when the material was distributed at the beginning of the season. In all years when woodchips were added, bare sand substrate was extensive throughout the 6, 7 and 8 exclosures during the breeding season, while woodchip substrate was estimated to cover less than 15% of this area.

Substrate availability and use by snowy plovers and least terns

In 2012, 158 (out of 185) plover nests found in the 6, 7, and 8 exclosures were within the woodchip addition area and had formal substrate sheets (Figure F.10) completed while still active. Areas that were below the upper high tide line, and less than 100 feet from the open riding area, were excluded from this analysis because: 1) they have never received woodchip patches, and 2) the likelihood of nesting is reduced below the upper high tide line as well as in close proximity to the boundary with the open riding area. Nests were assigned to a category (assorted debris, bare sand, vegetation, or woodchips) based upon the one meter by one meter assessment, centered upon the nest, in the formal substrate sheet. The bare sand category represented nests wherein bare sand constituted greater than 90% of the coverage. Vegetation required either the nest was in substantial live vegetation or the vegetation coverage in the area was 10% or greater. Assorted debris were any combination of non-woodchip debris that constituted 10% or greater substrate cover. Woodchips had to stand alone as 10% or greater, and be the higher percentage if another category also held a substantial percentage greater than 10%.

Of the 158 nests, 56 (35%) were found in woodchip substrate, 47 (30%) in assorted debris (both natural and human litter other than material brought in as enhancement), 53 (34%) in bare sand, and two (1%) in vegetation (Figures F.4 and F.5). This is slightly lower than the average for nests found in woodchips from 2008-11 (41%).

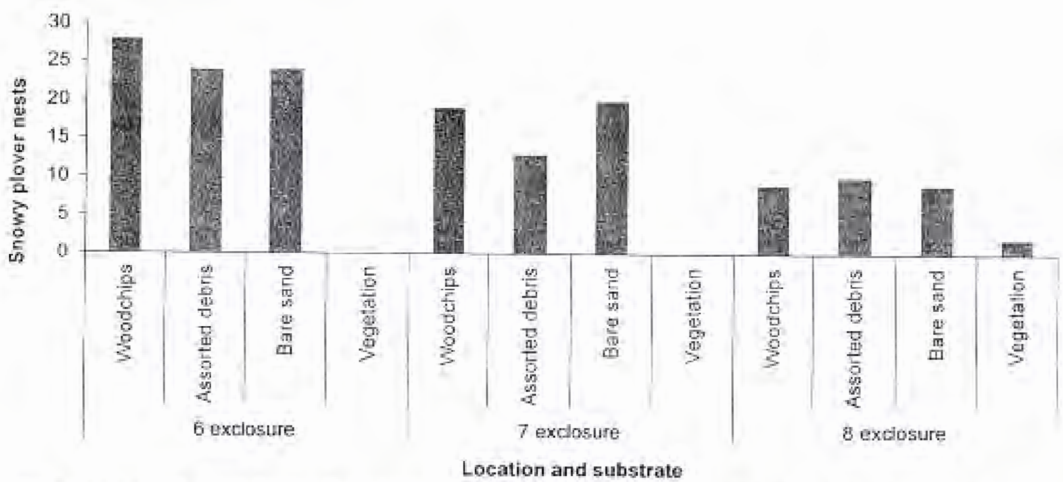


Figure F.4. Total number of snowy plover nests established in each substrate (woodchips, assorted debris, bare sand, and vegetation) in 6, 7, and 8 exclosures at ODSVRA in 2012. Only nests (n=158) with determined substrates within the woodchip distribution area in the Southern Exclosure are included.

Appendix F. Habitat enhancement actions in 6, 7, and 8 exclosures at ODSVRA (continued).

Of the 56 snowy plover nests in woodchip debris in 2012, 64% hatched (Figure F.5), 20% were depredated, 9% were abandoned (two abandoned pre-term, one abandoned with wind as suspected cause, two abandoned unknown if pre- or post-term), 4% failed to unknown cause, and 4% had an unknown fate. In prior years, nests in woodchips had a higher hatch rate than those in other categories, but this year these nests had a lower hatch rate. For 47 nests in assorted debris, 79% hatched, 2% were depredated, 11% were abandoned (four abandoned pre-term, one abandoned unknown if pre- or post-term), 2% overwashed by tide, and 6% had an unknown fate. Of the 53 plover nests in bare sand substrate, 79% hatched, 6% were depredated, 11% were abandoned (three abandoned pre-term, two abandoned with wind as suspected cause, one abandoned post-term), 2% failed to unknown cause, and 2% had an unknown fate. Both nests in vegetation hatched (100%). Mini-exclosures and 10 foot by 10 foot exclosures can increase hatch rates when used, but nests receiving this additional protection were not addressed separately in this analysis of substrate hatching success. In 2012, less than 25% of nests in the 6, 7, and 8 exclosures received a mini-exclosure or 10 foot by 10 foot exclosure and nest substrate was not a factor in their selection.

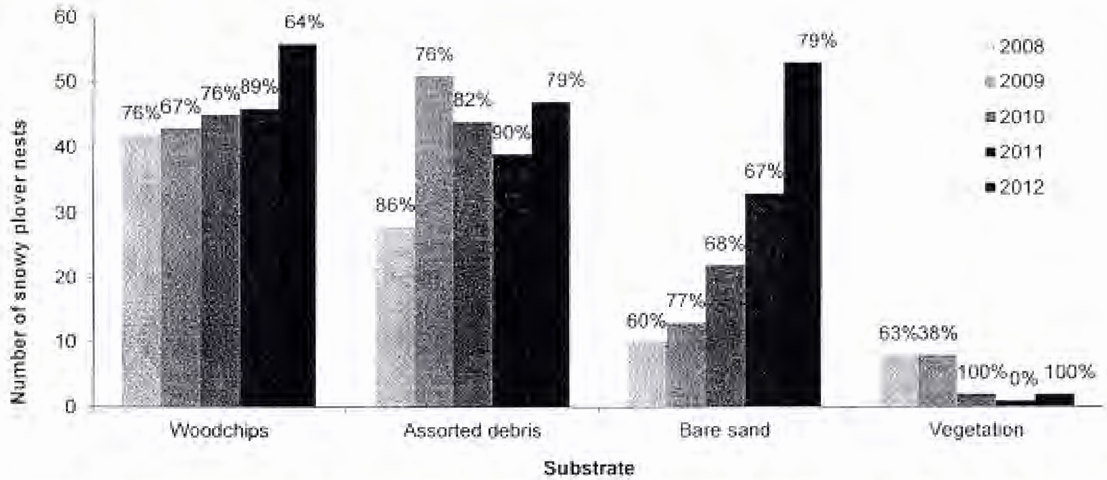


Figure F.5. Number and percentage of snowy plover nests hatching per the total number of nests in each substrate (woodchips, assorted debris, bare sand, and vegetation) in 6, 7, and 8 exclosures at ODSVRA in 2008-12.

The overall hatch rate for all nests within the woodchip distribution area in the 6, 7, and 8 exclosures with formally defined substrates (Figure F.6) was 74% in 2012 and compares to an average of 77% for 2008-11. Nests in woodchips had a 64% hatch rate, compared to an average of 77% for 2008-11, while assorted debris had a 79% hatch rate, compared to 83% for 2008-11. Nests in bare sand had a 79% hatch rate, which was higher than the average of 68% for 2008-11 (Table F.1). Even though bare sand accounts for approximately 89% of the Southern Exclosure (based upon results from substrates at random points), only 11% of the Southern Exclosure's plover nests were in bare sand in both 2008 and 2009, 19% in 2010, 28% in 2011, and 34% in 2012; the higher rate in 2011-12 reflects the change in substrate collection methods (set minimum substrate at 10%, anything lower counted as bare sand).

Table F.1. Nest numbers and fates (hatched, depredated, abandoned) for different substrates (woodchips, assorted debris, bare sand, and vegetation) in 6, 7, and 8 exclosures at ODSVRA from 2008-12.

Only nests within the woodchip distribution area in the Southern Exclosure are included. %H = percent hatched, %D = percent depredated, %A = percent abandoned. All other nest fates (i.e. failed, cause unknown, unknown fate, overwash, etc.) not included.

		Woodchips				Assorted debris				Bare sand				Vegetation				Total
Year	Location	No. nests	%H	%D	%A	No. nests	%H	%D	%A	No. nests	%H	%D	%A	No. nests	%H	%D	%A	No. nests
2008	6 excl	13	77	8	15	17	94	0	6	3	67	0	33	0	-	-	-	
	7 excl	16	94	0	0	5	100	0	0	4	75	25	0	6	50	0	50	
	8 excl	13	54	15	15	6	50	0	17	3	33	0	67	2	100	0	0	
	Total	**42**	**76**	**7**	**10**	**28**	**86**	**0**	**7**	**10**	**60**	**10**	**30**	**8**	**63**	**0**	**38**	88
2009	6 excl	20	70	15	5	18	100	0	0	3	100	0	0	0	-	-	-	
	7 excl	12	92	0	8	19	79	11	5	2	50	0	50	2	50	0	50	
	8 excl	11	36	45	9	14	43	36	14	8	75	0	13	6	33	67	0	
	Total	**43**	**67**	**19**	**7**	**51**	**76**	**14**	**6**	**13**	**77**	**0**	**15**	**8**	**38**	**50**	**13**	115
2010	6 excl	21	81	5	14	23	91	0	4	14	71	14	14	0	-	-	-	
	7 excl	17	76	12	12	8	88	13	0	6	67	0	33	0	-	-	-	
	8 excl	7	57	14	14	13	62	8	23	2	50	50	0	2	100	0	0	
	Total	**45**	**76**	**9**	**13**	**44**	**82**	**5**	**9**	**22**	**68**	**14**	**18**	**2**	**100**	**0**	**0**	113
2011	6 excl	20	90	0	5	23	100	0	0	15	53	0	27	0	-	-	-	
	7 excl	17	100	0	0	9	100	0	0	9	89	0	11	0	-	-	-	
	8 excl	9	67	11	11	7	43	57	0	9	67	0	22	1	0	0	100	
	Total	**46**	**89**	**2**	**4**	**39**	**90**	**10**	**0**	**33**	**67**	**0**	**21**	**1**	**0**	**0**	**100**	119
2012	6 excl	28	71	11	14	24	79	0	4	24	88	4	8	0	-	-	-	
	7 excl	19	63	32	0	13	77	8	15	20	75	5	10	0	-	-	-	
	8 excl	9	44	22	11	10	80	0	20	9	67	11	22	2	100	0	0	
	Total	**56**	**64**	**20**	**9**	**47**	**79**	**2**	**11**	**53**	**79**	**6**	**11**	**2**	**100**	**0**	**0**	158
Grand total		232	74	12	9	209	82	7	7	131	73	5	17	21	57	19	24	593

Appendix F. Habitat enhancement actions in 6, 7, and 8 exclosures at ODSVRA (continued).

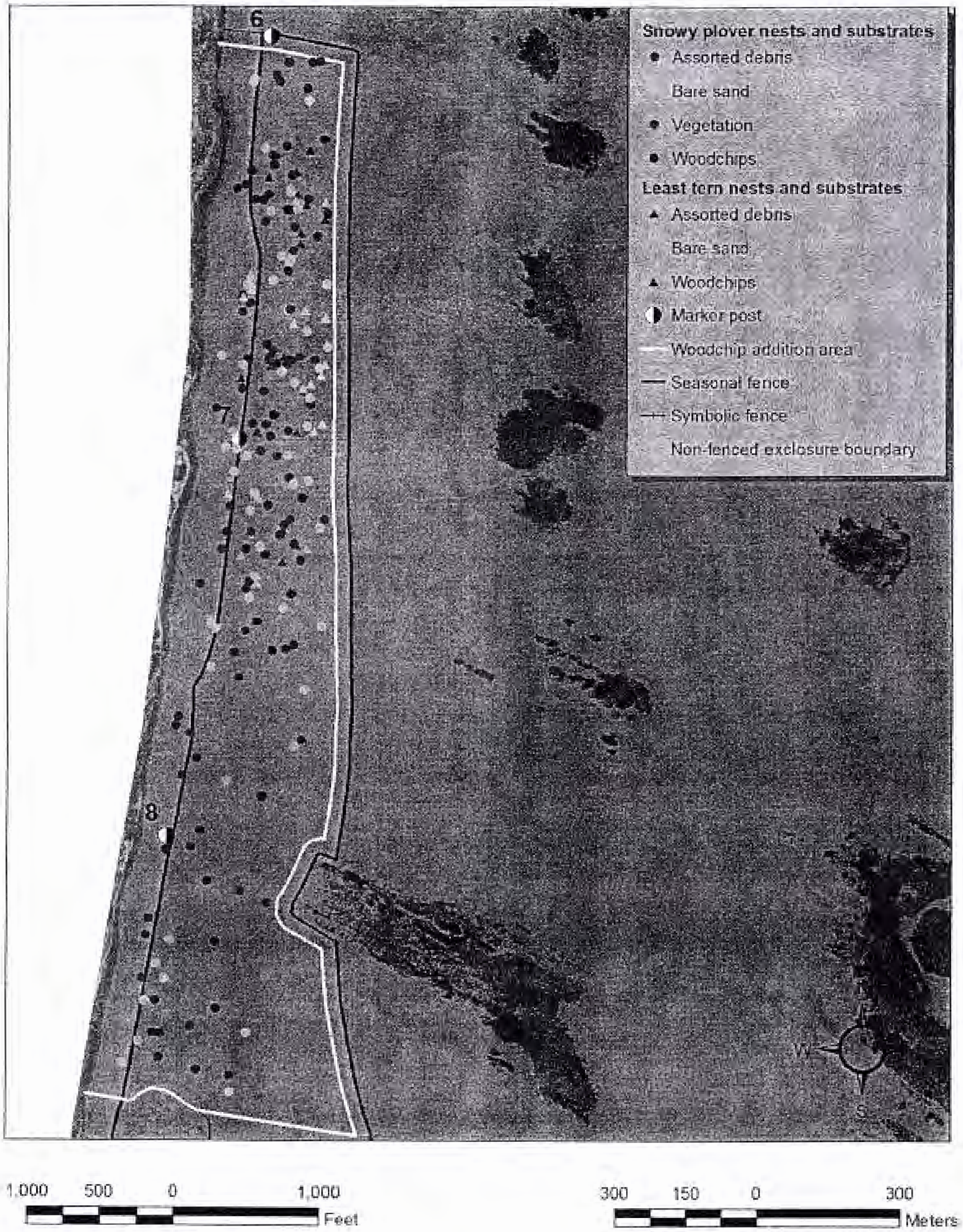


Figure F.6. Nest substrates of least terns and snowy plovers in 6, 7, and 8 exclosures at ODSVRA in 2012.

Only those nests in the woodchip addition area and with formal assessments on nest substrate forms conducted while the nests were active are included in this map: 158 plover nests and 38 tern nests in 2012.

Appendix F. Habitat enhancement actions in 6, 7, and 8 exclosures at ODSVRA (continued).

Of the 38 least tern nests located in the woodchip addition area with formal substrate assessments in 2012, 12 (32%) were in woodchips, four (11%) in assorted debris, and 22 (58%) in bare sand. For those least tern nests in woodchip debris, 75% hatched, 8% were abandoned (one abandoned post-term), and 17% had an unknown fate. Of nests in assorted debris, 75% hatched and 25% were abandoned (one abandoned pre-term). In bare sand, 64% hatched, 14% were abandoned (one abandoned post-term, two abandoned unknown if pre- or post-term), and 5% failed to unknown cause (Figures F.6, F.7 and F.8).

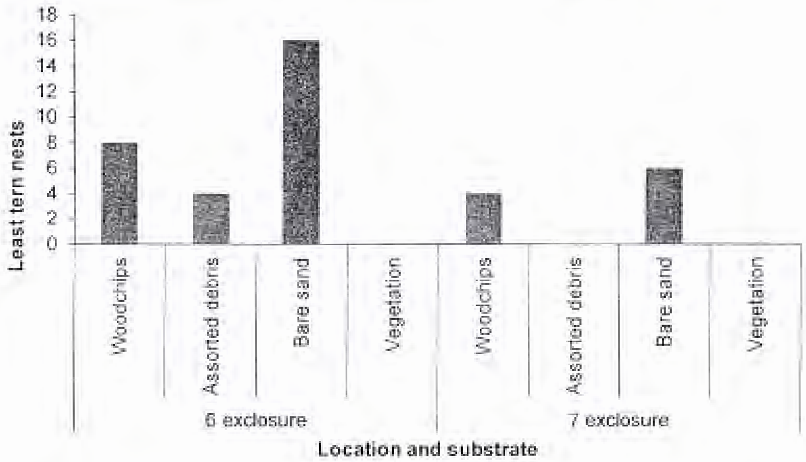


Figure F.7. Total number of least tern nests established in each substrate (woodchips, assorted debris, and bare sand) in 6 and 7 exclosures at ODSVRA in 2012.

No least terns nested in 8 exclosure. Only nests (n=38) within the woodchip distribution area in the Southern Exclosure and with identified substrates are included.

