STATE OF CALIFORNIA—THE RESOURCES AGENCY GRAY DAVIS, GOVERNOR

CALIFORNIA COASTAL COMMISSION
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October 17, 2002

To: California Coastal Commissioners and Interested Persons

From: Peter M. Douglas, Executive Director
Jaime C. Kooser, Deputy Director, Energy, Ocean Resources and Water Quality
Alison J. Dettmer, Manager, Energy and Ocean Resources Unit
Marina Cazorla, Analyst, Energy and Ocean Resources Unit

Subject: Commission determination of conformity with the Coastal Act of the Coastal Conservancy's enhancement plan *In Progress Review: Ancillary Data and Observations from Caulerpa Taxifolia Eradication Efforts at Agua Hedionda Lagoon and Huntington Harbor of the Southern California Caulerpa Action Team (SCCAT).*

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1. INTRODUCTION

Pursuant to Public Resources Code section 31258, the Coastal Conservancy requests the Commission to determine that the Conservancy's enhancement plan for the eradication of a highly environmentally hazardous invasive alga, *Caulerpa taxifolia* (referred to hereafter as "Caulerpa"), is consistent with Coastal Act policies. Such a determination will allow the Coastal Conservancy to disburse a $1,000,000 grant for funding of ongoing Caulerpa eradication work.

2. STAFF RECOMMENDATION

Motion: I move that the Commission find that the Coastal Conservancy's enhancement plan *In Progress Review: Ancillary Data and Observations from Caulerpa Taxifolia Eradication Efforts at Agua Hedionda Lagoon and Huntington Harbor of the Southern California Caulerpa Action Team* conforms with the policies of the Coastal Act.

Recommendation: The staff recommends a yes vote. Passage of the motion will result in adoption of the following resolution and findings. The motion passes only by affirmative vote of a majority of the Commissioners present.

Resolution: The Commission hereby finds that the Coastal Conservancy's enhancement plan *In Progress Review: Ancillary Data and Observations from Caulerpa Taxifolia Eradication Efforts at Agua Hedionda Lagoon and Huntington Harbor of the Southern California Caulerpa Action Team* conforms with the policies of the Coastal Act.

3. BACKGROUND ON *CAULERPA TAXIFOLIA*

On June 12, 2000, Merkel & Associates biologists surveying transplanted eelgrass discovered the invasive, non-native green alga *Caulerpa taxifolia* in Agua Hedionda Lagoon in San Diego County. This discovery marked the first time that Caulerpa was known to have occurred in the Western Hemisphere. On July 27, 2000, Caulerpa was reported to be present in Huntington Harbor in Orange County. Caulerpa grows quickly as a dense smothering blanket, covering and killing all native aquatic vegetation in its path when introduced in a non-native marine habitat. Fish, invertebrates, marine mammals, and sea birds that are dependent on native marine vegetation could be displaced or die off from the areas where they once thrived. Although warmer southern California habitats are most vulnerable, the whole California coast is at risk. All shallow marine habitats could be impacted. If this alga were to become established permanently along the State's coastline, it would have devastating ecological consequences.

In June 2000, the Southern California Caulerpa Action Team ("SCCAT") was established to respond quickly and effectively to the discovery of Caulerpa infestations in Southern California. The group consists of representatives from several State, federal, local and private agencies and is led by Robert Hoffman of the National Marine Fisheries Service ("NMFS"). The goal of SCCAT is to completely eradicate all Caulerpa infestations.

On August 7, 2000, the Executive Director of the Coastal Commission issued to Merkel & Associates, on behalf of NMFS and the California Department of Fish and Game ("CDFG"), Emergency Permit 6-00-99-G to eradicate Caulerpa from a small area of the inner Agua Hedionda Lagoon. The program included placement of tarps over areas of Caulerpa, treatment with chlorine, and capping the areas to preclude regrowth. On April 17, 2002, the Executive Director issued Emergency Permit E-02-012-G to NMFS for further eradication and monitoring activities (which superseded Emergency Permit 6-00-99-G). On July 5, 2002, NMFS submitted to the Coastal Commission a general consistency determination (CC-051-02) to cover past and future Caulerpa eradication efforts. Consistency determination CC-051-02 is tentatively scheduled for the Commission's consideration at the December 2002 hearing.

In October 2002, the SCCAT applied to the Coastal Conservancy for a $1,000,000 grant to fund ongoing Caulerpa eradication efforts. The Conservancy has prepared the subject enhancement plan to govern the grant. Public Resources Code section 31258 requires the Commission to make findings regarding the conformity of enhancement plans with the Coastal Act. The purpose of this staff report is to assess the enhancement plan for Coastal Conservancy funding of Caulerpa eradication work and its conformity with the Coastal Act.

4. SUMMARY OF THE ENHANCEMENT PLAN

The enhancement plan, entitled *In Progress Review: Ancillary Data and Observations from Caulerpa Taxifolia Eradication Efforts at Agua Hedionda Lagoon and Huntington Harbor of the Southern California Caulerpa Action Team*, describes ongoing and future Caulerpa eradication efforts and enhancement and restoration work for affected areas. Section 31258 of Division 21 (Coastal Conservancy) of the California Public Resources Code requires that:

> *(a) Following completion of a coastal resource enhancement plan, the conservancy shall forward the plan to the commission for determination of conformity of the plan with the policies and objectives of Division 20 (commencing with Section 30000). The commission shall have 60 days to review the project and transmit the findings on the plan to the conservancy. If no comments are received within the period, the restoration plan shall be deemed to be in accord with Division 20 (commencing with Section 30000).*
> *(b) Where the enhancement plan will be implemented in whole or in part in an area in which the commission retains coastal development permit jurisdiction pursuant to subdivision (b) of Section 30519, or in an area in which two or more local governments have jurisdiction, or where a local coastal program amendment is required to implement the plan, the commission shall be responsible for enhancement plan review and shall conduct the review in the following manner. The commission shall review the enhancement plan for consistency with the policies and objectives of Division 20, as provided in subdivision (a), for the area subject to retained coastal development permit jurisdiction pursuant to subdivision (b) of Section 30159 and where a local coastal program amendment is required, and shall review the plan for consistency with certified local coastal programs for areas under local government coastal development permit jurisdiction.*

The areas in which the enhancement plan will be implemented are all within the Coastal Commission's retained coastal development permit jurisdiction, therefore no local review of the enhancement plan's consistency with a local coastal program is required. The enhancement plan consists of two categories of activities: (a) Caulerpa eradication, containment, and access restrictions; and (b) Caulerpa surveying at infestation sites, and surveillance in areas of infestation sites and in areas at highest risk of infestation.