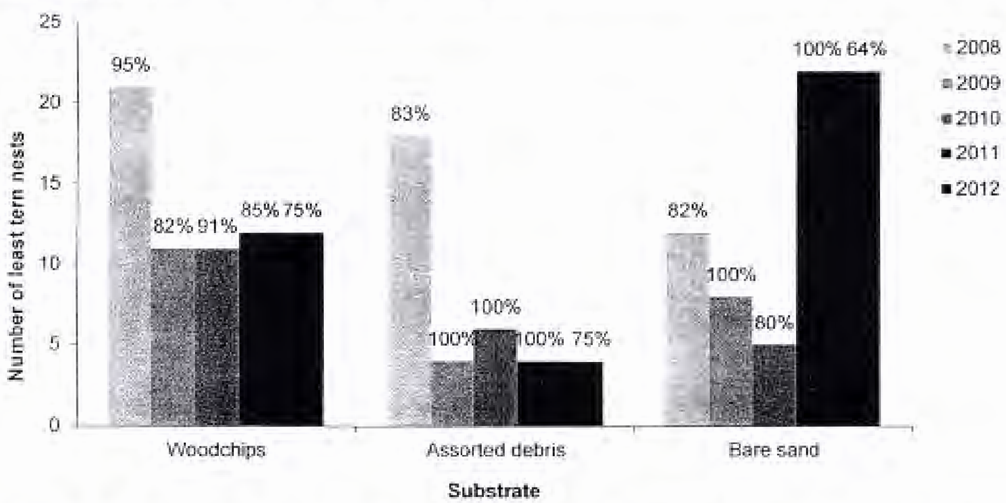


Figure F.8. Number and percentage of least tern nests hatching per the total number of nests in each substrate (woodchips, assorted debris, and bare sand) in 6, 7, and 8 exclosures at ODSVRA from 2008-12.

The increase in bare sand nests in 2011-12 reflected a trend showing increased tern nesting over time and the change in substrate category assignment that required greater than 10% coverage for assignment and defaulted to bare sand.

Appendix F. Habitat enhancement actions in 6, 7, and 8 exclosures at ODSVRA (continued).

The same substrate categorization criteria were used for a set of randomly generated points (in ArcMap 10) in 6, 7, and 8 exclosures, collected at the end of the season (prior to the exclosure's removal). The random points (92 total in the woodchip addition area) give a snapshot of the substrates available in the exclosure, while the nest points (196 total nests including least tern and snowy plover nests in the woodchip addition area) give an indication of substrate selection by plovers and least terns while nests were still active (Table F.2). Of the available habitat (as revealed by random points), both plovers and terns showed a preference for areas with higher substrate or woodchip cover. In 2012, a greater proportion of snowy plover nests (66%) occurred in substrate patches than would be expected if they nested at random (11%); this is demonstrated in the high percentage of random points with substrate cover at low percentages, indicating bare sand. Least terns showed a similar, but less pronounced preference (42%). Since woodchips are the only substrate that management is currently distributing on a large basis, many of these nests occurred in woodchip patches with a density greater than 10%. While the woodchip patches and assorted debris provide nesting substrate attractive to plovers, it is important to note they do not provide chicks with the cover and shelter that is available with larger material such as driftwood, wrack, plants, and vegetated hummocks.

Table F.2. The percentage occurrence of random points, snowy plover, and least tern nests for all substrates except bare sand for the 6, 7, and 8 exclosures in 2012.
Greater than 10% substrate coverage over bare sand within one meter by one meter of the nest or point was required to be included in a substrate category. All substrate includes the maximum value in all categories other than bare sand while woodchips looks specifically at the contribution of woodchips to the one meter by one meter area. The sample size of random points, snowy plover nests, and least tern nests is shown in parentheses.

Exclosure	Woodchips, assorted debris, and vegetation combined			Woodchips		
	Random points	Snowy plovers	Least terns	Random points	Snowy plovers	Least terns
6	12% (33)	68% (76)	43% (28)	3% (33)	37% (76)	29% (28)
7	10% (29)	62% (52)	40% (10)	3% (29)	37% (52)	40% (10)
8	10% (30)	70% (30)	-	7% (30)	30% (30)	-
Total	11% (92)	66% (158)	42% (38)	4% (92)	35% (158)	32% (38)

In further analysis, the total percentage of bare sand in a one meter by one meter area centered on the point of interest (nest or random point) was averaged and standard error of the mean was calculated. To make the comparisons more accurate, only the random points in the 6 and 7 exclosures were averaged to compare to the least tern mean, while all random points were averaged to compare to the snowy plover mean (Table F.3, Figure F.8). Interestingly, the averages for random points including and excluding 8 exclosure were nearly identical (96.04% and 96.35% respectively). The average amount of bare sand around snowy plover nests (83%) was 13% lower than the average for the random points (96%). The least tern nests (90%), on average, had 6% less bare sand (alternately, 6% more substrate) than random points in 6 and 7 exclosures (96%).

Appendix F. Habitat enhancement actions in 6, 7, and 8 exclosures at ODSVRA (continued).

Table F.3. The mean, median, mode, standard error, and standard deviation for all random points, snowy plover nests and least tern nests in the woodchip distribution area in 2012.

Statistic	Snowy plovers	Random points in 6, 7, and 8 exclosures	Least terns	Random points in 6 and 7 exclosures
Mean	83.35	96.04	90.32	96.35
Standard error	0.97	0.72	1.29	0.66
Median	85	98	92.5	98
Mode	90	99	96	99
Standard deviation	12.22	6.88	7.94	5.20
Count	158	92	38	62

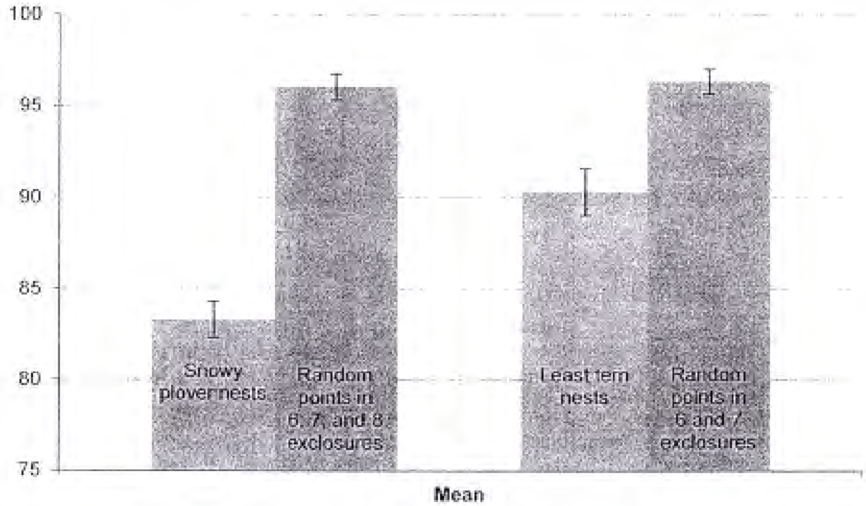


Figure F.9. The mean of the value for bare sand coverage in the one meter by one meter area centered around the random points, snowy plover nests, and least tern nests in 2012. For comparison purposes, only random points from the 6 and 7 exclosures were included to compare to least tern substrates.

ODSVRA Nest Data - Location and Substrate Date/ Initials:

Nest number: Species: SNPL LETE

Nest exclosure (Note if in 7.5):

Habitat Type (circle all that apply): Beach Foredune Stable Dune Altered Sand Sheet Hummocks

Marker:

Est. dist. to foredune (OF):

Est. dist. to nearest active nest (office):

PERCENT TOTAL SUBSTRATE OTHER THAN SAND:

(Please fill out at nest)

Photos taken?

Nest bowl substrate: Sand Gravel Woodchip Shell Glass Cinder Vegetation Other:

In the table below: **PC column:** Percent cover and a blank box means not present. **Discrete Column:** is checked if the material is in a discrete area of quadrat. **Parks column:** is checked if it is known habitat enhancement by parks.

Substrate	1m X 1m			5m X 5m			25m X 25m
Wood material	PC	Discrete	Parks	CC	Discrete	Parks	Similar to 5 X 5? Y N
Woodchips (Parks)							Distinctive features or differences:
Logs (Parks)							
Natural Wood							
Veg. height & species	PC	Discrete	Parks	CC	Discrete	Parks	
low (?1")							
medium (>1" and ?12")							
high (>12")							
Species List* (circle all that are present)	CAMA AMCH ATLE ABMA other			CAMA AMCH ATLE ABMA other			
Wrack	PC	Discrete	Parks	CC	Discrete	Parks	
Wrack							
Other natural substrate	PC	Discrete		CC	Discrete		
Sand (0.0025-0.08in)							
Rocks							
Shell							
Dead vegetation							
Other:							
Human misc. debris	PC	Discrete		CC	Discrete		
Misc debris (glass, metal, plastics, cinders, etc)							
Topographic Relief (circle one)	Flat Concave Convex Undulating (height ___)			Flat Concave Convex Undulating (height ___)			Flat Concave Convex Undulating (height ___)

Notes:

Definitions:

Habitat Type

Altered: ORA and seasonally closed area, starts w/ limited disruptive cover. Enhanced in patches with woodchips, driftwood, wrack, least tern shelters, seed and plants (6, 7, 8, BY).

Beach: Waterline to foredunes.

Foredunes: Slightly asymmetric ridge above beach high tide line. Forms from sand accumulating in sparse vegetation.

Back Dunes: Vegetated dune landward of the foredunes.

Sand Sheet: Featureless area of sand, usually east of foredunes or stable dunes.

Hummocks: Vegetated hummocks not associated with foredunes.

*** Species List (circle all that apply)**

CAMA: sea rocket (*Cakile maritima*)

AMCH: beach bur (*Ambrosia chamissonis*)

ABMA: sand-verbena (*Abronia maritima*)

ATLE: saltbush (*Atriplex leucophylla*)

Topographic Relief

Flat: surface is overall flat

Concave: Surface is overall bowl formation

Convex: Surface is overall hill formation

Undulating: Surface has hummocks.

Figure F.10. Field sheet for substrate collection at nests and random points, 2012.

Appendix G. Predator summary tables and figures.

Table G.1. Summary of predators detected in the Southern Exclosure and Oso Flaco at ODSVRA in 2012.

Observations from 1 March - 10 September (a 194-day period). Contracted predator management specialists were essentially done and observer presence in field by park staff was reduced after the first week of September (no remaining chicks). Max no. individ. = maximum number of different individuals identified during one day. This number was not typically determined for mammals or owls as these species are primarily nocturnal with occurrences detected by tracks.

Species	First date observed	Last date observed	No. days detected	Max no. individ.	Notes
Mammals					
Bobcat	8 Mar	31 Aug	7	-	Tracks primarily encountered in Boneyard. Also noted in 8 exclosure, North Oso Flaco, and South Oso Flaco.
Coyote	8 Mar	10 Sep	119	-	Common on the Southern Exclosure shoreline and North Oso Flaco shoreline. Noted inside the predator fencing of the Southern Exclosure on 57 days.
Domestic dog	3 Mar	11 Aug	2	-	Documented by tracks and live sightings. Two occurrences on 6 exclosure shoreline, three occurrences in South Oso Flaco, and one occurrence on 7 exclosure shoreline.
Opossum	11 Mar	31 Aug	25	-	Majority of activity in 6, 7 and 8 exclosures. Occasionally occurring in South Oso Flaco, North Oso Flaco, and Boneyard.
Raccoon	3 Mar	10 Sep	137	-	Highest occurrence in 8 exclosure. Less frequently noted in South Oso Flaco, North Oso Flaco, 6, and 7 exclosure, (especially near 7.5 revegetation area).
Skunk	13 Mar	7 Sep	19		Majority of activity in 6, 7 and 8 exclosure. Less frequently noted in North Oso Flaco and Boneyard.
Avian					
Osprey	18 Mar	7 Sep	44	4	Although not documented as a predator of plovers and least terns, ospreys are included in this table due to their disturbance when perched for longer periods of time in sensitive areas. Primarily observed flying over the shoreline and North Oso Flaco. Also seen at Oso Flaco Creek. Occasionally perching on the Southern Exclosure shore and fence during the later part of the season. Four individuals seen at one time on 25 September.
Northern harrier	2 Mar	10 Sep	47	3	Typically observed flying over South Oso Flaco. Frequent sightings flying in 6, 7, and 8 exclosures between 2 May and 12 May. Almost all observations in flight. Minimum of seven individuals (based on age and sex characteristics) observed during this season: three adult males, two adult females, and two juveniles (one identified as female).
Cooper's hawk	14 Aug	14 Aug	1	1	Seen once at Oso Flaco Lake.
Red-tailed hawk	27 Mar	10 Sep	74	3	Observed most often perched at north end of North Oso Flaco. Also many observations in South Oso Flaco as well as perched in 8 exclosure and 7.5 revegetation area. Minimum of four individuals (based on age characteristics) observed during this season: one adult male, one adult female, one subadult, and one juvenile.
American kestrel	12 Jul	7 Sep	10	2	Seen in 6, 7, and 8 exclosures and North Oso Flaco. Observed in flight and perch hunting. Minimum of three individuals (based on age and sex characteristics) observed during the season.

Appendix G. Predator summary tables and figures (continued).

Table G.1. Summary of predators detected in the Southern Exclosure and Oso Flaco at ODSVRA in 2012 (continued).

Species	First date observed	Last date observed	No. days detected	Max no. individ.	Notes
Avian					
Merlin	15 Mar	10 Sep	5	1	Observed in 6, 7 and 8 exclosure and North Oso Flaco.
Prairie falcon	20 Aug	20 Aug	1	1	One sighting of a banded bird in 7 exclosure feeding on a small prey item.
Peregrine falcon	6 Mar	3 Sep	52	2	Observed throughout the Southern Exclosure, North Oso Flaco and South Oso Flaco in flight and perching, sometimes over an extended time period. Multiple observations pursuing and/or consuming prey on the shoreline and inside the exclosure. Two plover chicks and one plover nest depredated by peregrine falcon. Minimum of six individuals (based on age characteristics) observed during this season: one adult male, one adult female, one subadult male, one subadult female, and two juveniles.
Large owl spp.	4 Mar	10 Sep	53	2	Primarily identified by tracks. Most tracks believed to be from great horned owl. Primarily noted inside the Southern Exclosure. Also seen in Boneyard and South Oso Flaco. Less frequently noted in 6 and 7 exclosures.
Gull spp.	Present daily throughout season				The maximum number of gulls in the Southern Exclosure and Oso Flaco was recorded during the month of September. Includes birds in flight, foraging on shoreline, and roosting.
Loggerhead shrike	29 Jun	10 Sep	11	1	Observed in South Oso Flaco, North Oso Flaco, and Boneyard. One seen perching on east fence of 8 exclosure. Minimum number of 10 individuals based on number trapped and observations after trapping.
American crow	8 Mar	22 Jul	5	3	Observed primarily flying over South Oso Flaco. Also seen flying over 7 and 8 exclosure on 18 March and 18 June.
Common raven	16 Mar	2 Jul	14	3	Observed primarily over South Oso Flaco, North Oso Flaco, Boneyard, and 8 exclosure. Several observations flying over 6 and 7 exclosures. All observations of birds in flight.
Corvid spp.	19 Jun	22 Jul	3	-	Tracks present at three depredated plover nests. Brief observations flying over 7 and 8 exclosures. Corvid spp. refers to crow or raven.

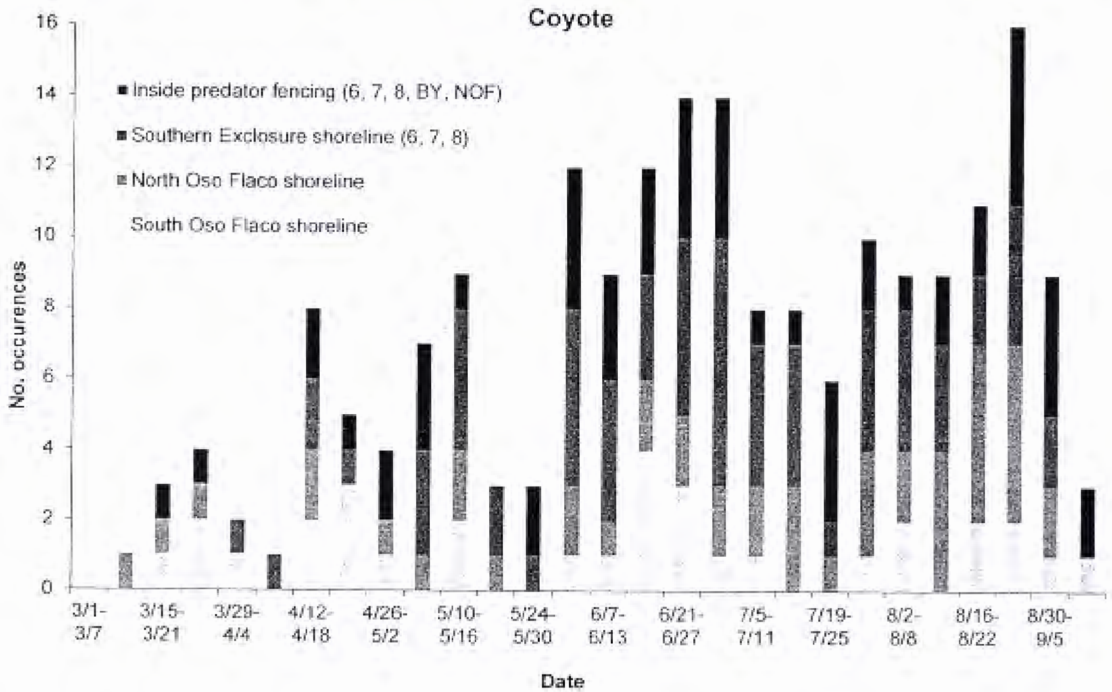
Appendix G. Predator summary tables and figures (continued).