Eradication, Containment and Access Restrictions

Eradication or "treatment" of Caulerpa is achieved by installing impermeable tarps over infested areas weighted down by gravel bags. Chlorine in the form of either solid "pucks" or liquid solution is then inserted into these tarp-covered infested areas to bleach and kill the Caulerpa. Following treatment, sediment cores within treated patches are examined to see whether viable Caulerpa fragments remain and to determine whether additional "post-application" treatment is needed. Post-application treatment options include: dredging of selected patches and enclosing the site with silt screen using a suction dredge that will extract sediment and plant material to a depth of 20 centimeters; capping of infested areas using a geosynthetic liner and a sediment cap for a year or more; and monitoring and spot eradication to control resurgence from residual Caulerpa rhizoids.

Because fishing and anchoring of vessels have been identified as potential causes of the spread of Caulerpa to different locations, boat access in areas of infestation is either prohibited or restricted in certain areas of Agua Hedionda Lagoon and Huntington Harbor. In Agua Hedionda Lagoon, all fishing and anchoring of vessels within the inner lagoon is prohibited for an initial period of one year. In addition, recreational access to the Lagoon is regulated by establishment of zones with varying types of use limitations or restrictions to protect and facilitate eradication and surveying work. The City of Carlsbad regulates vessel access to Agua Hedionda Lagoon, in consultation with SCCAT, under Chapter 11.24 of the Carlsbad Municipal Code. In Huntington Harbor, temporary restrictions were requested of homeowners by the homeowners' association during initial treatment work. Shallow ponds are already closed to harbor traffic and are used only by paddleboats and swimmers. The infestation in the adjacent portion of the harbor that is accessible to boats is considered to present a low risk of spreading, and therefore no harbor closures have been necessary.

Surveying and Surveillance

"High-intensity" surveys of eradication areas are performed regularly to track the success of Caulerpa eradication. Eradication surveys are used in Agua Hedionda Lagoon to cover areas of known infestations and in areas where visibility prevents use of towed-diver surveys. Eradication surveys are the sole means of surveillance in Huntington Harbor because the infestation at that site is largely restricted to small saltwater ponds with low visibility and because the restricted nature of the ponds makes the towed-diver approach impractical. Eradication surveys are conducted by divers moving along deployed transect lines, which allows for a comprehensive search of areas where visibility may be reduced by poor water quality or dense eelgrass. Divers are spaced between 1 and 1.5 meters apart while surveying and in this manner can identify even small fronds of Caulerpa.

Surveillance surveys in infestation areas and at other areas at most risk of a new Caulerpa infestation area are also performed regularly. These surveys use divers that are towed at 1 to 1.5 knots along transects by a small boat using survey-grade differential GPS. Surveillance surveys occur not only in Agua Hedionda Lagoon, but also in other areas at risk of infestation, including outside the lagoon mouth of Agua Hedionda Lagoon, the entire Huntington Harbor (although infestation is currently limited only to two small ponds and a small portion in the harbor itself), and regional surveys along the southern California coastline. Surveillance surveys along the coastline have been performed at Alamitos Bay, Oceanside Harbor, Anaheim Bay, Mission Bay, Carlsbad offshore, Marina Del Rey, Ballona 'Del Ray' Lagoon, Newport Bay, Dana Point Marina, San Luis Rey River, San Diego River, Channel Islands Harbor, Ventura Harbor, Santa Barbara Harbor, and King Harbor. These surveys are usually performed using side-scan sonar, with spot checks by divers for areas of vegetation or "suspicious" survey returns. Divers also survey along beaches, walls, riprap, piers, discharge points, and any other potential entry points for Caulerpa.

5. CONFORMITY WITH COASTAL ACT POLICIES

5.1 Placement of Fill in Coastal Waters

Coastal Act §30233(a) states in part:

> *The diking, filling, or dredging of open coastal waters, wetlands, estuaries, and lakes shall be permitted in accordance with other applicable provisions of this division where there is no feasible less environmentally damaging alternative, and where feasible mitigation measures have been provided to minimize adverse environmental effects, and shall be limited to the following:*
>
> *(1) New or expanded port, energy, and coastal-dependent industrial facilities, including commercial fishing facilities.*
>
> *(2) Maintaining existing, or restoring previously dredged depths on existing navigational channels, turning basins, vessel berthing and mooring areas, and boat launching ramps.*
>
> *(3) In wetland areas only, entrance channels for new or expanded boating facilities; and in a degraded wetland, identified by the Department of Fish and Game pursuant to subdivision (b) of Section 30411, for boating facilities if, in conjunction with such boating facilities, a substantial portion of the degraded wetland is restored and maintained as a biologically productive wetland. The size of the wetland area used for boating facilities, including berthing space, turning basins, necessary navigation channels, and any necessary support service facilities, shall not exceed 25 percent of the degraded wetland.*
>
> *(4) In open coastal waters, other than wetlands, including streams, estuaries, and lakes, new or expanded boating facilities and the placement of structural pilings for public recreational piers that provide public access and recreational opportunities.*
>
> *(5) Incidental public service purposes, including but not limited to, burying cables and pipes or inspection of piers and maintenance of existing intake and outfall lines.*
>
> *(6) Mineral extraction, including sand for restoring beaches, except in environmentally sensitive areas.*
>
> *(7) Restoration purposes.*
>
> *(8) Nature study, aquaculture, or similar resource dependent activities.*

Coastal Act §30108.2 defines "fill" as "earth or any other substance or material ... placed in a submerged area." The tarps and gravel bags that are placed on the seafloor, although temporary, constitute fill under this definition. The total area of seafloor currently impacted by the tarps and

gravel bags is approximately 2.3 acres in Agua Hedionda Lagoon and 2.1 acres in Huntington Harbor, for a total fill area of 4.4 acres.

Coastal Act § 30233(a) authorizes a project that includes fill of open coastal waters only if it meets three tests. The first test requires the proposed activity to fit into one of eight categories of uses enumerated in Coastal Act §30233(a)(1)-(8). The second test requires that there be no feasible less environmentally damaging alternative. The third and last test mandates that feasible mitigation measures be provided to minimize the project's adverse environmental effects.

(1) Allowable Use Test

Coastal Act §30233(a)(8) allows for fill of coastal waters for "restoration purposes." The proposed project is a restoration project to restore marine resources via the eradication of an invasive, non-native species, and thus meets the allowable use test.

(2) No Feasible Less Environmentally Damaging Alternative

After qualifying as an allowable use under §30233(a), the Commission must find that there is no feasible less environmentally damaging alternative to the proposed project, *i.e.* the enhancement plan submitted to the Coastal Conservancy. There is no known effective alternative to the proposed use of chlorine treatments to eradicate Caulerpa. The SCCAT assessed two potential alternatives, mechanical removal and no action, but found both to be more environmentally damaging alternatives.

Mechanical Removal

The mechanical removal of Caulerpa is a means to reduce the volume of biomass requiring herbicide treatment and to protect against potential discharge of viable fragments that may be liberated by dying plants after herbicide treatment. Tests have included manual collection of alga by divers and two efforts using different suction dredging techniques (aspirator and centrifugal pumps) to remove plants and sediments.

Diver harvesting is moderately successful at removing the experimental volumes of material; however, considerable plant breakage occurs where rhizoids are firmly anchored in sediments or are intertwined with eelgrass rhizomes. To test the efficacy of suction dredging, small portions of an eelgrass bed were extracted using two different dredges. Suction dredging has a significant benefit over hand extraction in that smaller fragments of damaged algae are generally vacuumed up around the dredge nozzle and few escape the immediately vicinity of the nozzle. However, the dredging approach also has several drawbacks relative to hand harvesting. The suction nozzle is not as controlled as hand harvesting and many more small fragments would be generated. Some of these fragments would be released far beyond the influence of the suction head, where it would be necessary to collect them.

The two dredges evaluated produced substantially different results in that the aspirator type lacked adequate power to extract eelgrass and sediments. Plugging, burping, backwash, and the plume associated with these problems caused substantial resuspension of small fragments and

thus would aid the spread rather than the collection and containment of *Caulerpa.* Although the centrifugal pump dredge proved more powerful (assuming gallons per minute-GPM), it was also not capable of collecting all the plant debris. The greatest impediment to dredging of *Caulerpa* is the need to efficiently treat large volumes of water to remove viable plant material, while at the same time either dispose of clean water or return it to the lagoon. Approximately 11,000 GPM may be generated by the dredging operation and the total liquid volume may reach several million gallons.

No Action Alternative

Under the no action alternative, the *Caulerpa* infestation would continue unabated. Considering the invasive nature of *Caulerpa*, algae would continue to spread within Seagate Lagoons, Huntington Harbor, and within any other areas suitable to the growth of algae. The *Caulerpa* would displace native vegetation, sensitive eelgrass habitat, and have long-term adverse significant impacts on fish and aquatic ecosystems.

The Coastal Commission thus finds there is no feasible, less environmentally damaging alternative to the proposed enhancement plan, and therefore the enhancement plan is consistent with the second test of Coastal Act §30233.

(3) Feasible Mitigation Measures

The final requirement of Coastal Act §30233(a) is that filling of coastal waters may be permitted if feasible mitigation measures have been provided to minimize any adverse environmental impacts. The express purpose of the tarps and gravel bags is to prevent an adverse environmental impact, Caulpera, from spreading. To minimize any adverse environmental impacts that may be associated with the placement of tarps and gravels on the seafloor, they will be removed once eradication efforts are complete. The details of this mitigation program will be addressed in the NMFS's general consistency determination that will be considered by the Coastal Commission at the December 2002 hearing. Since the fill will be temporary, the Coastal Commission finds that the third and final test of Coastal Act §30233(a) has been met.

5.2 Marine Resources and Water Quality

Coastal Act §30230 states:

> *Marine resources shall be maintained, enhanced, and where feasible, restored. Special protection shall be given to areas and species of special biological or economic significance. Uses of the marine environmental shall be carried out in a manner that will sustain the biological productivity of coastal waters and that will maintain healthy populations of all species of marine organisms adequate for long-term commercial, recreational, scientific, and educational purposes.*

Coastal Act §30231 states:

> *The biological productivity and the quality of coastal waters, streams, wetlands, estuaries, and lakes appropriate to maintain optimum populations of marine organisms and for the protection of human health shall be maintained and, where feasible, restored through, among other means, minimizing adverse effects of waste water discharges and entrainment, controlling runoff, preventing depletion of ground water supplies and substantial interference with surface water flow, encouraging waste water reclamation, maintaining natural vegetation buffer areas that protect riparian habitats, and minimizing alteration of natural streams.*

The potential impacts associated with the enhancement plan's eradication and treatment activities for invasive Caulerpa in Agua Hedionda Lagoon and Huntington Harbor include: (1) water quality impacts from chlorine treatment, (2) impacts to benthic habitat from shading and chlorine treatment, and (3) impacts to eelgrass from shading and chlorine treatment.

5.2.1 Water Quality

Water quality impacts may result from unintentional releases of chlorine into the waters of Agua Hedionda Lagoon or Huntington Harbor. However, during eradication development and implementation at Agua Hedionda Lagoon, and during eradication at Huntington Harbor, water samples were collected from under the tarp, immediately adjacent to the tarp, and from the water column in the vicinity of the tarp. Free chlorine was undetectable outside the tarps in all cases, while concentrations remained adequate under the tarp to treat the Caulerpa. Chlorine demand under the tarp is high due to the large amount of organic material. Any chlorine that is not consumed through reactions with Caulerpa is quickly consumed by the substrate that has a high organic content. Measurements have indicated that once the treatment pucks have fully dissolved, chlorine is undetectable under the tarps within 24 hours.

If security of a tarp were compromised in some way, the release of water from under a tarp would be diluted immediately in the water column. When considering the volume of water in the immediate area of the tarp in relation to the volume under the tarp, any escaped chlorine would be diluted to an undetectable level and would present no threat to marine life. In addition to taking physical measurements, divers working on the project have not observed any ill effects on plants or animals of chlorine treatment beyond the tarped areas, although some fish are attracted to the tarps. The non-native yellowfin goby (*Acanthogobius flavimanus*), which is the most abundant species in the ponds, quickly colonize the margins of the tarps and fastening-sand bags in large numbers. The SCCAT believes that if there were inhospitable conditions around the tarps that these fish would move elsewhere or die, but neither has been observed.