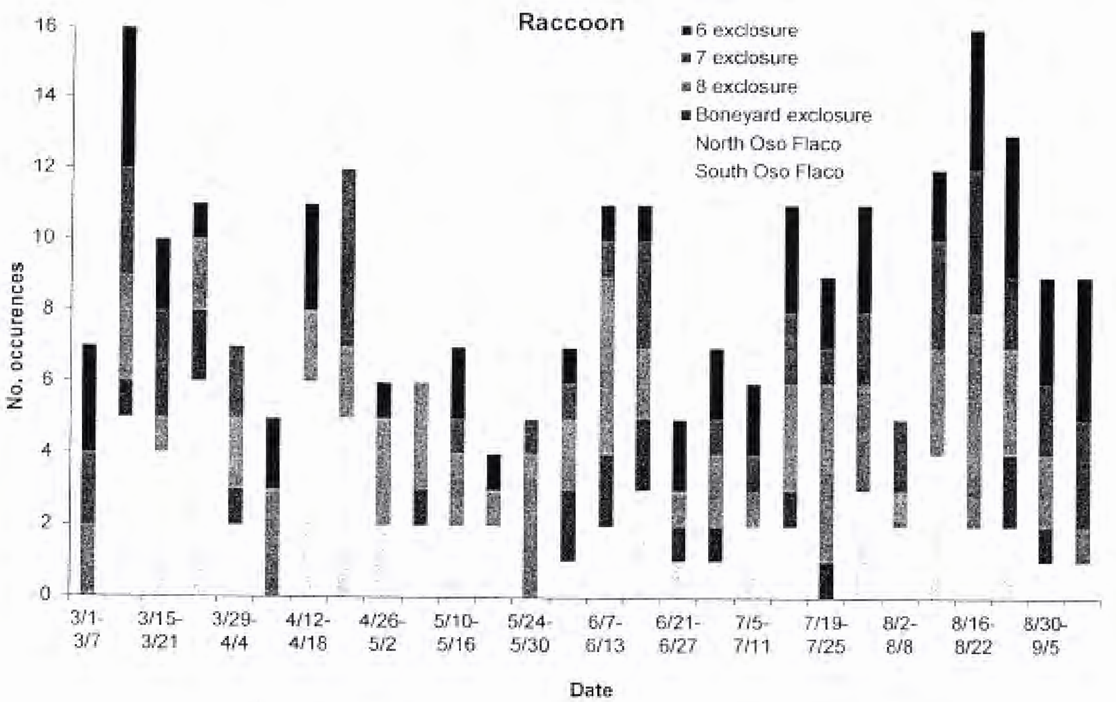
Table G.2. Mammalian and avian predators removed under predator management actions for least terns and snowy plovers at ODSVRA in 2012.
Eleven coyotes, six raccoons, and one northern harrier were lethally removed. All other animals were live-trapped and relocated. All animals trapped or removed were within ODSVRA boundaries.

Date	Species	Age/Sex	Location
Mammals			
15 May	coyote	female	Boyscout
15 May	coyote	male	South Oso Flaco
17 May	coyote	male	East Boneyard
30 May	coyote	female	Boyscout
5 Jun	coyote	male	South Oso Flaco
13 Jun	coyote	male	Boneyard exclosure
14 Jun	coyote	male	South Oso Flaco
20 Jun	coyote	male	South Oso Flaco
27 Jun	coyote	female	South Oso Flaco
29 Jun	coyote	male	South Oso Flaco
31 Jul	coyote	male	South Oso Flaco
31 Jul	raccoon	male	South Oso Flaco
31 Jul	raccoon	female	South Oso Flaco
1 Aug	raccoon	female	South Oso Flaco
8 Aug	raccoon	male	South Oso Flaco
14 Aug	raccoon	female	8 exclosure shoreline
17 Aug	raccoon	female	8 exclosure shoreline
Avian			
6 Feb	American kestrel	adult male	North Oso Flaco
16 Feb	loggerhead shrike	adult	South Oso Flaco
7 Mar	American kestrel	adult male	Dune Preserve
6 Apr	northern harrier	adult male	Oso Flaco Lake
18 Apr	great horned owl	adult female	Pipeline revegetation area
30 Apr	great horned owl	adult female	Maidenform revegetation area
12 May	northern harrier	adult male	Open riding area, east of 6 exclosure
23 May	peregrine falcon	sub-adult female	7 exclosure shoreline
30 May	great horned owl	adult male	North Oso Flaco
29 Jun	loggerhead shrike	juvenile	North Oso Flaco
12 Jul	loggerhead shrike	juvenile	North Oso Flaco
16 Jul	loggerhead shrike	juvenile	Tabletop revegetation area
24 Jul	barn owl	adult	Pipeline revegetation area
24 Jul	barn owl	adult	Pipeline revegetation area
26 Jul	loggerhead shrike	juvenile	North Oso Flaco
3 Aug	loggerhead shrike	juvenile	North Oso Flaco
6 Aug	loggerhead shrike	juvenile	North Oso Flaco
13 Aug	loggerhead shrike	juvenile	Pipeline revegetation area
14 Aug	loggerhead shrike	juvenile	North Oso Flaco

Appendix G. Predator summary tables and figures (continued).

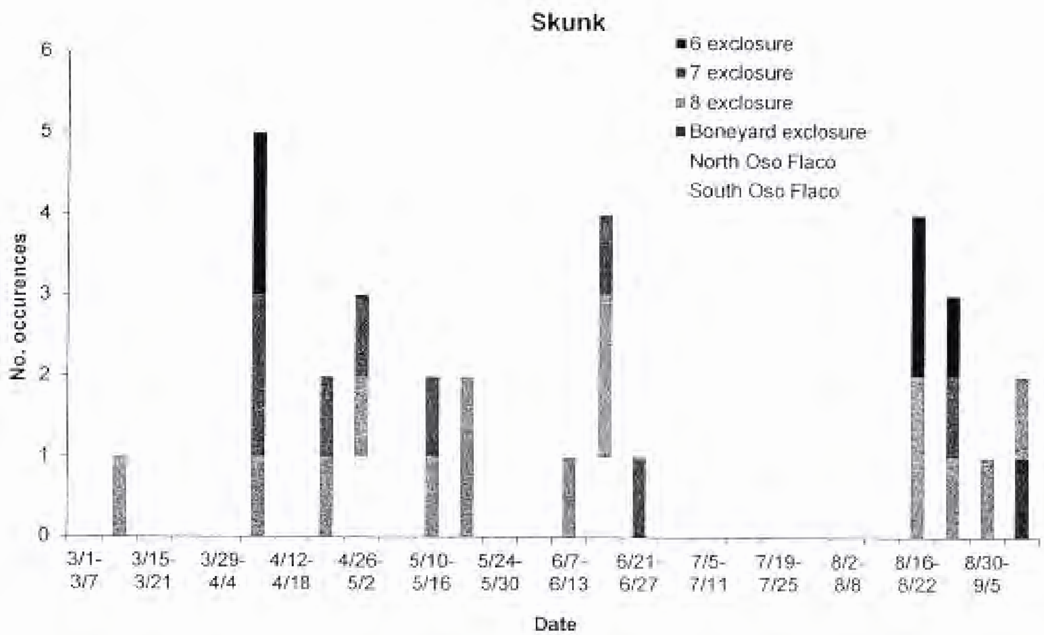
Figure G.1. Mammalian occurrences documented in the Southern Exclosure and Oso Flaco at ODSVRA in 2012.
Observations from 1 March - 10 September (a 194-day period).





Appendix G. Predator summary tables and figures (continued).

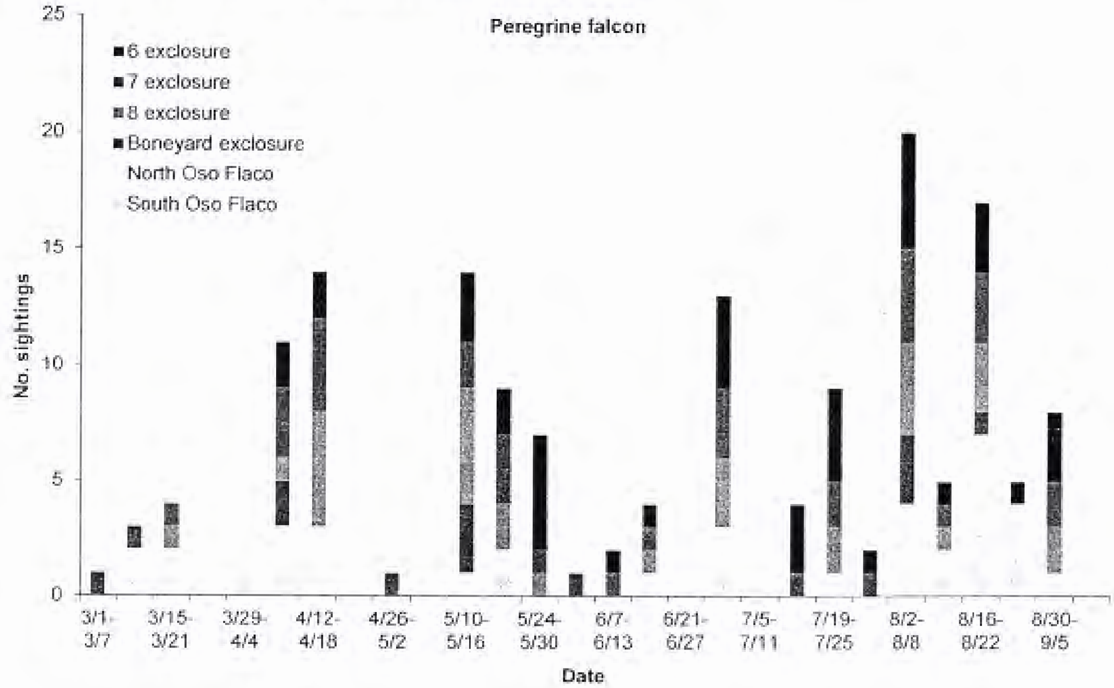
Figure G.1. Mammalian presence documented in the Southern Exclosure and Oso Flaco at ODSVRA in 2012 (continued).

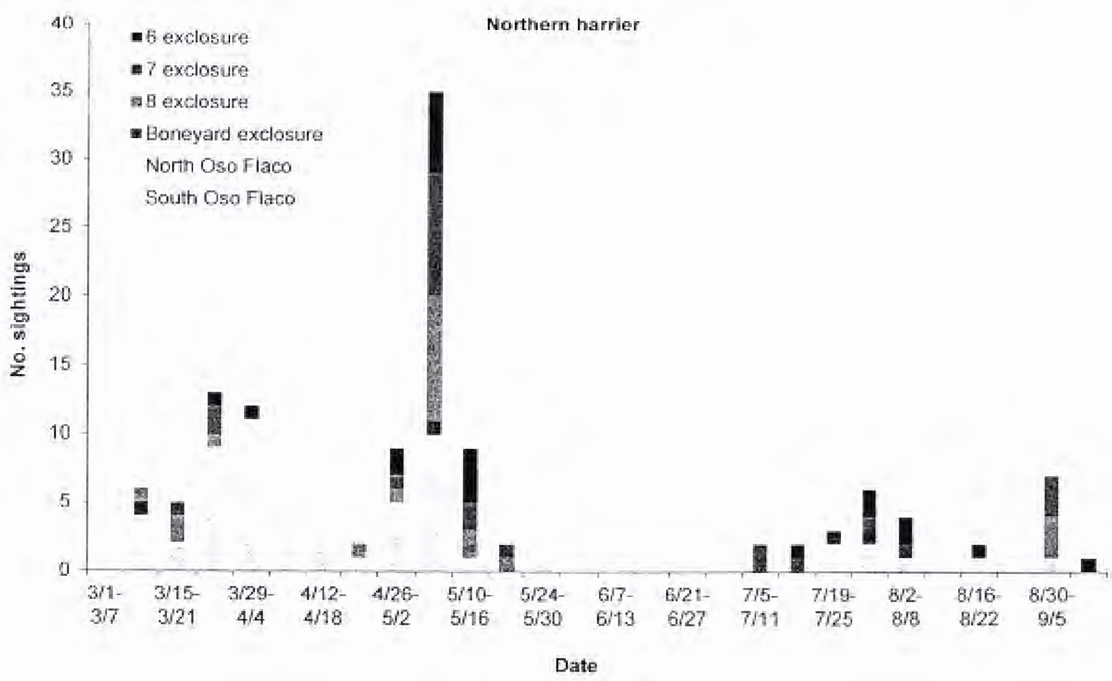


Coyote presence is documented for the Southern Exclosure shoreline (6, 7, and 8 exclosures), North Oso Flaco shoreline, South Oso Flaco shoreline, and inside the predator fencing of the Southern Exclosure (6, 7, 8, Boneyard, and North Oso Flaco) as separate occurrences. For the Southern Exclosure (6, 7, 8, and Boneyard exclosures) and North Oso Flaco, a distinction is made between the shoreline and inside the predator fencing of the exclosures because coyotes are typically excluded from the area protected by predator fencing.

Raccoon and skunk presence is documented for each of the areas of the Southern Exclosure (6, 7, 8, and Boneyard exclosures), North Oso Flaco, and South Oso Flaco as separate occurrences. For raccoon and skunk, no distinction is made between the shoreline and inside the predator fencing of the exclosure since raccoons are able to climb over the predator fencing and some skunks are able to walk through the two by four inch mesh fencing.

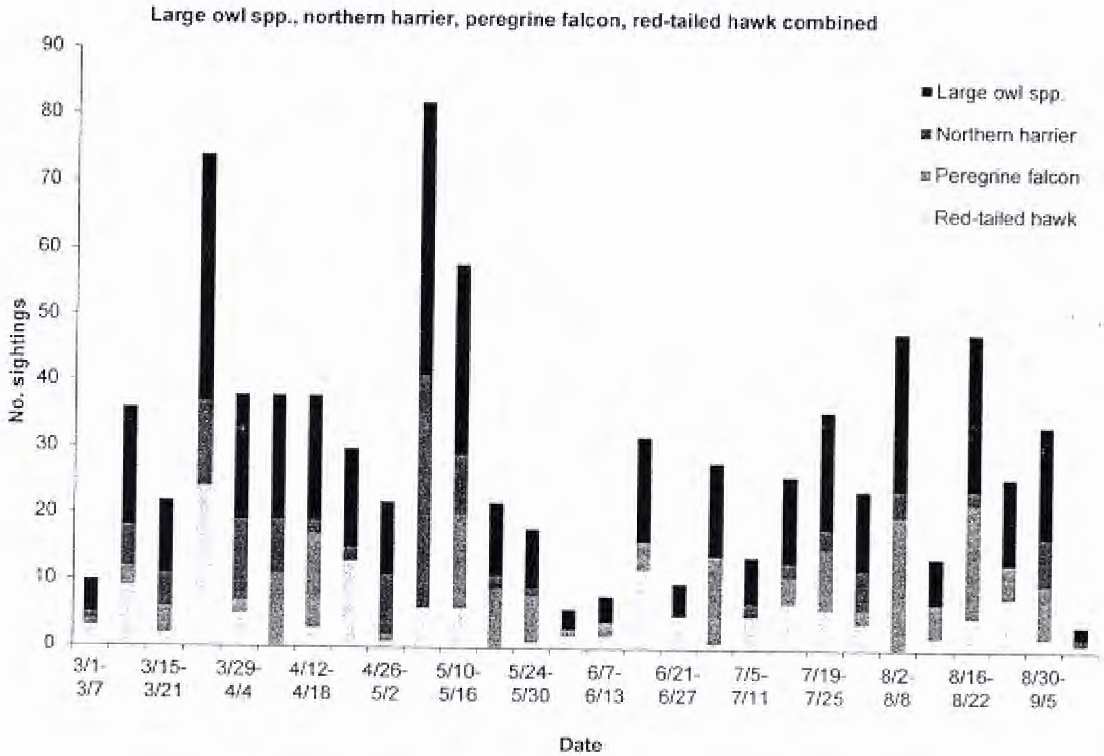
Figure G.2. Avian predator sightings documented in the Southern Exclosure and Oso Flaco at ODSVRA in 2012.
Observations from 1 March - 10 September (a 194-day period).





Appendix G. Predator summary tables and figures (continued).

Figure G.2. Avian predator sightings documented in the Southern Exclosure and Oso Flaco at ODSVRA in 2012 (continued).



Appendix H. Documented mortality of California least tern and snowy plover chicks, juveniles, and adults at ODSVRA from 1 March to 30 September 2012.

Table H.1. Documented predation of least terns.

No. (age)	Predator	Location	Notes
1 (fledgling or near-fledgling)	Peregrine falcon	6 exclosure	On 31 July, a peregrine falcon was observed inside 6 exclosure with prey. Remaining feathers from prey collected and determined to be from a least tern (fledgling or near fledgling).
1 (likely juvenile)	Unknown avian	6 exclosure	On 11 August, feather remains and a bicolor B/W aluminum band used to band terns at ODSVRA were found inside 6 exclosure. The feathers collected were from a least tern (likely juvenile).
1 (unknown)	Coyote	east of southern North Oso Flaco	On August 9, coyote scat was found east of the southern portion of North Oso Flaco. One bicolor B/W aluminum band used to band least terns at ODSVRA was found.