5.2.2 Benthic Habitat

Impacts to benthic habitat may occur due to shading by tarps and gravel bags, and from direct chlorine exposure. Benthic organisms in treated areas are likely to experience high mortality. However, the area of treatment is small, currently a total of 4.4 acres, and once eradication is eventually completed, these areas are expected to naturally recover and recolonize the impacted

areas. In addition, the Caulerpa eradication enhancement plan will produce significant environmental benefits for benthic habitat and organisms in the form of restored habitat. If Caulerpa were left to expand unchecked, it would rapidly colonize and monopolize the seafloor, leaving no habitat available for native benthic vegetation and organisms.

5.2.3 Eelgrass

Eelgrass present in Agua Hedionda Lagoon or Huntington Harbor may be adversely impacted due to shading by tarps and gravel bags, and from direct chlorine exposure. However, the area of eelgrass potentially impacted is relatively small, a maximum potential impacted area of 4.4 acres (the current amount of area covered by treatment materials). Eelgrass on the perimeter of the tarped treatment areas may also be impacted. Despite these potential impacts to eelgrass, the overall impact of Caulerpa eradication efforts will be beneficial, as the eradication of Caulerpa will prevent existing eelgrass from being destroyed through the spread of Caulerpa, and will restore available habitat for eelgrass that is currently severely threatened. If Caulerpa were left to expand unchecked, it would rapidly colonize the seafloor, monopolizing available habitat for eelgrass and eventually destroying large areas of eelgrass. Therefore, Caulerpa eradication work is also eelgrass restoration work, and will have a net benefit for eelgrass and eelgrass habitat. Therefore, the enhancement plan is consistent with Section 30230 of the Coastal Act, which requires that "marine resources shall be maintained, enhanced, and where feasible, restored."

5.2.4 Conclusion – Marine Resources and Water Quality

Based on the above analysis, the Coastal Commission finds that the enhancement plan is consistent with the requirement that "marine resources shall be maintained, enhanced, and where feasible, restored" as required by Coastal Act §30230. The Executive Director also finds that the enhancement plan will be carried out in a manner such that the "biological productivity of coastal waters, streams, wetlands, estuaries, and lakes appropriate to maintain optimum populations of marine organisms and for the protection of human health shall be maintained," as required by Coastal Act §32031. The project is therefore consistent with Coastal Act §30230 and 30231.

5.3 Public Access and Recreation

Coastal Act §30210 states:

> *In carrying out the requirement of Section 4 of Article X of the California Constitution, maximum access, which shall be conspicuously posted, and recreational opportunities shall be provided for all the people consistent with public safety needs and the need to protect public rights, rights of private property owners, and natural resource areas from overuse.*

Coastal Act §30211 states:

> *Development shall not interfere with the public's right of access to the sea where acquired through use or legislative authorization, including, but not limited to,*

the use of dry sand and rocky coastal beaches to the first line of terrestrial vegetation.

Coastal Act §30220 states:

Coastal areas suited for water-oriented recreational activities that cannot readily be provided at inland water areas shall be protected for such uses.

Coastal Act §30234.5 states:

The economic, commercial, and recreational importance of fishing activities shall be recognized and protected.

Coastal Act §30214 states:

(a) The public access policies of this article shall be implemented in a manner that takes into account the need to regulate the time, place, and manner of public access depending on the facts and circumstances in each case including, but not limited to, the following:

(1) Topographic and geologic site characteristics.

(2) The capacity of the site to sustain use and at what level of intensity.

(3) The appropriateness of limiting public access to the right to pass and repass depending on such factors as the fragility of the natural resources in the area and the proximity of the access area to adjacent residential uses.

(4) *The need to provide for the management of access areas so as to protect the privacy of adjacent property owners and to protect the aesthetic values of the area by providing for the collection of litter.*

The enhancement plan involves temporary restrictions of public access and recreation in Caulerpa-infested areas and possibly in areas that are infested in the future.

Recreational boating is restricted in the inner basin of Agua Hedionda Lagoon due to eradication and surveying activities, as regulated by the City of Carlsbad's municipal ordinance. On June 11, 2002, the City of Carlsbad approved a one-year plan to limit, but still provisionally allow, recreational boating in Agua Hedionda Lagoon. Different zones of the Lagoon are restricted or closed on a daily or weekly basis, and the height of wakes left by boats is limited. The overall impact of the restrictions are rotating closures based on the schedule of eradication and surveying work, but access and recreation are still allowed when closures are not in effect. In addition, public notices are posted at the Lagoon identifying which areas are open and closed to recreation on a given day, which will assist the public to identify where recreational activities are allowed.

In Huntington Harbor, temporary voluntary restrictions on entering Caulerpa-infested waters were requested of homeowners by the homeowners' association during initial treatment work. However, no new access restrictions are likely to necessary in Huntington Harbor, as the shallow ponds infested by Caulerpa are already closed to harbor traffic and are used only by paddleboats and swimmers. In addition, the infestation in the adjacent area of the harbor that is accessible to

boats is considered to present a low risk of spreading Caulerpa, and therefore no harbor closures have been necessary are or foreseen to be necessary.

Section 30214 of the Coastal Act requires that public access policies take into account the time, place, and manner of public access depending on the facts and circumstances relevant to each case. In the case of this Caulerpa eradication plan, temporary public access and recreation restrictions are necessary to perform Caulerpa eradication and surveillance work. This work will protect and restore sensitive marine resources in infested areas and prevent further damage to non-infested areas through prevention of the spread of invasive Caulerpa. Therefore, the enhancement plan is consistent with Section 30214 because Caulerpa eradication activities and public access restrictions in Agua Hedionda Lagoon (and in any potential new infestation areas) have been developed based on a scientific assessment and consideration of the time, place, and manner of restrictions necessary to protect marine resources.

Therefore, the Commission finds that the project, as conditioned, will be carried out in a manner that will not interfere with the public's access to and recreational use of the coast. The project is therefore consistent with Coastal Act Sections 30210, 30211, 30220, 30234.5, and 30214.