Table H.2. Documented predation of snowy plovers.

No. (age)	Predator	Location	Notes
1 (chick)	Northern harrier (adult male)	7 exclosure	On 9 May, an adult male northern harrier was observed landing and grabbing a recently hatched chick from SP6 east of 7.5 revegetation. The harrier flew northeast with chick in talons.
2 (chicks)	Peregrine falcon (sub-adult female)	Border of 6 and 7 exclosure shoreline	On 23 May, a sub-adult female peregrine falcon hunting over 6 exclosure shoreline was seen to catch and eat one chick and a possible second. The falcon was live-trapped and placed in a carrier prior to relocation. A regurgitated pellet containing seven plastic color bands was removed from the carrier, representing a minimum of two chicks. Bands found were two violet, one red[1], one green, one aqua, one white, and one yellow.
1 (juvenile)	Peregrine falcon	6 exclosure	On 3 July, a peregrine falcon was inside 6 exclosure with suspected plover prey. An intact carcass of a juvenile plover from SP33 (VV:WY) was recovered at the site. This juvenile was 48 days old.
1 (adult size)	Unknown	8 exclosure	On 18 July, a pair of adult-sized plover wings was found five feet west of a mini-exclosure at SP159. On 9 July coyote tracks circled mini-exclosure and over-tracked plover tracks present outside of exclosure. Fresh plover tracks were documented at the three egg nest on 12 July.
1 (chick) 2 (unknown)	Coyote	east of southern North Oso Flaco	On 26 and 31 July and 9 August, four separate coyote scats were found east of the southern portion of North Oso Flaco. Eleven plastic color bands were found representing a minimum of three plovers. On 26 July two bands (one red and one orange) were found. On 31 July one green band was found and on 9 August eight bands (three green, two red[1], two white, and one orange) were found.
1 (adult size)	Unknown	8 exclosure shoreline	On 22 August, an adult-sized plover wing found half-buried in 8 exclosure near SP47 nest site. On 7 May, the nest received a mini-exclosure. On 22 May two of the three eggs pre-hatching had cracks. On 24 May, three eggs were found 20-30% buried with no plover tracks in or around mini. The mini-exclosure was removed after abandonment confirmed.
1 (chick) 2 (unknown)	Unknown avian	6 exclosure shoreline	On 7 September a regurgitated pellet was found on north 6 exclosure shoreline. The regurgitated pellet was comprised of small bones, feathers, and eleven plastic color bands representing a minimum of three plovers. Bands found were two red[1], two violet, two yellow, two pink, one blue, one green, and one violet tape.
3 (unknown)	Gull sp.	6 exclosure shoreline	On 13 September a regurgitated gull pellet was found 165 feet west of west fence on northern 6 exclosure shoreline. The pellet contained crustacean exoskeleton parts, sand and nine plastic color bands representing a minimum of three plovers. Bands found were three green, two pinks, one blue, one yellow, one violet and one unidentified color. The pellet measured 1 1/8" long with a diameter (at the widest) of 13/16".

[1] The red tape covering the red band had a white adhesive backing. Such red tape was first used at ODSVRA in 2012 and indicates a chick was taken.

Appendix H. Documented mortality of California least tern and snowy plover chicks, juveniles, and adults at ODSVRA from 1 March to 30 September 2012 (continued).

Table H.3. Mortality, other than predation, of least terns.

No. (age)	Location	Notes
1 (chick)	6 exclosure	On 7 July, one live and one dead chick were present within 2.5 feet of the nest. Both chicks were alive on the previous day (observed through spotting scope from the outside the exclosure).

Table H.4. Mortality, other than predation, of snowy plovers.

No. (age)	Location	Notes
1 (chick)	6 exclosure shoreline	On 12 June, the carcass of one chick from SP66 was seen while observing two siblings being brooded in area. All three chicks from this brood were seen alive on 4 June at eight days old (one subsequently fledged). The carcass was not collected due to proximity of other small plover broods in the area.
1 (chick)	North Oso Flaco shoreline	On 3 August, the intact decomposed carcass of small plover chick from SP158 was found on the surface of the sand. All three chicks from this brood were last observed on 25 July at one day old (no chicks known to fledge).
1 (adult)	ORA northeast of 6 exclosure	On 18 August, the carcass of an unbanded adult plover was found partially buried in the sand in faint tire tracks. The carcass was fresh and had dried blood on the chest. Necropsy report did not indicate the plover was crushed (Necropsy attachment).
1 (chick)	7 exclosure shoreline	On 28 August, the intact decomposed carcass of one small chick from SP89 was found west of 7.5 revegetation area. All three chicks from this brood were last observed on 22 June at two days old (no chicks known to fledge).
1 (chick)	7 exclosure shoreline	On 28 August, the intact decomposed carcass of one chick from SP203 was found 10 feet west of west fence at mid-7 exclosure shoreline. Chick appeared older than one week. All three chicks from this brood were last seen on 5 August at one day old (no chicks known to fledge).
1 (chick)	North Oso Flaco	On 28 August, the intact decomposed carcass of one chick from either SP105 or SP200 was found in the northwest corner of North Oso Flaco exclosure. Chick appeared to be less than one week old. All three chicks from SP105 were last observed on 12 June at two days old and all three chicks from SP200 were last observed on 5 August at one day old (no chicks were known to fledge from either brood).
1 (adult or older juvenile)	7 exclosure shoreline	On 2 September, the desiccated intact carcass of an unbanded adult or older juvenile was found on 7 exclosure shoreline.
1 (adult)	6 exclosure shoreline	On 3 September, the decomposed intact carcass of an unbanded adult was found on the southern portion of the 6 exclosure shoreline.
1 (chick)	6 exclosure shoreline	On 13 September, the desiccated intact carcass of one small chick from SP74 or SP194 was found on the northern portion of 6 exclosure shoreline. All three chicks from SP74 were last seen on 3 June at four days old during adult aggression between broods where one chick from SP74 was picked up and dropped (no chicks known to fledge). The two chicks of SP194 were last seen on 7 August at nine days old (no chicks known to fledge).

USDA United States Department of Agriculture

Animal and Plant Health Inspection Service

Wildlife Services

P.O. Box 255348
Sacramento, CA 95865-5348

Oceano Dunes State Vehicular Recreation Area

2010 Predator Management Report

Submitted To:

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Submitted By:

Jason Green, Wildlife Specialist
&
Valerie Burton, Assistant District Supervisor
San Luis District
CA Wildlife Services Program

Introduction

Prior to the 2010 California Least Tern (LETE) and Western Snowy Plover (SNPL) nesting season, USDA-APHIS-Wildlife Services, entered into an agreement with Oceano Dunes State Vehicular Recreation Area (ODSVRA) to conduct predator management activities in the LETE and SNPL nesting areas. Wildlife Specialist (WS) Jason Green was assigned to the ODSVRA project to assist with mammalian and avian predator observations and removal for nesting SNPL and LETE protection.

On March 1, 2010 WS Jason Green began working for the LETE and SNPL projects at the ODSVRA. The first two weeks of work consisted of completing mandatory training (firearms training, trapping, ATV training, defensive driving, civil rights) which involved all aspects of the project. On March 4, 2010 WS Jason Green met with Senior Environmental Scientist, Ronnie Glick, to discuss the project and expectations of Wildlife Services throughout the season. On April 7, 2010, a predator management meeting was held at the ODSVRA to discuss predation of SNPL nests and the actions needed to be taken with regard to predator activity.

Methods of Predator Management

WS Jason Green utilized multiple methods in an effort to provide predator management for SNPL and LETE protection. Methods consisted of pole trapping, calling, spotlighting, shooting, cage trapping and padded leg-hold trapping. Daytime surveys were also conducted to monitor predator activity at ODSVRA.

Daytime surveys were conducted by driving and walking through the dunes, along the shoreline, as well as looking through binoculars in an attempt to locate predators. Positive identification was made after locating a predator. Surveys were conducted near the Dune Preserve/Dune Lakes (south of Arroyo Grande Creek), Pavilion Hill, Eucalyptus/Tabletop, Pipeline Re-vegetation, Boy Scout Camp/Refinery, Maidenform, Oso Flaco, North and South Oso Flaco (Appendix 1). WS Jason Green made an attempt to be in the field Monday through Friday depending on project related assignments to conduct daytime surveys.

Spotlight surveys were conducted by driving through the dunes at night and searching for eye shine reflection from predators with the use of a spotlight. After eye shine was located, binoculars were used for positive identification. WS Jason Green only utilized spot lighting for the removal of red fox near the campgrounds and maintenance.

Trapping was the most effective method to manage predator activity for the LETE and SNPL project at the ODSVRA. Trapping methods included pole traps for avian predators, mainly Great Horned Owls, cage traps for managing skunks and raccoons and padded leg hold traps for coyotes and red fox. Calling was also an effective method to remove coyotes.

Results of WS Efforts

Removal efforts were directed by targeting individual predators that were determined to pose a predation threat to SNPL and LETE nesting success. ODSVRA staff, WS Jason Green, Paul Young (Ventana Wildlife Society), and Doug George (PRBO Conservation Science) monitored predator activities daily.

Coyotes were observed entering the shoreline exclosure where SNPL forage throughout the season. Coyotes were also common in other areas near the SNPL and LETE nesting site and occasionally inside the larger nesting exclosure. WS Jason Greens' observations of coyotes entering the exclosures, shoreline and other surrounding areas were reported to ODSVRA Resource Field Leads. WS Jason Green and/or ODSVRA Resource staff monitored coyote activity and the travel paths used to enter and exit the re-vegetation exclosures and shoreline areas daily. Due to the predation threat coyotes pose to nesting SNPL and LETE and their chicks, the decision was made to begin predator control of the coyotes on April 12, 2010.

On May 6, 2010, one adult female coyote was removed east of the Oso Flaco boardwalk. On May 7, 2010, two coyotes were removed from the open riding area at the ODSVRA, one male east of Pipeline re-vegetation area and one female near Boy Scout. On May 14, 2010, two adult male coyotes were removed from the South Oso Flaco fore dunes near the shoreline. On May 20, 2010, one female coyote was removed from South Oso Flaco near the shoreline. On May 21, 2010, two female coyotes were removed in South Oso Flaco near the fore dunes at the southern boundary. On May 25, 2010, one male coyote was removed in South Oso Flaco near the shoreline at the southern boundary. All the coyotes removed were individuals targeted due to their presence in the vicinity of and threat they pose to the SNPL nesting site (Table 1). Coyote activity on the shoreline of the exclosures decreased dramatically after the removal of these animals. No SNPL remains or bands were ever found after necropsies were performed on these coyotes or in scat examined when present throughout the season.

Throughout the season, Great Horned Owl tracks were observed in or near SNPL and LETE nesting exclosures. On May 26, 2010, Paul Young and WS Jason Green were successful in capturing two Great Horned Owls near the Pipeline re-vegetation area. The owls were relocated the following day by Paul Young near Santa Cruz, California.

During the 2010 SNPL and LETE nesting season, Western and California gulls presented a threat at the ODSVRA site. On July 9, 2010, an adult western gull was seen acting suspiciously around SNPL chicks on the shoreline of the exclosure near the 7.5 re-vegetation area. Earlier that day resource staff had observed a gull eat a SNPL chick in the area. A decision was made to lethally remove the gull that day (Table 1). Upon removal, a necropsy was performed on the gull and three blue, plastic bands, likely from one depredated SNPL chick, were discovered.

Throughout the nesting season there were several reports of an adult male Northern Harrier near the SNPL nesting sight. On May 12, 2010, a male harrier was observed perching in 8 exclosure and flew south clutching a small prey item. Several times throughout the season resource staff observed a male harrier flying over the sight. WS Jason Green observed eight sightings of female harriers throughout the season. No harriers were removed by Wildlife Services.

Skunks and raccoons were observed entering the nesting SNPL and LETE exclosure throughout the season. Raccoon tracks were often observed throughout the nesting exclosures and in the north Oso Flaco fore dunes. Raccoons were also present in the north Oso Flaco fore dunes and were considered a potential threat to the project. Four raccoons were removed from the north Oso Flaco fore dunes during the season. Skunks were also considered a threat in the north Oso Flaco fore dunes. On June 21, 2010, a nest was reported depredated by a skunk in north Oso Flaco. One skunk was trapped on June 30, 2010 near the depredated nest in north Oso Flaco. Two more skunks were removed from north Oso Flaco on July 7, 2010. (Table 1)

Red fox was observed north of the SNPL and LETE nesting site and is a non-native predator that poses a threat to many native species including SNPL and LETE. WS Jason Green was successful in removing three red fox. On May 27, 2010, one adult red fox was removed near the Mid Ramps area west of the campgrounds. On June 8, 2010, one adult red fox was removed west of the campgrounds in the fore dunes. On August 6, 2010, one adult red fox was observed near the maintenance buildings at the ODSVRA and was removed. (Table 1)

Predator Removal Summary: (Table 1)

Date	Species	Sex	Location
5-6-2010	Coyote	Female	East of Oso Flaco
5-7-2010	Coyote	Male	East of Pipeline
5-7-2010	Coyote	Female	Boy Scout
5-14-2010	Coyote	Male	South Oso Flaco
5-14-2010	Coyote	Male	South Oso Flaco
5-20-2010	Coyote	Female	South Oso Flaco
5-21-2010	Coyote	Female	South Oso Flaco
5-21-2010	Coyote	Female	South Oso Flaco
5-25-2010	Coyote	Male	South Oso Flaco
7-9-2010	Western Gull		7 exclosure shoreline
6-30-2010	Striped Skunk		North Oso Flaco
7-7-2010	Striped Skunk		North Oso Flaco
7-7-2010	Striped Skunk		North Oso Flaco
6-29-2010	Raccoon	Female	North Oso Flaco
7-7-2010	Raccoon	Male	North Oso Flaco
7-7-2010	Raccoon	Male	North Oso Flaco
7-8-2010	Raccoon	Female	North Oso Flaco
5-27-2010	Red Fox	Male	Mid Ramps
6-8-2010	Red Fox	Female	Oceano Campgrounds
8-6-2010	Red Fox	Male	Maintenance Yard

Recommendations

WS recommends ongoing maintenance and maintaining the height of the perimeter fence surrounding the exclosures.

WS recommends public education that discourages wildlife feeding.

WS recommends that State Parks continue to enforce the leash law on the beach, especially during nesting season.

WS recommends that all garbage containers have reinforced lids, to prevent inadvertent wildlife feeding.

WS recommends removal of known SNPL and LETE predators prior to predation occurring.

WS recommends removal of dead animal carcasses from the beach that would provide an attractant and supplemental food source to scavenging predators such as coyotes.

Jason Green, Wildlife Specialist
San Luis District
CA Wildlife Services Program

Valerie Burton, Assistant District Supervisor
San Luis District
CA Wildlife Services Program

Appendix 1

Perimeter Fence
Exclosure Fence
Boneyard Interior Fence
Symbolic Fencing
Vegetation Islands
6
7
8
Cottonwood
North Eucalyptus
Eucalyptus
South Eucalyptus
7.5 Reveg.
Boy Scout
Pipeline Reveg.
Maidenform
Oso Flaco Lake
N
W
E
S
0.5
0
0.5 Miles
300
0
300
600 Yards

Avian Predator Management Project: Trapping and Relocation of Problem Avian Predators At Oceano Dunes State Vehicular Recreation Area in 2010

Department of Parks and Recreation- Oceano Dunes District/ Ventana Wildlife Society

Agreement Number – CO853004

Submitted to:

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Trapping and Relocation of Problem Avian Predators at
Oceano Dunes State Vehicular Recreation Area in 2010

Introduction

Oceano Dunes State Vehicular Recreation Area (ODSVRA) is in southern San Luis Obispo County, California. The park encompasses approximately 4900 acres of coastal sand dunes and approximately nine linear miles of coastline. The ODSVRA contains nesting habitat for California least terns *(Sternula antillarum browni)* and western snowy plovers *(Charadrius alexandrinus nivosus).* Contiguous nesting habitat continues to the south for approximately twelve miles in the Guadalupe-Nipomo Dunes complex (Henkle 2001 Report). The California least tern is currently listed as a state and federally endangered species. The Pacific Coast population of the western snowy plover is federally listed as threatened.

Due to human activities that alter the coastal environment, modern California coastal shorebird colonies are usually located in islands of partially native habitat surrounded by acres of farmland, housing tracts, recreational areas, marinas, and other developed areas. This has resulted in concentrations of rare or declining bird species in these remnant refuges, or "natural" areas. It also results in concentrations or localizations of predators because the prey they hunt is restricted to these small islands of habitat. In most predator-prey relationships, predator pressure is not severe enough to cause prey populations to decline. However, intensive predation at small, isolated breeding colonies can be a problem for certain declining species of birds by severely reducing their productivity. In response, biologists have initiated programs at some colonies to reduce predation. Since not every predator living in the vicinity of a particular breeding colony will prey on that species, predator removal and translocation is designed to address certain individuals that are actually targeting, or are likely to target, the prey species in need of protection.