SUBSTANTIVE FILE DOCUMENTS

Attachment 1: Letter from Coastal Conservancy requesting Coastal Commission approval of enhancement plan

Attachment 2: Coastal Conservancy's enhancement plan *In Progress Review: Ancillary Data and Observations from Caulerpa Taxifolia Eradication Efforts at Agua Hedionda Lagoon and Huntington Harbor of the Southern California Caulerpa Action Team (SCCAT)*, including maps of Caulerpa-infested areas in Agua Hedionda Lagoon and Huntington Harbor

Coastal Conservancy

September 27, 2002

Peter Douglas
Executive Director
California Coastal Commission
45 Fremont Street, Suite 2000
San Francisco, CA 94105-2219

Dear ~~Mr. Douglas~~ Peter:

The California State Coastal Conservancy requests that the Coastal Commission review for consistency with the Coastal Act the attached document, "In Progress Review: Ancillary Data and Observations from Caulerpa taxifolia Eradication Efforts at Agua Hedionda Lagoon and Huntington Harbor of the Southern California Caulerpa Action Team (SCCAT)" (January 2002). Conservancy staff have identified this document as a resource enhancement plan pursuant to Division 21, Chapter 6 of the California Public Resources Code (Coastal Resource Enhancement Projects) and seeks a timely Commission consistency review to facilitate consideration of a $1 million grant for Caulerpa taxifolia (C. taxifolia) eradication.

CPRC Division 21, Chapter 6 authorizes the Conservancy to undertake resource enhancement projects subject to several conditions. Section 31252 requires that a resource enhancement project be consistent with an adopted enhancement plan. Section 31258 requires that the Conservancy disburse funds for a resource enhancement project only after the Coastal Commission finds the relevant enhancement plan consistent with the Coastal Act.

The Southern California Wetland Recovery Project (SCWRP) board of governors has recommended that the Conservancy fund ongoing C. taxifolia eradication efforts as part of the WRP's FY 2002-2003 Work Program. On Dec. 4, 2002 the Conservancy board will consider the SCWRP board's recommendation. Pursuant to Division 21, Chapter 6 (Sections 31251-31270), possible Conservancy actions include (1) adoption of the above mentioned document, prepared by Merkel & Associates for SCCAT, as an enhancement plan, and (2) authorization of a $1 million resource enhancement grant to the Agua Hedionda Lagoon Foundation for C. taxifolia eradication at Agua Hedionda Lagoon (San Diego County) and Huntington Harbor (Orange County). Given the threat to coastal resources posed by C. taxifolia, and given the limited remaining financial resources available for continuing eradication efforts, the Conservancy requests that the Commission review the enhancement

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plan for Coastal Act consistency at the November board meeting in San Diego. While Public Resources Code permits the Commission as many as 60 days to review the plan, prompt Commission action will enable the Conservancy to process the Foundation's proposal in an expeditious manner.

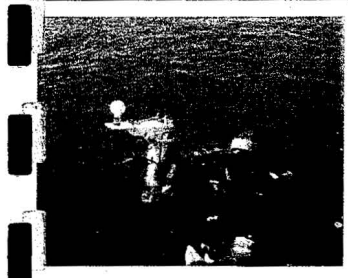
Sincerely,

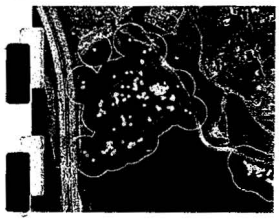
Deborah Ruddock
Project Manager

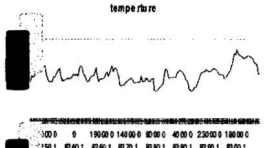
IN PROGRESS REVIEW:

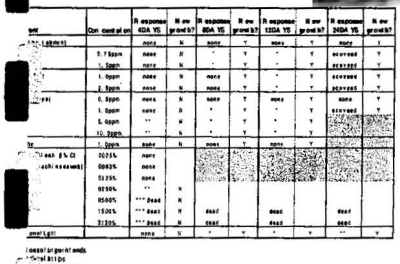
Ancillary Data and Observations from *Caulerpa taxifolia* Eradication Efforts at Agua Hedionda Lagoon and Huntington Harbour of the Southern California *Caulerpa* Action Team (SCCAT)

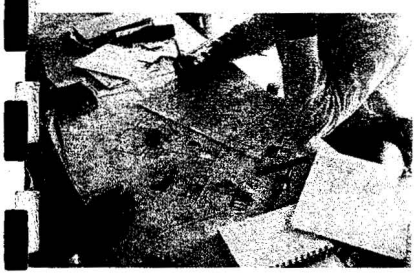
January 2001

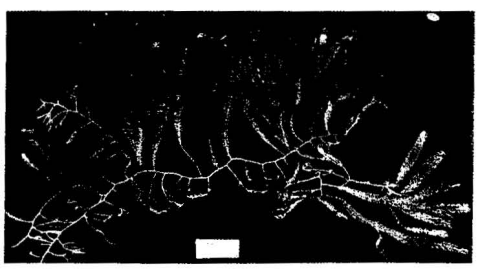












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FORWARD

On June 12, 2000, the Mediterranean strain of *Caulerpa taxifolia* was discovered in Agua Hedionda Lagoon, San Diego County, California, USA. This represented the first known occurrence of this invasive alga in the western hemisphere and, due to the highly publicized problems with this species in the Mediterranean Sea, it was recognized as a severe threat to ocean resources of Eastern Pacific coastal waters. Because of the concerns, immediate actions were taken to do the following:

- assemble a working group of resource managers, marine resource and pest control scientists, permitting agencies, marine biological consultants, land-owners and environmental stakeholder representatives. This group was termed the Southern California *Caulerpa* Action Team (SCCAT);

- contact *Caulerpa taxifolia* experts to collect information on the species, treatment and detection methods, outreach and surveillance efforts;

- initiate surveys to quantify the magnitude of the infestations within Agua Hedionda Lagoon;

- initiate testing of treatment options including dredging, chemical treatments, shading, and various treatment combinations;

- prepare an immediate action and eradication plan for the infestation;

- initiate public outreach to inform the region of the alga's presence, intended eradication, and need to be on the alert for other occurrences, and;

- initiate surveys, treatment, surveillance, and research actions outlined in the immediate action plan.

By July 5, 2000, the immediate action plan for eradication of *Caulerpa* was adopted by the SCCAT. By July 27, 2000 and as a result of outreach media coverage, the SCCAT was notified of a second infestation at Huntington Harbour, Orange County, approximately 60 miles north of Agua Hedionda Lagoon. Since the Huntington Harbour reports, no additional occurrences have been reported or located by SCCAT surveillance efforts. Both Agua Hedionda and Huntington Harbour are the subject of parallel treatment efforts.