During the 2001 plover and tern nesting season at the ODSVRA, before a predator management plan was in effect, loggerhead shrikes *(Lanius ludovicianus),* were regularly observed hunting within the nesting colony exclosure fencing, and the ODSVRA resource staff discovered at least seven USGS snowy plover bands in loggerhead shrike castings. The California Department of Parks and Recreation contracted with the UC Santa Cruz Predatory Bird Research Group in 2002 to monitor avian predator activities proximate to tern and plover nesting areas, evaluate the threat of avian predators to these nesting birds, determine which individual avian predators posed an unacceptable threat to the reproductive success of the terns and plovers at this site, and capture and relocate the predatory birds. The Ventana Wildlife Society (VWS) has been the fiscal agent for this contract for the last two years. The VWS usually consulted with the Senior Environmental Scientist at the ODSVRA, or his staff, before birds were removed. These avian predators were live-trapped, banded, and relocated in habitat appropriate for the species.

The Ventana Wildlife Society is a nonprofit organization dedicated to the conservation of native wildlife. The VWS was instrumental in the successful reintroduction of the Bald Eagle to Central California and is now working to restore a wild population of California Condors to the Central California area. The VWS also operates banding labs in order to monitor wild populations of birds in Central California in order to identify declines in local bird species before they become critical or irreversible. The VWS offers innovative solutions for problems regarding declining bird species, electrocutions and wire strikes, wind farm fatalities, and other unique raptor or endangered species issues.

Surveying, Monitoring, and trapping

Surveying for raptors and other avian predator species at the ODSVRA is a continual process throughout the tern and plover nesting season. Raptor populations are a combination of resident birds, transients, and, later in the season, juvenile birds dispersing into the ODSVRA from natal territories that are mostly outside the parks boundaries. Raptor movements within the park are dynamic, and areas need to be surveyed and resurveyed continuously in order to monitor the behavior of resident birds and to recognize the arrival of new avian predator species. Days that are not spent trapping are usually spent surveying or monitoring.

For the purposes of this report, single raptor sightings, or the total number of raptor sightings for a particular period were gathered from the ODSVRA's predator sighting log book, which consists of a combination of observations from Paul Young (VWS/The Bird Group) biological technician), Doug George (PRBO Conservation Science), Jason Green (USDA Wildlife Services), and the ODSVRA ecologists in the field each day. The observations of avian predators by ODSVRA ecologists greatly assist VWS efforts to monitor raptor movements within the park. There was a bias in the number of avian predator sightings reported toward the morning and early afternoon hours because this was the time most ODSVRA ecologists involved with plover and tern nest checks and plover and tern chick banding efforts were in the field. In the mid-afternoon and evening hours, just one or two park ecologists were in the field engaged in predator watch or monitoring plover and tern activity. Avian predator sightings recorded after 3 September, when there were no longer any unfledged plover or tern chicks at this site, were, generally, not included in this report.

Biological Technician Paul Young, the primary predator specialist at this site since 2002, educated ODSVRA ecologists in raptor identification and behavior. Frequent visits in the field and at predator management meetings between Young and resource ecologists served to keep resource ecologists, contractors, and management involved and up to date with the latest avian predator sightings and concerns. Regular e-mail updates from Young of his sightings, activities and concerns provided the primary flow of information regarding his daily activity.

Because ODSVRA is not accessible by paved roads, a four wheel drive vehicle was essential in order to trap and survey within the park. In addition, an all-terrain vehicle was also used on occasion in order to more quickly access certain areas of the park. In 2008, Paul Young was federally permitted to conduct supervised predator control activities within the plover and tern nesting areas which are closed to the public. This included the use of a vehicle along the shoreline area, which greatly facilitated surveying and trapping efforts in these areas.

Surveying consisted of moving slowly through a particular area, recording the sightings of raptors and other predators, and searching for nocturnal predator tracks. During the 2010 tern and plover nesting season at the ODSVRA, seventeen days were spent surveying the north portion of the park from Arroyo Grande (AG) Creek south to the Maidenform Revegetative Area (figure 1.) The Conocophillips refinery area was surveyed on six days. The Oso Flaco (OF) area was surveyed on fifteen days. The North Oso Flaco (NOF) Foredunes were surveyed on fifteen days. The South Oso Flaco (SOF) Foredunes were surveyed on ten days. In addition, the shoreline area was monitored or surveyed by vehicle on twenty days. The Dune Lakes area was surveyed by either Paul Young or Jason Green on eight days. Since gaining access to the privately-owned Dune Lakes was difficult, this area was surveyed from the Dune Lakes overlook area within the park's boundaries. The Shell Beach historic peregrine falcon nest site was surveyed on six days. For this report, days spent trapping were not considered surveying or monitoring days, although monitoring was often conducted while trapping.

Monitoring consisted of observing areas for extended periods with binoculars and a spotting scope from a single location, usually a parked vehicle or prominent observation point. Monitoring efforts usually occurred from the shoreline looking for suspicious gull activity (15 days), or the Oso Flaco area near the south end of the North Oso Flaco Foredunes, where avian predators, particularly shrikes, harriers, and kestrels would funnel through the NOF Foredunes and into the 8 exclosure.

A trap day is defined as any day or night when trapping was attempted. The length of any one trap day varied with the threat the avian predator posed to the plovers and terns, conditions, species targeted, and success. Sixty three days were spent trapping predatory birds at ODSVRA in 2010. Fourteen raptors or avian predators were live trapped and relocated during the 2010 season. These were three American kestrels (one adult female, one adult male, and one juvenile male), two loggerhead shrikes (two juveniles, unknown sex), three great horned owls (three adult males), one northern harrier (one adult female), three peregrine falcons (three juvenile females), and two red-tailed hawks (one immature female and one juvenile female) (Table 1). One kestrel was trapped as it hunted just west of the refinery (adult male) and two kestrels (adult female, juvenile male) were trapped inside the south end of the NOF Foredunes Exclosure (Figure 2). One shrike (juvenile) was trapped at the NE corner of the Pipeline Revegetation Area, and one shrike (juvenile) was trapped inside the south end of the NOF Foredunes Exclosure. One great horned owl (adult male) was trapped at the Eucalyptus Revegetative Area, and two great horned owls (adult male, adult male) were trapped at the Pipeline Revegetative Area. One northern harrier (adult female) was trapped in the Oso Flaco area. Three peregrine falcons (juvenile female, juvenile female, juvenile female) were trapped on the NOF Foredunes shoreline, the 7 Exclosure shoreline, and the open riding area just east of the 6 Exclosure. One red-tailed hawk (one immature female) was trapped on the 7 Exclosure shoreline as it perched in the 7.5 Revegetative Area, and one red-tailed hawk (juvenile female) was trapped at the SE corner of the Pipeline Revegetation Area. Eighteen days were spent attempting to trap kestrels, ten days were spent attempting to trap shrikes, five days were spent attempting to trap great horned owls, twenty one days were spent attempting to trap harriers, seven days were spent attempting to trap peregrine falcons, and two days were spent attempting to trap red-tailed hawks.

Birds live-trapped at the ODSVRA were put into padded and darkened animal carriers and transported and released as soon as possible in suitable habitat far enough away from the ODSVRA that they would be unlikely to return. If, on rare occasions, a bird could not be relocated the day of trapping, it was housed in a 12 ft. X 16 ft. flight pen, and fed until it could be relocated. Before release all birds were fitted with an appropriate sized USGS bird band. The three peregrine falcons trapped this year were also fitted with an alpha-numeric visual identification band (VID) on the unbanded leg. The large number and letter combinations on these VID bands can be read with the aid of a spotting scope in the field. The distance between the ODSVRA and the release site was determined by the species and the age of the trapped bird. Generally, juvenile birds were not taken as great a distance from the ODSVRA because they were in the process of dispersing from their natal areas. Adult, sub-adult, or immature birds were released a great deal farther away from the capture site. Since 2002, only one banded raptor that was trapped and relocated from the ODSVRA returned and was re-trapped. In 2009, a banded adult male kestrel was trapped at the refinery. It was originally trapped as an adult by Young at the refinery in 2008 and banded and released in San Jose. In 2010, a juvenile female peregrine falcon that was trapped just east of the 6 Exclosure in the open riding area on 30 August was found to be previously banded. This bird had a USGS band affixed to its left leg but did not have a VID band as well.

American Kestrel *(Falco sparverius)*

During the 2010 season three kestrels were trapped at the ODSVRA. An adult female was trapped early in the season from the south end of the NOF Foredunes. An adult male was trapped just west of the refinery in March prior to egg- laying, and a juvenile male was trapped at the south end of the NOF Foredunes late in the season. Eighteen days were spent attempting to trap kestrels.

On 4 February, Young observed an adult female kestrel perch hunting in the NOF Foredunes Exclosure. This bird was observed by him in this area on nine days, for long periods of time, before it was finally trapped on 23 February as it perch hunted from the south end of the NOF Foredunes. This bird was relocated to the Tehachapi area (Table 1) the next day.

As in previous years an effort was made to trap as many adult kestrels as possible prior to their nesting at the Conocophillips refinery area located approximately a mile and a half to the east of the 8 Exclosure. There have been no kestrel nests within the parks boundaries in recent years and the refinery provides the closest suitable nesting habitat for these birds. The refinery provides many nooks and crannies amongst the buildings and refinery equipment for the cavity-nesting kestrels to choose from. In earlier years, adult kestrels have been seen on many occasions foraging over the ODSVRA foredunes, and then flying back to the refinery to feed their young. On 28 July 2007, Doug George observed a female kestrel perched at the north end of the NOF Foredunes with a medium-sized plover chick in its talons. Because kestrels are a well-known predator of tern and plover chicks, and they are also one of the more challenging raptors to trap over the open dunes and beaches, the preemptive removal of adult kestrels near their nest sites at the refinery is an important predator management technique at this site.

Trapping adult kestrels at the refinery prior their egg-laying is preferred because once their eggs are laid or an adult kestrel was caring for young, ethical considerations and permit restrictions relating to the well-being of the young kestrels, would prevent the VWS from removing the adults unless we could also remove the eggs or young and care for them.

Early surveys in February and March of 2010, revealed that at least one pair of kestrels had set up a territory near the refinery. On 25 March, an adult male kestrel was trapped prior to egg-laying as it hover-hunted west of the refinery. This bird was relocated to the Tehachapi area.

Although the refinery was the nearest suitable kestrel nesting habitat in relation to the ODSVRA, it was not the only suitable kestrel nesting habitat near the park. Along Highway 1, from Oso Flaco Road near the town of Guadalupe, north to Pier Avenue in Oceano, large eucalyptus groves and various man-made structures also provide nesting sites for kestrels, and they have been seen in these areas by Young during the nesting season. On 20 June 2007, Young observed an adult male kestrel catch prey from the east end of the Pipeline Revegetative Area and fly with this prey item approximately one and a half miles east where it was lost to view in the Eucalyptus groves just north of the refinery. This bird was probably delivering this prey to a nest in this area. On 06 June 2008, park ecologists again observed a kestrel catch a small prey item from this same area and immediately fly to the east where it was lost to view.

At the ODSVRA in 2010 there were twenty three kestrel sightings from 1 February to 1 September. There were ten sightings in February, two sightings in March, two sightings in April, no sightings in May, two sightings in June, four sightings in July, two sightings in August and one sighting in September. All the sightings in February were of an adult female that was perch hunting in the NOF Foredunes Exclosure and eventually trapped on 23 February. Significant sightings included a female kestrel perched on the west fence of the NOF Foredunes Exclosure on 12 June, a male kestrel perched in the 7.5 Revegetation Exclosure on 19 June, a male kestrel seen perched on the west fence just south of the 7.5 Revegetation Exclosure on 13 July, and a male and female kestrel perched together on the Interior Boneyard Fence and, later, flying into the NOF Foredunes Exclosure on 3 August. After each of these sightings Paul Young trapped in the areas these kestrels had been observed for two or three days but there were no additional kestrel sightings in these areas at that time.

On 30 July, Young observed a male kestrel perch hunting inside the NOF Foredunes Exclosure from the West Boneyard Fence and was able to trap it there. This bird was a juvenile and was relocated to the Cuyama Valley on 31 July.

On 1 Sept, a female kestrel was observed perched on the east fence of the 7 Exclosure but was not trapped since only one plover chick remained on the shoreline and was scheduled to fledge on 3 September. This kestrel was flushed to the east by resource ecologists.

Loggerhead Shrikes *(lanius ludovicianus)*

Two juvenile shrikes were trapped during the 2010 plover and nesting season. One was trapped at the south end of the NOF Foredunes exclosure and one was trapped at the NE corner of the Pipeline Revegetation Area. Since these birds were not nesting adults, and did not have a strong vested interest in returning to a long held nesting territory, they were released in areas closer to the ODSVRA than had they been an adult shrike. Ten days were spent attempting to trap shrikes at the ODSVRA in 2010.

Loggerhead shrikes have been observed to prey upon least tern and snowy plover chicks at the ODSVRA in past years. In addition, in past years shrikes were strongly suspected in the deaths of several adult plovers killed inside small single nest exclosures with net tops.

Tern and plover chicks are particularly vulnerable to attacks from perch-hunting diurnal avian predators such as shrikes, kestrels, and red-tailed hawks that might perch-hunt near the shoreline of the exclosure areas. The typical plover chick defense response to an avian predator, after it is spotted, is to crouch and freeze and this works well, provided the avian predator does not stay in the area for an extended period. It is usually the case that the longer an avian predator remains in an area where plover and tern chicks are present the greater the likelihood the plover or tern chick avian predator defense response will prove inadequate over time. Unlike kestrels and red-tailed hawks, shrikes are exclusively perch hunters, and have the smallest territories of any avian predator found at the ODSVRA. Because their territories are so small, a shrike whose territory coincides with an abundance of plover or tern chicks can be expected to be found there most of the time. This, combined with the active predatory behavior of shrikes, and the slow and methodical way they hunt their territories, makes them a species of real concern from an avian predator management standpoint at the ODSVRA. A pair of adult shrikes, or a single shrike, whose territory included part of the Boy Scout area or the refinery area, was sometimes, in years past, not trapped, because their relatively small territories were far enough removed from the plover and tern habitat.

Early surveys and monitoring efforts at the ODSVRA during the 2010 season revealed only a single shrike. This unpaired bird was seen on seven occasions in March in the Dune Preserve area (Figure 1) approximately one mile south of the 6 Exclosure. This bird dispersed from this area before April and was last seen on 14 March.

On 30 June, Paul Young observed a shrike perch hunting from inside the south end of the NOF Foredunes Exclosure and the West Boneyard Fence. This bird was trapped later in the day and upon a closer examination of its plumage was identified as a juvenile. This bird was relocated the next day to the Cuyama Valley in Santa Barbara County.

From a predator management standpoint, the NOF Foredunes are a particularly sensitive area for perch-hunting avian predators to frequent, because the almost linear south to north elevated foredunes found in this area provide a clear view of the Boneyard Exclosure Area, the 8 Exclosure Area, and the NOF Shoreline Area. Of greatest concern would be a shrike that was perch- hunting from the fencing on the west side of the NOF foredunes where this predator would be on the shoreline amongst the plover chicks.

From the west fencing here, a shrike might move north along the shoreline fencing into the 8, 7, and 6 shoreline areas. Shrikes have been seen to do this at this site in past years.

On 15 July, Young observed another shrike perch-hunting inside the south end of the NOF Foredunes Exclosure. This bird flew east into the 40 Acre Wood area before it could be trapped. Young trapped in this area for the next two days but no shrikes were seen.

On 9 August, Young observed a shrike perched east of the SOF Foredunes and 100 yards south of the Oso Flaco Creek mouth. Young attempted to trap this bird in this location the next day but no shrikes were seen.

On 24 August, Jason Green (USDA-Wildlife Services) observed a shrike perched at the NE corner of the Pipeline Revegetation Area. This bird was trapped by Paul Young later in the day. A closer examination of this bird's plumage identified it as a juvenile. This bird was relocated the same day to the south end of the Santa Ynez Valley in Santa Barbara County.

The Pipeline Revegetation Area, along with the NOF Foredunes and the SOF Foredunes, are areas of special concern in regards to perch hunting avian predators. The Pipeline Revegetation Area juts into the area between the eastern portion of the 7 and 8 Exclosures, and provides an elevated view into the plover and tern nesting habitat. In past years shrikes have been seen to fly from the west end of the Pipeline Revegetation Area, directly west into the 7.5 Revegetation Exclosure on the shoreline. In a previous year, a shrike perch-hunting from the 7.5 Revegetative Exclosure and the West Fence near it, was observed to kill a tern chick in the 7 Exclosure and eat it in the 7.5 Revegetation Exclosure. This bird was strongly suspected in the disappearance of other plover and tern chicks in this area before it was finally trapped.

On 25 August, Young observed a shrike perch-hunting the south end of the NOF Foredunes Exclosure and the West Boneyard Fence for several hours. This bird flew south over the Oso Flaco Creek before it could be trapped. Young continued to trap for shrikes in this location for several days but no shrikes were seen again at the ODSVRA for the remainder of the active plover and tern nesting season. The last plover chick fledged, on schedule, on 3 September.

Shrikes were observed on thirteen days at the ODSVRA during the 2010 season. There were no sightings in February, seven sightings in March, no sightings in April and May, one sighting in June, two sightings in July, and three sightings in August.

Great Horned Owl *(Bubo virginianus)*

Three adult male great horned owls were trapped and relocated at the ODSVRA during the 2010 tern and plover nesting season. One was trapped at the Eucalyptus Revegatative Area (Figure 1) and two were trapped at the Pipeline Revegetation Area. Five nights were spent attempting to trap great horned owls. Trapping commenced at dusk and rarely lasted past midnight.

Great horned owls are a common resident species at the ODSVRA. Great horned owl predation of incubating or brooding adult terns and plovers at night is well documented at other sites and has occured in previous years at the ODSVRA. Great horned owl predation of plover chicks on the shoreline or tern chicks inside the nesting exclosures at the ODSVRA is less well known.

The great horned owl activity at the ODSVRA is monitored by regular surveys of all the revegetation areas surrounding the tern and plover nesting areas. During the 2010 tern and plover nesting season at the ODSVRA, the Pipeline, Maidenform, Eucalyptus, and Tabletop Revegetation Areas were surveyed for owl tracks by Paul Young on seventeen days. The Oso Flaco Area was surveyed on fifteen days, the NOF Foredunes Exclosure was surveyed on fifteen days, and the SOF Foredunes were surveyed on ten days. Careful attention was paid to owl tracks observed by resource ecologists and Doug George (PRBO-Conservation Science) inside the 6, 7, and 8 exclosure areas, which could not be surveyed by the VWS. When large owl tracks were observed inside the exclosure area they were reported over the resource line immediately so all interested parties were aware of them. While surveying, close attention was paid to the large great horned owl tracks left in the sand the previous night. During the windy portion of the season in March, April, and May, great horned owl tracks might be quickly covered over by wind-blown sand. For the rest of the season, the same track sign might remain, in sheltered areas, for weeks. Heavily vegetated areas, such as the Pipeline Revegetation Area and the Maidenform Revegetation Area, were sometimes surveyed during the day with the intent of flushing any roosting owls from the willow thickets in these areas. Spotlight surveys were conducted at night by Jason Green and the results were reported to Young. Since the actual predatory behavior of great horned owls is not easily observed at night at this site, the decision to preemptively remove a great horned owl from the park was influenced by the regularity and abundance of owl activity in a particular area as indicated by track sign and the proximity of this track sign to concentrations of nesting terns and plovers and their chicks.

During the 2010 tern and plover nesting season at the ODSVRA, large owl tracks were observed on forty two days either inside the exclosure areas, or in, or around, the revegetation exclosures immediately adjacent to these exclosure areas. This does not include the AG Creek area or the Carpenter Creek Area. There were no large owl tracks observed in February. In March, large owl tracks were observed on four days. In April, large owl tracks were also observed on four days. In May, large owl tracks were observed on twelve days. In June, large owl tracks were observed on eleven days. In July, large owl tracks were observed on seven days. In August, large owl tracks were observed on three days, and in early September, large owl tracks were observed on one day prior to 3 September when the active plover and tern nesting season ended after the last plover chick had fledged. Large owl tracks were observed on the greatest number of days in the 8 Exclosure (18), the Pipeline Revegetation Area (13), the Boneyard Exclosure (7), the Eucalyptus Revegetation Area (4), the NOF Foredunes Exclosure (3), the 7 Exclosure (3), the Oso Flaco Area (2), and the Tabletop Revegetation Area (1). There were no large owl tracks observed in the 6 Exclosure or the SOF Foredunes in 2010. These observations were limited only to the days that large owl tracks were observed at the ODSVRA, the number of sets of large owl tracks observed each day in any particular location varied.

On 16 March, Jason Green observed a great horned owl perched in the NE corner of the Eucalyptus Revegetation Area during the day. The Eucalyptus Revegetation Area is approximately 200 yards east of the 6 Exclosure. On 15 and 16 March, large owl tracks had been observed in the 7.5 Revegetation Exclosure. Paul Young attempted to trap this owl on 16 March at the Eucalyptus Revegetation Area but was unsuccessful and no owl was seen. On 17 March, he observed a great horned owl perched briefly at dusk on an open dune face at the NE corner of this revegetation area. On 18 March, Young trapped an adult male great horned owl at this location at dusk. This bird was banded and relocated the next day near Watsonville, Santa Cruz County.

It has been the experience of Young that the highly territorial and abundant great horned owls are the avian predator species most likely to quickly repopulate a vacant territory. Therefore, the timing of the removal of this species is critical, so as to provide adequate protection to the nesting terns and plovers but not trap great horned owls in unnecessary numbers. If possible, Young tried to confirm, prior to trapping, that a great horned owl was roosting in the Pipeline Revegetation Area or the Eucalyptus Revegetation Area. If this could be confirmed, then it would be unlikely that this individual was attached to an active nest site away from these areas since both the male and female adult great horned owls would both be expected to roost near their active nest site during the day.

Large owl tracks were observed in the vicinity of the nesting terns and plovers on the most number of days in May. In May, owl tracks were observed in the 8 Exclosure, the Pipeline Revegetetation Area, the Eucalyptus Revegetation Area, and the Tabletop Revegetation Area. On 25 May, Doug George observed that large owl tracks were "common" inside the 8 exclosure. On the night of 25 May, Jason Green and Paul Young attempted to trap a great horned owl, from the Eucalyptus Revegetation Area and the Pipeline Revegetation Area. At dusk, Jason green observed a great horned owl emerge from the Pipeline Revegetation Area but was not able to trap it. On 26 May, Green and Young concentrated their trapping efforts at the Pipeline Revegetation Area and two adult male great horned owls were trapped. One was trapped by Young using a Bal-chatri noose trap and one was trapped later that night by Jason Green using a pole trap. Both birds were banded and relocated the next day to the Santa Cruz area, Santa Cruz County.

On 09 March 2009, Young found an active great horned owl nest in an abandoned red-tailed hawk nest along the dirt road leading from the refinery to the Boy Scout Area. On 09 March 2010, surveys of this area revealed that this nest tree had blown down. On 21 and 31 May 2010, a single adult great horned owl was observed by Young and Green perched conspicuously during the day on a snag on the west side of the northern Oso Flaco Lake. On 08 June, Young observed a juvenile great horned owl perched in this same location. On 09 June, Green and Young observed an adult great horned owl and two juvenile great horned owls perched in the same tree in this location.

During the 2010 tern and plover nesting season at the ODSVRA, there were no owl tracks observed at an active plover or tern nest. Most Plover nest abandonments early in the season, that might have indicated the death of one of the adults, were coincident in timing to extreme wind events in March, April, and May. There were some plover nest abandonements later in the year that were probably not related to extreme wind events. A single plover nest in the Carpenter Creek Area, approximately two miles south of the 6 Exclosure, was abandoned between 22 May and 23 May and might possibly have been the result of avian predation. Several sets of owl tracks were observed in the vicinity of the 10 X 10 foot exclosure with a net top.

Peregrine Falcon *(Falco peregrinus)*

Three peregrine falcons were trapped and relocated at the ODSVRA during the 2010 tern and plover season. All three birds were juvenile females. The first was trapped at the NOF Foredunes shoreline and the second was trapped at the 7 shoreline. The third was trapped approximately 100 yards east of the 6 Exclosure. A total of seven days were spent attempting to trap peregrine falcons.

Peregrine falcons are a common local resident at the ODSVRA. There is a historic peregrine falcon nest site on a sea cliff in the Shell Beach area approximately three miles to the north of the northern boundary of the ODSVRA. There are also active peregrine falcon nest sites near Avila Bay to the north, an active peregrine falcon nest site near the small town of Edna to the east, and a suspected peregrine falcon nest site near Point Sal to the south. In addition to these resident adults, there are other adult peregrine falcons, sub-adult peregrine falcons, immature peregrine falcons, and juvenile peregrine falcons, that are usually seen each year at the ODSVRA during the tern and plover nesting season.

The historic peregrine falcon nest site near Shell Beach was surveyed five times. This nest site was inactive this year and an adult female was not seen at the nest cliff. An immature female peregrine and a sub-adult female peregrine were seen at different times perched at the nest site. An adult male, was seen here as well. No copulation was observed between this male and the sub-adult female. The sub-adult female was the bird most likely to be found perched near the historic nest site. On 1 April, Young observed a territorial dispute here between the sub-adult female and an immature female. At this time, the sub-adult female drove the immature female out of view to the south and then returned to the nest site. None of these birds seen at this location were banded.

Between 1 February and 8 September 2010, peregrine falcons were observed at the ODSVRA on at least 86 days. Peregrine falcons were seen in February (2 days), March (10 days), April (17 days), May (17 days), June (8 days), July (10 days), August (16 days), and September (4 days). In 2009, peregrine falcons were observed at the ODSVRA on at least 36 days. Most of the sightings in 2010 were of adult peregrines and these sightings were probably of the adult male peregrine previously attached to the Shell Beach nest site. It is possible that this bird, since it did not have to share incubation duties or nest defense efforts, was more free to expand its hunting range, and this might account for the over two-fold increase in peregrine falcon sightings at the ODSVRA in 2010.

It was sometimes difficult to identify peregrine falcons in the field according to age. The factors that contributed to these difficulties included visibility challenges (distance, heat shimmer, fog), the mobility of the falcon (perched, flying), the similarities between the plumages of peregrines of different ages (adult, sub-adult, immature, juvenile), and the experience of the observer. Despite the challenges of identifying peregrine falcons in the field according to age, most identifications were reliable enough to include in a breakdown of age specific peregrine falcon sightings at the ODSVRA for the 2010 season.

Adult peregrine falcons were observed on 27 days at the ODSVRA during the 2010 plover and tern season. These observations occurred multiple times in each month from February to September. Most of these sightings were probably of an adult male peregrine previously attached to the Shell Beach nest site. Early in the season, a sub-adult female peregrine falcon was probably misidentified as an adult on several occasions. Immature peregrine falcons were observed on 10 days. Most of these observations were probably of a female immature peregrine falcon. Immature peregrine falcons were observed in February, March, April and early May. No immature peregrine falcons were observed at the ODSVRA after 5 May. Sub-adult peregrine falcons were observed on 7 days. Most of these sightings were probably of a female sub-adult peregrine falcon. Sub-adult peregrine falcons were observed on 5 days from 1 February to 4 May, and then on two days on 7, and 8 September. Juvenile peregrine falcons were observed on 11 days at the ODSVRA. These sightings occurred between 17 July and 8 September.

Peregrine falcons were observed to persue, catch, and consume birds of many species at the ODSVRA in 2010. On approximately 21 occasions peregrine falcons were observed to catch or were observed eating a bird. During the 2009 season peregrine falcons were only observed catching or consuming birds on 11 occasions. In 2010, these included a rock dove (1), California gull (1), ring-billed gull (1), Heermans gull (2), unidentified gull (3), western grebe (2), common murre (1), whimbrel (1), snowy plover (2), swallow (1), small shorebird (1), unidentified small bird (4), and unidentified medium-sized bird (1). Adult peregrine falcons were identified as being associated with 8 of these kills, immature peregrine falcons were associated with 3 of these kills, sub-adult peregrine falcons were associated with 2 of these kills and juvenile peregrine falcons were associated with 2 of these kills.

On 6 August, Paul Young and resource ecologists observed a juvenile peregrine falcon catch a small shorebird high above the south end of the 8 Exclosure. After it had caught this bird the juvenile peregrine falcon landed in the Boneyard Exclosure and consumed its prey there. After this bird had flown to the south, Young and resource ecologists were able to retrieve prey remains including a male snowy plover head and both plover legs with the four colored bands still attached. This adult male plover was identified as the attending adult associated with two small chicks last seen at the 8 Exclosure shoreline. Resource staff and Doug George captured the orphaned chicks in the 8 Exclosure and transferred them to an animal care facility in Santa Barbara specializing in the care of snowy plovers.

On 27 August, an adult peregrine falcon was observed to catch a small shorebird, probably a sanderling or a snowy plover, over the 6 Exclosure. The falcon landed briefly in the 6 Exclosure before flying with its prey to the east where it was not relocated.

On 31 August, Doug George observed an adult peregrine falcon perched at the 8 Exclosure shoreline with a banded plover in its talons. This bird flew with its prey before the band combination could be read and was not relocated.

On 2 September, resource ecologist Dano Costello found a detached small shorebird wing at the NOF Foredunes shoreline. This wing was later identified by Doug George as belonging to a snowy plover. This snowy plover was probably killed by an avian predator and possibly killed by a peregrine falcon.

On 17 July, a juvenile peregrine falcon was observed to kill a gull at the 6 Exclosure shoreline and consume it there. This was the first day a juvenile peregrine falcon had been observed at the ODSVRA in 2010. It has been the experience of Young that juvenile peregrine falcons, when they start dispersing into the park in July, can be problematic from a predator management standpoint. Juvenile peregrine falcons are more likely than adult peregrine falcons to perch for long periods of time on the shoreline or inside the 6, 7, and 8 Exclosures. When juvenile peregrine falcons are flushed from these areas they are more likely to fly a short distance and re-perch, sometimes in a more sensitive area. Flushing a perched avian predator from inside the exclosure area requires time-consuming and careful coordination among the resource ecologists in the field at the time in order to prevent the tern and plover chicks from running out of the exclosures and into the open riding area. In past years, juvenile peregrine falcons have been observed perched inside the 6 Exclosure for periods of up to an hour in close proximity to crouched, flight-incapable tern chicks, that tend to congregate in this exclosure. When there are many flight- incapable but highly mobile tern chicks inside the 6 Exclosure, a juvenile peregrine falcon sometimes cannot be flushed from this area because a human presence inside the exclosure might cause tern chick movement that could be noticed by the falcon or tern chick movement out into the open riding area. For these reasons juvenile peregrine falcons are usually trapped when they are repeatedly observed perched inside the exclosure area.

On 18 July, Young was surveying for peregrine falcons on the 6 shoreline when he was notified by resource ecologists that a juvenile peregrine falcon was perched on the NOF Foredunes shoreline. This bird was trapped a short time later with a pigeon harness. Once in the hand this bird was identified as a female juvenile peregrine falcon. On his way off the beach, Young observed another juvenile peregrine falcon flying north to south along the 6 Exclosure shoreline. A juvenile peregrine falcon was observed perched at the Oso Flaco Creek mouth a short time later by resource ecologists and was then observed flying north through the NOF Foredunes, and the 8, 7, and 6 Exclosures. Young released the juvenile peregrine falcon into a 12 foot x16 foot flight pen at his residence and returned to the ODSVRA with additional trapping gear but there were no additional peregrine falcon sightings that day.

On 19 July, a juvenile peregrine falcon was observed by park ecologists as it perched on the 7 Exclosure shoreline. Young was able to trap this bird approximately 30 minutes later with a remote-controlled bow net. This bird was identified by Young as a female juvenile peregrine falcon. On this day both falcons were banded with a USGS band on one leg and a VID band on the other leg and released in southeast Kern County near Tejon.

On 30 August, another juvenile peregrine falcon was observed hunting over the 6 and 7 Exclosure and the shoreline west of these exclosures. This bird perched on the 6 Exclosure fencing and was flushed by resource ecologists and re-perched 100 yards east of the 6 Exclosure. Resource ecologists noted, at the time, that this bird had a silver band on its left leg. This bird was trapped at this location by Young using a pigeon harness. Upon closer examination this bird was identified as a female juvenile peregrine falcon. This bird already had a silver USGS band affixed to its left leg and therefore was not banded by Young. The band information was submitted to the USGS and the results are pending. This bird was relocated to the southeast corner of Kern County near Tejon on the same day it was trapped.

On at least nine days during the 2010 plover and tern nesting season at the ODSVRA, peregrine falcons were flushed by resource ecologists, Doug George, or Paul Young, from areas inside the plover and tern nesting exclosures.

Northern Harrier *(circus cyaneus)*

One adult female northern harrier was trapped and relocated at the ODSVRA during the 2010 tern and plover nesting season. This bird was trapped just east of the southeast corner of the NOF Foredunes Exclosure. A total of twenty days were spent attempting to trap northern harriers.

Harriers were observed on at least 58 days at the ODSVRA in 2010. From 1 February to 3 September, harriers were observed in February (10 days), March (9 days), April (19 days), May (4 days), June (2 days), July (8 days), August (5 days), and September (1 day). These sightings were of adult female harriers, adult male harriers, and juvenile harriers. Harriers are easily identified according to age and sex by differing plumage characteristics. However, it is difficult to differentiate between juvenile female harriers and juvenile male harriers since the plumage is the same for both and there is only a size difference.

Adult female harriers were observed on 35 days. Adult female harriers were observed on 10 days in February, 9 days in March, and 16 days in April. Often, there were multiple female harrier sightings each day. There were no adult female harrier sightings at the ODSVRA after 21 April. Most of the sightings of adult female harriers, as in previous years, were at the Oso Flaco Area and the heavily vegetated southeast corner of the NOF Foredunes Exclosure. Adult female harriers were also observed hunting, and perched at the NOF Foredunes Exclosure and the Pipeline Revegetation Area, but rarely were observed hunting low through the 8, 7, and 6 Exclosures.