As a basic premise of the efforts undertaken in southern California, the goal has been a complete eradication of *Caulerpa* from marine waters. Field actions within eradication sites have been directed exclusively toward survey and treatment, reserving basic research for laboratory programs which have been funded at USDA and the U.C. Davis, Bodega Bay Marine Laboratory. These efforts are not discussed in this document.

This information package is a compendium of notes, reports, and data collected by Merkel & Associates as a byproduct of eradication efforts and in support of survey and treatment activities.

As a result of the SCCAT focus on eradication, field data collection has been principally involved those investigations that directly aid in treatment efforts underway at the two infestation sites. As such, substantial information has been collected through *ad hoc* opportunistic investigations that, as a mission mandate, could not impact the efficiency of the eradication program. For this reason, much of the information presented herein is observational, partially replicated, or not replicated at all. Further, many of the various treatment or observation plots monitored during field efforts fell victim to lethal treatments before reaching a stage of finality in the studies. While the program has not fostered ideal field experimental designs and executions, it has been useful in advancing the practical and applied knowledge of *Caulerpa* eradication in the U.S.

The information compiled in this package is not organized into a formal report format, but is rather a collection of various documents generated over the course of our work. Much of the material reflects activities in progress or information used to assist in answering field questions for which no formal presentation of data has been contemplated. Because of the work-in-progress nature of the information, it will be useful in the future to prepare presentation papers on the work conducted. Some of these documents and figures can be very difficult to interpret without considerable familiarity with the project or significant explanation. Please feel free to contact us with any questions that may arise, we will be happy to provide detailed explanation of all aspects of the compiled information, as well as any supplemental materials that may be desired.

Keith Merkel
Rachel Woodfield
Dr. Robert Mooney
January 2002

ANNOTATED CONTENTS

A. Revised Eradication Plan for *Caulerpa taxifolia* in California: Surveillance, Eradication, and Current Status (November 2001)

B. Agua Hedionda – Maps of Caulerpa Distribution (November 2001)

Information about the known distribution of *Caulerpa* in Agua Hedionda over time has been compiled into a of four maps. Each map shows the distribution of *Caulerpa* in the East Basin (the only basin found to be infested to date) and a summary of the total extent of the *Caulerpa* cover. References to "the grid" refer to the square seen in the northernmost cove of the basin (Snug Harbor). This is a rope grid permanently deployed on the lagoon bottom that allows for repeated, systematic surveys that can be used to closely monitor trends in *Caulerpa* distribution. This grid was originally deployed shortly after the discovery of the infestation and was believed at the time to encompass the full extent of the infestation. The terminology used in the legends is explained in detail in the enclosed document entitled: Defining, Describing, and Assessing Metrics for Success in the Eradication of *Caulerpa taxifolia* at Agua Hedionda Lagoon, Carlsbad CA (November 2001).

Lagoon-wide survey effort increased from remote sensing tools to diver transects spaced out on 5 meter centers to 3 meter centers, and ultimately 1 meter as eradication efforts progressed and it became clear that other patches of *Caulerpa*, much smaller than those originally identified in Snug Harbor, were detected. As a result of the later detection of older patches in areas away from Snug Harbor, an areal coverage value for the entire lagoon was not available for the first two maps. It is important to note that *Caulerpa* found outside of the grid in the Spring/Summer 2001 survey is believed to have been present to a substantial degree at the time of the original discovery, rather than the result of rapid spread to other parts of the basin.

C. Huntington Harbour – Maps of Caulerpa Distribution (November 2001)

D. Defining, Describing, and Assessing Metrics for Success in the Eradication of *Caulerpa taxifolia* at Agua Hedionda Lagoon, Carlsbad CA. (November 2001)

E. One Year Status Report – Eradication and Surveillance of *Caulerpa taxifolia* within Agua Hedionda Lagoon (September 2001)

The one-year status report was compiled during the Summer/Fall 2001 survey effort and as such this information presents preliminary data for this period. The one-year report reviews the history of the eradication effort, summarizes the work conducted during the first year, and tracks *Caulerpa* coverage in the lagoon. The data presented in the Agua Hedionda – Maps of Caulerpa Distribution (November 2001) document provide the final results of the Summer/Fall 2001 survey.

F. Tarp Removal From Treated *Caulerpa taxifolia* in the Huntington Harbour Infestation (December 2001)

G. Investigation of Eradication Treatments of *Caulerpa taxifolia* in Agua Hedionda (December 2001)

H. Timeline of Events Relative to *Caulerpa taxifolia* Infestation in California (September 2001)

I. Rapid Response and Eradication Program for the Invasive Green Alga Caulerpa taxifolia at Agua Hedionda Lagoon – ORIGINAL DRAFT (July 2000)

J. Data CD:

A. File name: Water quality summary.xls (MS Excel file)

Water quality data were collected at various sites when opportunities were presented. Data reflect a range of environmental conditions experienced during the work periods in both Agua Hedionda and Huntington Harbour. Untended Hydrolab Datasonde 4 units were occasionally deployed for several weeks at a time in or near a *Caulerpa* bed in order to record water temperature, dissolved oxygen, salinity, turbidity and photosynthetically active radiation (PAR). The units were calibrated to manufacturer specifications, however data have not been exhaustively reviewed to remove spurious readings and to perform post-calibrations, or report on factors that may have affected recorded parameters (e.g. eelgrass wrapped around turbidity probe, sediment deposition on PAR meter due to adjacent diver activity).

B. File name: Master Spreadsheet for Agua Hedionda.xls (MS Excel file)

Data in the Master Spreadsheet are organized into six worksheets. Each worksheet is labeled as being either "outside grid" or "inside grid" followed by the season of data collection. Outside grid refers to all Agua Hedionda waters with the exception of that area within the 160x160m grid that was established in the summer of 2000. The grid was placed to facilitate survey and eradication efforts within what was then believed to be the only area of *Caulerpa* infestation within Agua Hedionda. Although *Caulerpa* has since been found outside of this grid, data are still maintained separately for waters within and outside the grid. Maintaining these areas separately allows for evaluation of eradication methods within the smaller and well-delineated 'in grid' management unit.

Data have been maintained in the Master Spreadsheet since spring 2001. The spreadsheet was initiated at that time as it became apparent that there might be large quantities of *Caulerpa* outside of the grid. It was quickly becoming too cumbersome to track all of the collected data in ArcView as had been done to that point. The Excel spreadsheet allows a means to quickly enter position and size data for *Caulerpa* patches as well as track the eradication progress. When time allows, data are transferred to ArcView for graphical presentation. The quality of the data in the Master Spreadsheet has improved over time, as the protocols for reporting, documenting, and tracking collected information are refined.