In 2008, a pair of northern harriers nested near Mudd Lake, which is part of the privately owned Dune Lakes area approximately three quarters of a mile to the east of the 6 Exclosure. Because of the close proximity of this nest to the plover and tern nesting exclosures, observations of harriers hunting over the plover and tern nesting habitat were more common that year than in previous years. In order to reduce the chances of a similar situation occurring again, an effort was made to trap adult female harriers at the ODSVRA before harrier nesting could begin. On 3 March, Paul Young trapped an adult female harrier at the Oso Flaco Area just east of the southeast corner of the NOF Foredunes Exclosure. This bird was relocated the next day near Lone Pine in Inyo County. Because this bird was an adult and was attached to a territory it was necessary to relocate this bird a greater distance from the ODSVRA so as to increase the chance that it would not return.

In 2010, the Dune Lakes area was surveyed eight times during the season by Paul Young or Jason Green. Adult female harriers were observed in this area but no nesting occurred. Adult female harrier sightings continued at the ODSVRA until 21 April, but there were no adult female harrier sightings after this at the park. Juvenile harrier sightings at the ODSVRA began occurring fairly early (17 June), and it is likely that the adult female harrier seen in mid March and April began nesting after 21 April, probably to the south of the ODSVRA. On 12 May, the Chevron property was surveyed by Young and an adult male and adult female harrier were observed in the same area but at different times at this site.

Adult male harriers were observed on 9 days at the ODSVRA during the 2010 season. Rarely were adult male harriers seen more than once each day. During the 2009 season an adult male harrier was observed on 14 days. During the 2010 season adult male harriers were observed on 0 days in February, 0 days in March, 3 days in April, 4 days in May, 0 days in June, 1 day in July, 1 day in August, and one day in September. Most of these sightings were of an adult male harrier hunting low through the NOF Foredunes

Exclosure, the Boneyard Exclosure, the 8 Exclosure, and the 7 Exclosure. This bird usually came from the south and returned to the south, and judging by its behavior, was probably the same male harrier that has been seen hunting over the tern and plover nesting areas for the last several years.

During the 2008 and 2009 plover and tern nesting seasons at the ODSVRA, an adult male harrier was suspected by Young in the depredations of some of the plover nests that were lost to avian depredation. In 2008, Doug George was able to investigate a freshly-depredated plover nest in the Boneyard Exclosure Area after an adult male harrier was seen to immediately leave this area. The egg contents were still wet in the sand, and tracks consistent in size and shape to a male harrier were found at the nest site. On 10 June 2009, a male harrier was observed by resource ecologists, to land at an active plover nest in the 8 Exclosure and eat all three plover eggs there. Egg shell fragments were at the nest site and egg contents were clumped into the sand beneath the nest bowl.

In 2010, an adult male harrier was not observed to depredate a plover nest, and harrier tracks were not found at a depredated plover nest. Never-the-less, an adult male harrier was suspected by Young in the loss of eight plover nests that were lost to avian predation at the ODSVRA during the 2010 plover and tern nesting season. Most of these plover nest losses occurred in the earlier part of the season when male harrier sightings were more common. There have been few raven sightings at the ODSVRA for the last three years and crows have not been observed foraging over the 6, 7, or 8 Exclosure areas. Egg shell fragments were sometimes found at the nest site and the egg contents clumped in the sand beneath the nest bowl. The spillage of the egg contents was similar to those depredation events documented to involve an adult male harrier in 2008 and 2009. A snowy plover nest depredation involving corvids or gulls usually involves less spillage and the eggs are sometimes carried a short distance from the nest before being consumed. It is possible that the small size and shape of a harrier beak is the cause of this spillage. Avian predator tracks at a depredated plover nest are over-tracked within minutes as the adult plovers investigate their former nest and remove and carry off any remaining egg shell fragments.

When an adult male harrier was first observed hunting at the ODSVRA on 8 April, Young attempted to trap it. Trapping efforts usually occurred at the south end of the NOF Foredunes Exclosure Area or the west end of the Pipeline Revegetation Area. Most of these trapping attempts occurred in April and May. These trapping attempts proved unsuccessful, probably because of the overall infrequency of adult male harrier sightings and the long periods of time between sightings.

A juvenile harrier was first seen on 17 June at the ODSVRA during the 2010 season. Between 17 June and 1 September, juvenile harriers were observed on 14 days. Sometimes there were multiple sightings each day. On several days two juvenile harriers were seen together. Juvenile harriers were observed in June (2 days), July (7 days), August (4 days), and September (1 day). Juvenile harriers were most often seen hunting the Oso Flaco Area and then flying through the NOF Foredunes Exclosure or the Boneyard Exclosure and then hunting the Pipeline Revegetation Area, or, flying over the NOF Foredunes Exclosure and then flying high over the 8, 7, and 6 exclosure. During the 2010 season juvenile harriers rarely hunted low over the tern and plover nesting habitat. On several occasions, juvenile harriers appeared to be driven away from the exclosure areas by the mobbing behavior of the adult terns. Juvenile harriers have killed tern and plover chicks in past years at the ODSVRA and so must be monitored closely. During late July several days were spent attempting to trap juvenile harriers but these trapping efforts were suspended as the hunting behavior of the individual birds being observed was more clearly understood over time and the overall juvenile harrier sightings decreased significantly in August.

Red-Tailed Hawks *(Buteo jamaicensis)*

Two red-tailed hawks were trapped and relocated at the ODSVRA during the 2010 plover and tern nesting season. An immature female red-tailed hawk was trapped at the 7 Exclosure shoreline as it perched at the 7.5 revegetation Exclosure, and a juvenile red-tailed hawk was trapped in the open riding area as it perched at the southeast corner of the Pipeline revegetation Area. Two days were spent attempting to trap Red-tailed hawks.

Red-tailed hawks are a common local resident at the ODSVRA. There were three active red-tailed hawk nests located between the refinery and the eastern boundary of the park. All three of these nests fledged at least two young during 2010. There was also a suspected red-tailed hawk nest located in the vicinity of the Oso Flaco Lake area.

Red-tailed hawks have not been observed to take adult plovers or terns or their chicks or eggs at the ODSVRA. They have been observed to depredate plover nests and kill plover and tern chicks at other sites. Red-tailed hawks were the most commonly observed raptor at the ODSVRA. Most of these sightings were of a resident pair of adults that were seen almost daily hunting the heavily vegetated areas east of the plover and tern nesting areas. Earlier in the season there were sightings of immature red-tailed hawks and later in the season there were numerous sightings of juvenile red-tailed hawks. The resident pair of red-tailed hawks had not been trapped because they usually hunt to the east of the plover and tern nesting habitat and rarely are observed perch hunting in areas that overlook the areas that plover or tern chicks are located at. Red-tailed hawks that are observed perch hunting at the west end of the Pipeline Revegetation Area, the NOF foredunes Exclosure, the SOF Foredunes , or the 7.5 Revegetation Exclosure, are a concern. Red-tailed hawks that are observed perched in these locations are identified according to age so the correct individual can be trapped should this behavior persist.

During 2010, red-tailed hawks were observed perched in the NOF Foredunes on 8 days, the SOF Foredunes on 6 days, the 7.5 Revegetation Exclosure on 6 days and the west end of the Pipeline Revegetation Area on 1 day. Red-trailed hawks were observed perched in these sensitive areas in March (4 days), April (8 days), May (0 days), June (0 days), July (2 days), and August (3 days).

On a total of 6 days in March and April, a red-tailed hawk was observed perched inside the 7 Exclosure at the 7.5 Revegetation Exclosure. On three of these days this bird was definitely identified as an immature red-tailed hawk. On 23 April, an immature red-tailed hawk flew from the east and landed on the east fence of the 6 Exclosure. It then flew to the 7.5 revegetation Exclosure and perched there. Paul Young trapped this bird from this location several hours later with a Bal-chatri trap placed at the shoreline. At this time this bird was identified as a female immature red-tailed hawk. This bird was relocated the next day to the Cuyama Valley, San Luis Obispo County. After this bird was trapped, there were no additional sightings of red-tailed hawks perched inside the 7 Exclosure.

On 26 and 28 July, a juvenile red-tailed hawk was observed perch-hunting at the NOF Foredunes Exclosure. At the time there many plover broods on the shoreline adjacent to this area. Young attempted to trap this bird on 29 July at the Pipeline Revegetation Area because it had been seen to fly from this area to the NOF Foredunes on 26 July. On 29 July, a juvenile female red-tailed hawk was trapped in the open riding area from a perch location at the southeast corner of the Pipeline Revegetation Area. This bird was relocated the same day to the south end of the Santa Ynez Valley, Santa Barbara County. Other juvenile red-tailed hawks were seen at the ODSVRA after this bird was removed but there were no additional red-tailed hawk sightings at the NOF Foredunes for the rest of the active plover and tern nesting season. A red-tailed hawk was observed perched at the SOF Foredunes on three days in August.

Merlin *(Falco columbarius)*

No merlins were trapped at the ODSVRA during the 2010 plover and tern nesting season. No days were spent attempting to trap these birds.

Merlins are a small, highly migratory falcon that spend the fall and winter months in California and other southern areas, and migrate out of the ODSVRA at approximately mid-April to their nesting grounds to the north. Merlins and peregrine falcons are the diurnal raptors most likely to take adult snowy plovers at the ODSVRA. Merlins have usually migrated north before the snowy plover chicks have hatched, and are almost always gone before the least terns arrive at the ODSVRA to begin nesting.

During the 2004 to 2006 seasons at the ODSVRA, merlins were seen to catch and consume an adult snowy plover on one occasion each year. No merlins were seen to catch or consume any snowy plovers during the 2007, 2008, 2009, or 2010 seasons. Merlins were observed on 8 days at the ODSVRA in 2010. Merlins were seen in February (2 days), March (1 day), April (4 days), and May (1 day).

Other Raptors

Red-shouldered hawks *(Buteo lineatus)* were seen regularly at the campgrounds near Pier Avenue and probably nested near there. There were several sightings of this bird near Oso Flaco Lake, and one sighting of a red-shouldered hawk flying south to north over the east end of the Pipeline Revegetation Area.

Ospreys *(Pandion haliaetus)* were sometimes seen hunting for fish along the shoreline. There were fewer osprey sightings at the ODSVRA this year than last year.

Coopers hawks *(Accipiter cooperi)* were observed on nine days at the ODSVRA and were usually passing through or hunting the more-heavily vegetated portions of the park.

Sharp-shinned hawks *(Accipiter striatus)* were observed on six days. These sightings occurred in February, March, and April. Sharp-shinned hawks were usually seen as they migrated north to their nesting grounds.

Barn Owls *(Tyto alba)* were not observed at the ODSVRA during the 2010 tern and plover nesting season.

Burrowing owls *(Athene cunicularia)* were seen on four occasions perched in the 7.5 Revegetation Exclosure. Burrowing owl tracks were seen in this area and the 7, and 8 Exclosures. All of these sightings occurred in March and April and there were no sightings after 7 April. It is rare for burrowing owls to nest near the coast in the Counties of Santa Barbara or San Luis Obispo.

Golden eagles *(Aquila chrysaetos)* were seen on several occasions.

Recommendations

We encourage the park management to continue the practice of depositing wood chips and other substrates into the 6, 7, and 8 Exclosures early in the season. This substrate probably makes it harder for avian predators to locate incubating terns and plovers and their chicks. The manufactured tern chick shelters and the larger pieces of substrate can provide a hiding place for tern and plover chicks should an avian predator suddenly appear. In addition, the deposition of rack on the exclosure shoreline by resource ecologists should be continued in order to provide hiding places for plover chicks.

It is also important to maintain the current large size of the fenced tern and plover nesting exclosures. One of the most basic advantages nesting terns and plovers enjoy at the ODSVRA is the large size of the exclosure area in relation to the number of birds that nest there. If the exclosure area were to be reduced in size, the nesting plovers and terns would be more concentrated and probably more easily discovered by mammalian or avian predators. Lastly, we recommend that trapping and relocating raptors as has been done at ODSVRA should continue.

Acknowledgements

The Ventana Wildlife Society staff members and cooperators wish to thank Ronnie Glick and all the ODSVRA ecologists for their assistance with this project. In addition, we thank Doug George (PRBO-Conservation Science), and Jason Green (USDA-Wildlife Services). The compiled observations of park ecologists, Doug George, and Jason Green, were greatly appreciated and were used in the production of this report. We also thank the management of the Conocophillips Refinery and Chevron. We especially wish to thank Brian Latta and The Bird Group (formerly UC Santa Cruz Predatory Bird Research Group).

Table 1. Avian Predators Trapped at the ODSVRA and Relocated in 2010

Species	Trapped	Location OSDVRA Site	Released	Location (Area, County)	Sex	Age	USFWS Band	VID Band
AMKE	23-Feb	NOF	25-Feb	Tehachapi, Kern	F	Adult	1593-22068	NA
NOHA	03-March	Oso Flaco Area	04-March	Lone Pine, Inyo	F	Adult	1705-35722	NA
GHOW	18-March	Euc Reveg	19-March	Watsonville, Santa Cruz	M	Adult	788-47951	NA
AMKE	25-March	C P Refinery	27-March	Tehachapi, Kern	M	Adult	1593-22069	NA
RTHA	23-April	7 shoreline	24-April	Lancaster, Los Angeles	F	Imm	987-43894	NA
GHOW	26-May	Pipeline Reveg	27-May	Santa Cruz, Santa Cruz	M	Adult	788-47953	NA
GHOW	26-May	Pipeline reveg	27-May	Santa Cruz, Santa Cruz	M	Adult	788-47952	NA
LOSH	08-July	NOF	09-July	Cuyama Valley, San Luis Obispo	U	Juv	1751-02304	NA
PEFA	18-July	NOF Shoreline	19-July	SE Kern County	F	Juv	1807-28281	G over 3
PEFA	19-July	7 Excl Shoreline	19-July	SE Kern County	F	Juv	1807-28282	9 over 8
RTHA	29-July	Pipeline Reveg	29-July	Santa Ynez Valley, Santa Barbara	F	Juv	987-43893	NA
AMKE	30-July	NOF	31-July	Cuyama Valley, San Luis Obispo	M	Juv	1593-22005	NA
LOSH	24-Aug	Pipeline Reveg	24- Aug	Santa Ynez Valley, Santa Barbara	U	Juv	1751-02305	NA
PEFA	30-Aug	East of the 6 Excl	30-Aug	SE Kern County	F	Juv	1807-89166*	D over Y