The first sheet of the Excel spreadsheet contains detailed notes on the data collection with explanations of terms and layout.

A. Revised Eradication Plan for *Caulerpa taxifolia* in California:

Surveillance, Eradication, and Current Status (November 2001)

REVISED ERADICATION PLAN FOR *CAULERPA* TAXIFOLIA IN CALIFORNIA: SURVEILLANCE, ERADICATION, AND CURRENT STATUS.

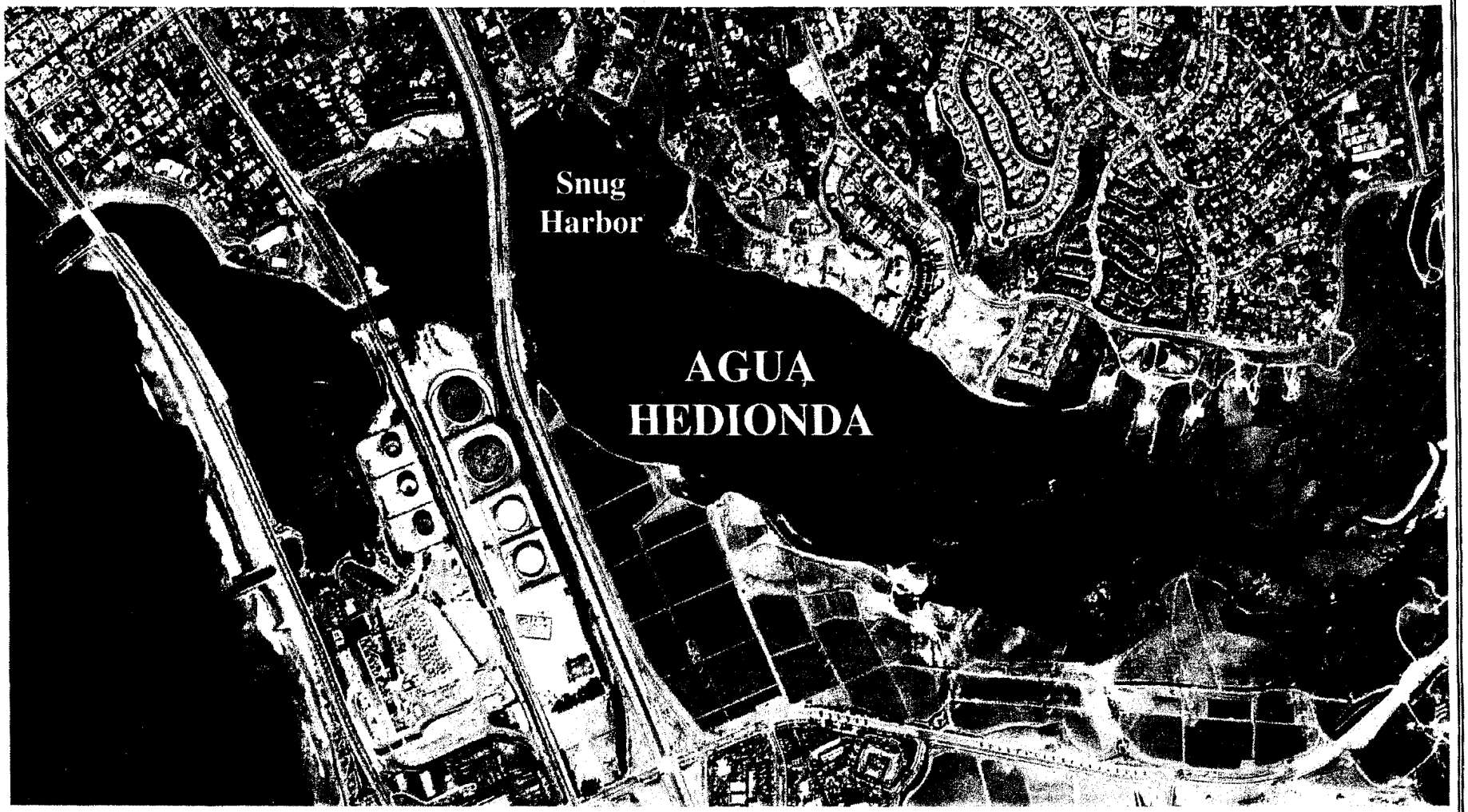
Merkel & Associates, November 2001

BACKGROUND

The highly invasive Mediterranean strain of the tropical alga, *Caulerpa taxifolia*, has become established in Agua Hedionda Lagoon, Carlsbad, California, where it was first discovered in June 2000 (Figure 1). This site represents the first known occurrence of this invasive strain within the Western Hemisphere and is considered to pose a major threat to coastal ecosystems, as well as to recreational and commercial uses of resources. While the species has now been confirmed at a second site in Huntington Harbour, Huntington Beach, California, Agua Hedionda reflects the larger of the known infestations (Figure 2). It is not known whether other infestations also exist and the continued wide availability of this species in the commercial aquarium trade is of high concern.

The invasive strain of this species was banned from international import or interstate commerce since 1999 through the Federal Noxious Weed Act, and legislation was recently passed 2001 in the State of California banning the possession and sale of several species of potentially invasive *Caulerpa,* including *taxifolia.* Since the Carlsbad discovery in June 2000, eradication, surveillance, and public outreach efforts, as well as eradication research and legislative efforts have been initiated and are on-going. The primary, but not the sole, focus of a Southern California *Caulerpa* Action Team (SCCAT) has been on eradication of the known infestations.

This document describes the current surveillance and eradication protocols for Agua Hedionda Lagoon, Huntington Harbour, and the surveillance effort being undertaken in and around other sites of likely introduction in southern California. The primary impetus for this document was the realization that there have been some deviations in methodologies anticipated by the document, Rapid Response and Eradication Program for the Invasive Green Alga, *Caulerpa taxifolia* at Agua Hedionda Lagoon, Carlsbad California. This document was prepared before eradication began at Agua Hedionda and before the second infestation at Huntington Harbour was discovered. Hence, it is reasonable to anticipate that the predicted methodologies would vary from the realized methodologies. Moreover, the demands of the eradication program have left little time for reporting the progress of the eradication effort. After discussing the protocols used to survey for and eradicate *Caulerpa* in southern California, this document will briefly describe the current status of the eradication effort. Finally, a protocol for future reporting will be considered.