* Previously banded

Figure 1. ODSVRA Location Reference Map

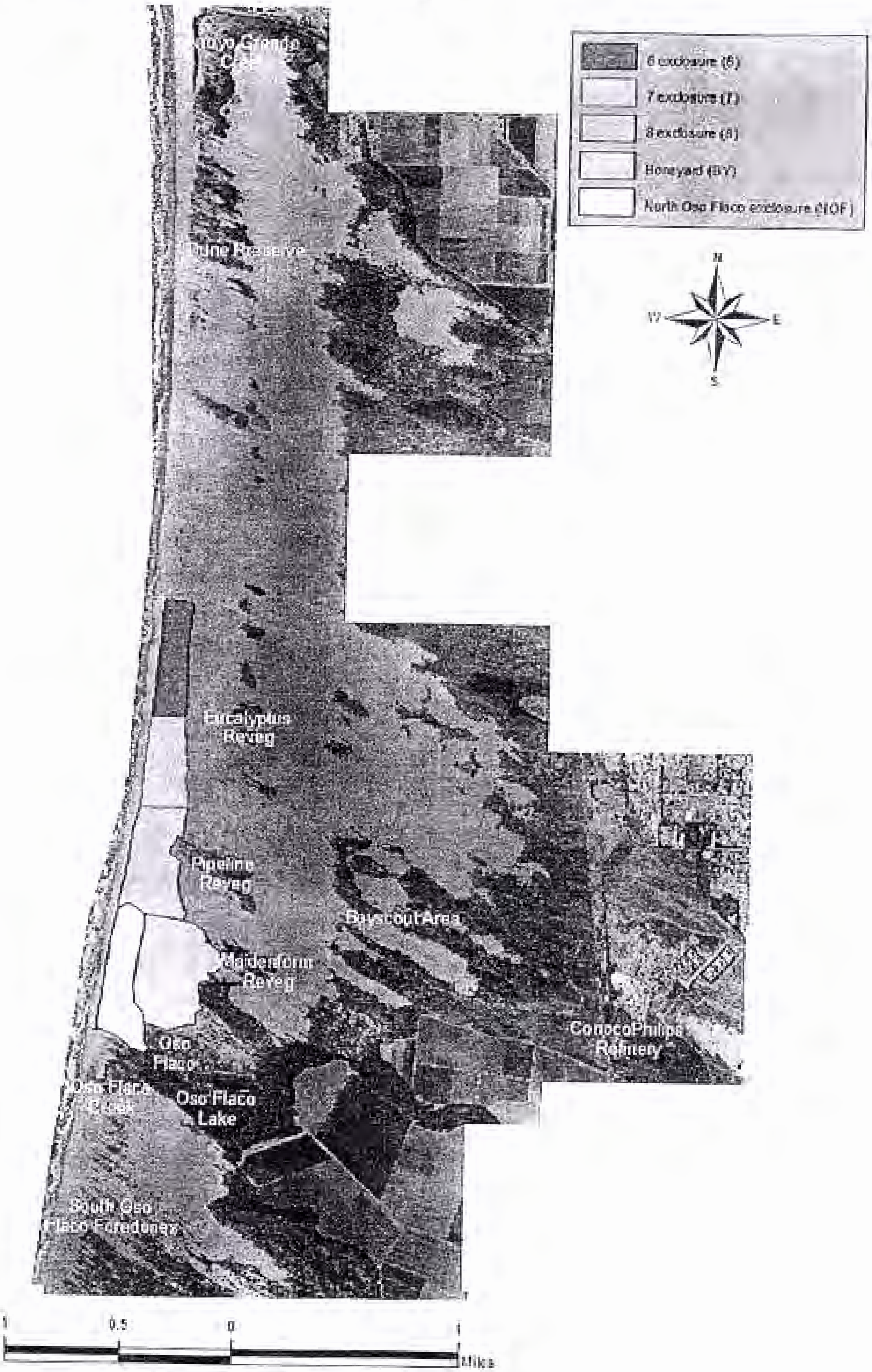
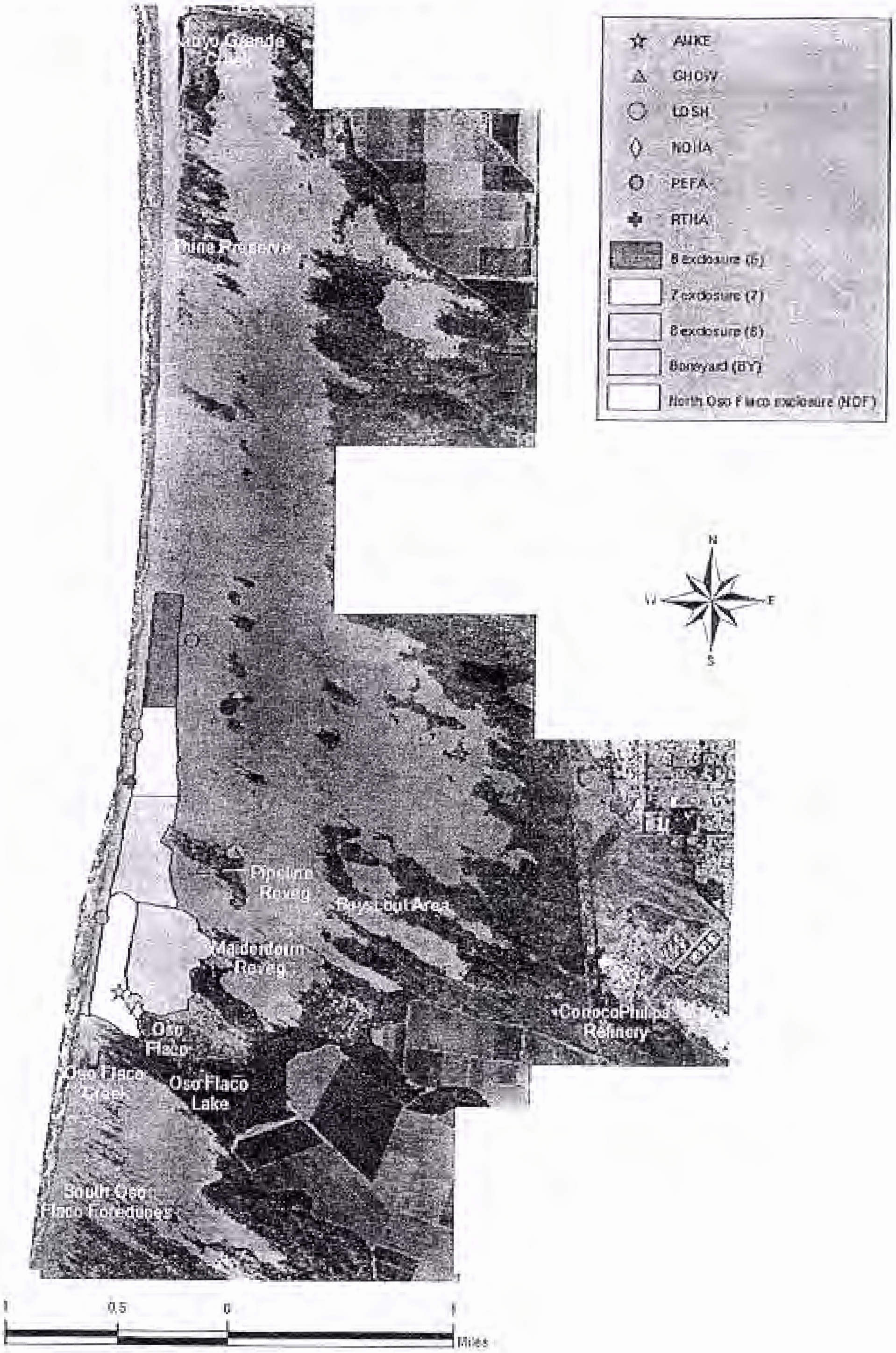


Figure 2. Avian Predator Trapping Locations



California Animal Health & Food Safety
Laboratory System
PO Box 1770
Davis, CA 95617
(530) 752-8700

Final
Version 1
This report supersedes all previous reports for this case

CAHFS Case #: D1002293
Referral #:
Date Collected:
Date Received: 03/09/2010
Case Coordinator: Leslie Woods, DVM, PhD, DACVP
Electronically Signed and Authorized By: Woods, Leslie on 3/15/2010 1:52:27PM

Email To:
OCEANO DUNES SVRA
rglick@parks.ca.gov

Collection Site:
OCEANO DUNES SVRA-RONNIE GLICK
340 JAMES WAY, SUITE 270
PISMO BEACH, CA 93449

Specimens Received: 1 Carcass;

Comments: 1 carcass

Case Contacts

Submitter	OCEANO DUNES SVRA	805-773-7180	340 JAMES WAY, SUITE 270, PISMO BEACH, CA 93449

Specimen Details

ID	ID Type	Taxonomy	Gender	Age
	CAHFS Internal ID	Snowy Plover		

Laboratory Findings/Diagnosis

Cause of death undetermined (see summary).
Gross and microscopic findings:
a. Abdominal muscle rupture
b. Parabronchial fluid and bacteria; Hafnia alvei isolated.

Case Summary

3-115-10. There were no new significant findings. This bird aspirated terminally, but the cause of the aspiration was not determined. The intestine protruding through the abdominal wall may have been due to a scavenger since I did not see any blood at the edges of the tear. The Hafnia was likely in the aspirated fluid so not likely a primary pathogen. I did not see any bruising on the head that may suggest trauma, but this does not rule out the possibility of trauma (with cerebral edema) in view of the location of this bird by the pole and the lack of any other findings. This completes testing on this case.

3-14-10. I did not see any gross or microscopic changes that would suggest an infectious cause of death. The intestines protruded through a rupture in the abdominal wall but it is difficult to determine if this was antemortem or postmortem due to the degree of autolysis. I did not see any hemorrhage associated with the rupture. There was fluid in the lungs with massive numbers of bacteria. Hafnia alvei was isolated from the lungs and liver. There was no associated inflammation (terminal aspiration). A final report will follow when all testing is complete.

Clinical History

Dead snowy plover found on March 6, 2010 at 12:36 in closed area of park (3 ft. East of W59WIM, 8 Excl.). Appears fresh, not decaying, some insects in eye cavity, not scavenged, no obvious external injuries. Found close to fence that has wood and metal posts.

Gross Observations

Postmortem state of this male Snowy Plover is fair-poor. The intestine protrudes through a rupture in the abdominal muscle. This bird is moderately fleshed. The lungs are red. The liver, kidneys, are unremarkable. The spleen cannot be found (autolysis). No bursa is seen grossly. The intestines are autolyzed. The contents from the gizzard are saved. There is abundant contents. No fractures are observed or palpated.

Bacteriology

BACTERIAL AEROBIC CULTURE

Animal/Source	Specimen	Specimen Type	Date Resulted	Results
D1002293-01	Snowy Plover	Liver Tissue	12-Mar-2010	Hafnia alvei Mod#
D1002293-01	Snowy Plover	Lung Tissue	12-Mar-2010	Hafnia alvei Lg# Mixed flora Rare

SALMONELLA CULTURE - AVIAN

Animal/Source	Specimen	Specimen Type	Date Resulted	Results
D1002293-01	Snowy Plover	Intestinal Contents	15-Mar-2010	No Salmonella detected

Biotechnology

Avian Influenza matrix gene qRT-PCR

Animal/Source	Specimen	Specimen Type	Date Resulted	Results
D1002293-01	Snowy Plover	Oropharyngeal Swab	11-Mar-2010	Negative

Histology

Brain, heart, liver, kidney, lungs, spleen, intestines, proventriculus, gizzard, skeletal muscle, feathered skin, peripheral nerves, trachea, esophagus, adrenal gland, testes are examined. There is proteinic edema fluid and bacteria within the parabronchi in the lungs with no associated inflammatory reaction. There are no other significant changes.

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Final
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CAHFS Case #: D1002700
Referral #:
Date Collected: 03/17/2010
Date Received: 03/19/2010
Case Coordinator: Mark L. Anderson, DVM, PhD
Electronically Signed and Authorized By: Anderson, Mark L. on 3/23/2010 9:57:48AM

Email To:
OCEANO DUNES SVRA
rglick@parks.ca.gov

Collection Site:
OCEANO DUNES SVRA-RONNIE GLICK
GRAND AVENUE - OCEANO DUNES PARK
PISMO BEACH, CA 93449

Specimens Received: 1 Carcass;

Comments: 1 Carcass

Case Contacts

Submitter	OCEANO DUNES SVRA	805-773-7180	340 JAMES WAY, SUITE 270, PISMO BEACH, CA 93449

Specimen Details

ID	ID Type	Taxonomy	Gender	Age
	CAHFS Internal ID	Snowy Plover		

Laboratory Findings/Diagnosis

Snowy Plover received for necropsy.
1. Poor postmortem condition.
2. Open coelomic cavity, extensive contamination by external debris with partial loss of internal organs.
3. No remarkable histologic lesions detected in tissues available for examination.

Case Summary

03/23/10:
No remarkable histologic lesions were detected in the tissues examined. The cause for the death was not determined.

03/19/10:
It was not possible to do routine cultures on the internal organs of this bird due to the postmortem condition and internal contamination. Histopathology will be attempted. Another report will be forthcoming.

Clinical History

Unbanded Snowy Plover found on 3/17/10 morning approximately 600 feet south of Grand Avenue in the vehicular driving area of Oceano Dunes State Park. Possibly driven over by vehicle, but cause of death unknown. Please check for bacteria or other illness that may be cause of death.

Gross Observations

Examined was a 42.4 gram Plover which was in poor postmortem condition. The eyes were sunken into the orbits. The bird is markedly flattened, dorsoventrally. The ventrum of the bird is covered by sand. The skin and coelomic wall of the ventrum is absent. The coelomic cavity is exposed to the exterior and the entire coelomic cavity contains particles of dirt and sand. The individual organs are difficult to identify. The heart can be identified. The trachea and lungs can be identified, although the lungs are covered by sand. The proventriculus and ventriculus are identified and the external surfaces are covered by sand. The intestine and liver can not be identified grossly. There were fragments of tissue, admixed with sand within the coelomic cavity, which were sampled for possible identification as liver or other organs. The spleen, kidneys and gonads could not be identified.

Biotechnology

Avian Influenza matrix gene qRT-PCR

Animal/Source	Specimen	Specimen Type	Date Resulted	Results
D1002700-01	Glick	Oropharyngeal Swab	22-Mar-2010	Negative

Histology

Histologic examinations were performed on samples of brain, trachea, lung, heart, kidney, proventriculus, ventriculus and skeletal muscle. The tissues are in fair postmortem condition. No remarkable histologic lesions were detected in the multiple sections of brain examined. In the sections from the internal organs, there are considerable artifacts, due to the presence of debris embedded within the tissue (sand). No significant histologic lesions were detected in any of the tissues at the sites of section. Liver, spleen and intestines were not identified.

California Animal Health & Food Safety Laboratory System

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Final
Version 1
This report supersedes all previous reports for this case

CAHFS Case #: D1009141
Referral #:
Date Collected: 09/10/2010
Date Received: 09/15/2010
Case Coordinator: Mark L. Anderson, DVM, PhD
Electronically Signed and Authorized By: Anderson, Mark L. on 9/18/2010 8:47:44AM

Email To:
OCEANO DUNES SVRA
rglick@parks.ca.gov

Collection Site:
OCEANO DUNES SVRA
340 JAMES WAY, SUITE 270
PISMO BEACH, CA 93449

Specimens Received: 1 Carcass;

Comments: 1 CARCASS

Case Contacts

Submitter	OCEANO DUNES SVRA	805-773-7180	340 JAMES WAY, SUITE 270 PISMO BEACH, CA 93449

Specimen Details

ID	ID Type	Taxonomy	Gender	Age
	CAHFS Internal ID	Snowy Plover		

Laboratory Findings/Diagnosis

Snow Plover:
1. Presumptive acute traumatic injuries with dorsoventral compression of the coelomic cavity, rib fractures, coelomic wall and skin lacerations with displacement and fragmentation of internal organs.
2. Histologic examination:
   A) Lung, liver kidney: Acute hemorrhage and tissue laceration.
   B) Small intestines: Cestode infection.
   C) Postmortem autolysis.
3. Toxicology unremarkable.

Case Summary

09/18/10:
The histologic changes are nonspecific and compatible with acute trauma. All tests are now completed and the results remain the same as previously reported.

09/15/10:
The cause of death of this Snowy Plover is not certain, but there are lesions consistent with acute trauma. Various tests are in progress and another report will be forthcoming.

Clinical History

This Western Snowy Plover was found dead at Oceano Dunes State Vehicular Recreation Area on September 10, 2010. Crushed fresh carcass of bird found in tire tracks on beach. Please run a full necropsy, including bacteria and parasites, to determine cause of death. It is a banded (VV:RB) adult that hatched at ODSVRA in 2009.

Gross Observations

Received was a Snowy Plover which was in fair postmortem condition. The bird is flattened dorsoventrally with lacerations through the skin on the right caudal aspect of the neck, right shoulder and extending through the coelomic wall in the right abdominal area. The abdominal viscera is displaced externally. There is focal hemorrhage on the surrounding feathers. The sternum is compressed with multiple rib fractures on the right thoracic wall. Internally, the organs have been displaced. The heart is separated from the major vessels and surrounded by hemorrhage. The lungs are dark red and filled with hemorrhage. The liver is lacerated in multiple points and displaced through the right abdominal wall. The area in and around the kidneys is difficult to assess with multiple lacerations and separation of the normal organs. It is thought that the animal is a female. No other remarkable histologic lesions are identified.

Bacteriology

Salmonella PCR and Culture

Animal/Source	Specimen	Specimen Type	Date Resulted	Results
D1009141-01	OCEANO DUNES	Intestinal Contents	16-Sep-2010	No salmonella detected

BACTERIAL AEROBIC CULTURE

Animal/Source	Specimen	Specimen Type	Date Resulted	Results
D1009141-01	OCEANO DUNES	Lung Tissue	17-Sep-2010	Mixed flora Rare
D1009141-01	OCEANO DUNES	Liver Tissue	17-Sep-2010	Coliform Sm# Mixed flora

Biotechnology

Avian Influenza matrix gene qRT-PCR

Animal/Source	Specimen	Specimen Type	Date Resulted	Results
D1009141-01	OCEANO DUNES	Oropharyngeal Swab	17-Sep-2010	Negative

Histology

Histologic examinations were performed on samples of brain, trachea, lung, heart, liver, kidney, testes, adrenal, crop, proventriculus, small intestine, pancreas and skeletal muscle. The tissues are in fair postmortem condition. In the sections of the lung, there is widespread acute hemorrhage into air spaces and intense congestion. The liver has widespread separation of the tissues with acute hemorrhage. There is no significant inflammatory change noted. Similar areas of tissue separation with acute hemorrhage are noted in the kidney. The spleen and testes are histologically unremarkable, but surrounded by hemorrhage. In the proventriculus, there is focal lymphoplasmacytic infiltrate in dense clusters in the interstitium between the proventricular glands. In the sections of small intestine, there are multiple cestodes attached to the mucosa. There is considerable autolysis of the mucosa.

Parasitology

FECAL EXAM - DIRECT WET SMEAR

Animal/Source	Specimen	Specimen Type	Date Resulted	Results
D1009141-01	OCEANO DUNES	Intestinal Contents	17-Sep-2010	No parasites seen

Toxicology

Reporting Limit (Rep. Limit): The lowest routinely quantified concentration of an analyte in a sample. The analyte may be detected, but not quantified, at concentrations below the reporting limit.

The detected liver mineral results are within acceptable or non-diagnostic ranges for this species.

HEAVY METAL SCREEN

Animal/Source	Specimen	Specimen Type	Date Resulted
D1009141-01	OCEANO DUNES	Liver Tissue	17-Sep-2010

Analyte	Result	Units	Rep. Limit	Units	Ref. Range
Lead	Not Detected	PPM	1.000	PPM	
Manganese	3.6	PPM	0.040	PPM	
Iron	270	PPM	0.200	PPM	

Mercury	Not Detected	PPM	1.000	PPM
Arsenic	Not Detected	PPM	1.000	PPM
Molybdenum	0.82	PPM	0.400	PPM
Zinc	38	PPM	0.100	PPM
Copper	6.7	PPM	0.100	PPM
Cadmium	6.5	ppm	0.300	ppm