Agua Hedionda
June 2000
Carlsbad, CA

Figure
1

Merkel & Associates, Inc.

Map of Known *Caulerpa taxifolia* Infestation in Huntington Harbour
October 26, 2000
Huntington Beach, CA

Figure
1

Merkel & Associates, Inc.

SURVEILLANCE

INSIDE LAGOON SURVEY EFFORTS (AGUA HEDIONDA AND HUNTINGTON HARBOUR)

The eradication program presently underway includes two levels of survey. The first is a high-intensity surveillance that is being used in regions of Agua Hedionda Lagoon where *Caulerpa* has not previously been identified. The second is an even higher intensity eradication-area survey used in infested areas (defined as all areas where *Caulerpa* has ever been detected plus a 162-ft [50m] buffer) or where visibility is limited.

High Intensity Surveillance

This survey method employs the use of divers being towed at 1 to 1.5 knots along transects by a small boat using survey-grade differential GPS. Early in the eradication efforts, this surveillance was initiated using a 5-meter separation between transects with the expectation that the clustered distribution of *Caulerpa* would allow areas of infestation to be identified by such methods. As eradication efforts have moved forward and a greater understanding of *Caulerpa* distribution patterns has been developed, this surveillance technique has been intensified from 5-meter, to 3-meter, and ultimately to a 1-meter spacing that is used currently to ensure complete coverage.

High intensity surveillance level surveys were employed in summer 2001 in order to comprehensively survey the entire lagoon to detect any further infestations outside of Snug Harbor. This technique is primarily intended to identify established patches that have escaped earlier detection and to survey areas with suitable water clarity.

Eradication Area Surveys

As with the high intensity surveillance discussed above, eradication area surveys are also conducted by divers. However, instead of being towed by a vessel at a slow speed, divers move at an appropriate rate along deployed transect lines, thus allowing for a more comprehensive search of areas where visibility may be reduced by poor water quality or dense eelgrass. As with the high-intensity surveillance approach, divers conducting eradication area surveys are spaced between 1 and 1.5 meters apart. Using this method it is possible to conduct intensive surveys that can locate very small fronds of *Caulerpa*, even within dense eelgrass beds.

Eradication area surveys are used in Agua Hedionda Lagoon to effectively cover areas of known infestations and in areas where visibility prevents use of towed-diver, high intensity surveys. Eradication area surveys are the sole means of surveillance in Huntington Harbour because the infestation is largely restricted to small saltwater ponds with low visibility. Moreover, the restricted nature of the ponds makes the towed diver approach impractical.

Snug Harbor Grid

Due to frequent references made to it in other documents regarding *Caulerpa* in Agua Hedionda, the "grid" in Snug Harbor should be briefly explained. Shortly after the discovery of *Caulerpa* growing in the most northern portion of the east basin of Agua Hedionda, known as Snug Harbor, a survey grid of line was immediately deployed over what was believed to be the extent of the infestation. This grid has numbered and lettered axes that allow for

systematic, repeatable surveys and facilitate mapping and recovery of discovered *Caulerpa* for treatment. This grid remains in place and is surveyed as part of regular quarterly surveys. The results of grid surveys are often reported separately from lagoon-wide surveys because they allow for simple tracking of temporal and spatial changes in *Caulerpa* distribution. Survey area, methodology, and intensity in the grid have changed very little since June 2000, whereas methodology in lagoon-wide surveys has evolved throughout the first year of the eradication, making temporal comparisons more difficult.

OUTSIDE LAGOON SURVEY EFFORTS

Agua Hedionda

Surveys have been conducted outside of the lagoon mouth with the assumption that any *Caulerpa* that had been freed in the lagoon could be transmitted out of the lagoon either by tidal action, or through the power plant cooling system. The power plant cooling water system has a mechanical traveling screen that captures and rejects most drift debris prior to it being passed through the plant to the ocean discharge. Any rejected material is disposed of in an upland landfill.

Outside of Agua Hedionda Lagoon, surveys are conducted with a combination of video, side-scan sonar, and diver surveys. Where no vegetation is present, side-scan sonar allows large areas to be effectively surveyed. Any suspect features returned by the side-scan sonar are then spot surveyed by divers or video to determine the nature of the material. Reefs offshore of Agua Hedionda are considered to be the most likely place that drift *Caulerpa* leaving the lagoon would be trapped and are therefore targeted by the diver surveys.

Huntington Harbour

The infestation at Huntington Harbour occurs in two ponds and in a small portion of the harbor itself. The infestation is in the furthest point from the mouth of the harbor. In order to ensure that *Caulerpa* did not occur elsewhere in the harbor, the entire harbor was surveyed to the mouth by divers in May 2001.

Regional Surveillance Efforts

Regionally, surveys are being conducted along the southern California coastline. Table 1 lists the surveillance sites and the search types performed. Generally, side-scan sonar has been used to thoroughly search the target water body. Any vegetation or suspicious returns from the sonar are then spot checked by divers. Additionally, divers swim along beaches, walls, rip-rap, piers, bridges, discharge points, and any other potential entry points for *Caulerpa*.

In addition to the specific survey efforts of the SCCAT, the SCCAT has prepared information advisories for public dissemination through outlets such as dive shops, dive clubs, boat ramps and clubs, internet web sites, bait and tackle shops, newspapers, and focused journals. Many local dive clubs have been briefed on *Caulerpa* and are watching for it during their recreational dives.

Table 1. Surveillance effort for southern California regional surveys (as of December 2001).

Site	Survey Days	Diver Days	Sonar
Alamitos Bay	4	9	Yes
Oceanside Harbor	2	4	Yes
Anaheim Bay	2	4	Yes
Mission Bay	11	6	Yes
Carlsbad Offshore	4	6	Yes
Marina Del Rey	3	7	Yes
Ballona 'Del Rey' Lagoon	1 (boat visual)	0	No
Newport Bay	3	0 (Volunteer)	Yes
Dana Point Marina	2	3	Yes
San Luis Rey River	1 (boat visual)	0	No
San Diego River	1 (boat visual)	0	No
Channel Islands Harbor	4	8	Yes
Ventura Harbor	2	4	Yes
Santa Barbara Harbor	2	2	Yes
King Harbor	1	0	Yes

ERADICATION IMPLEMENTATION

CONTAINMENT

When *Caulerpa* was discovered in Agua Hedionda in June 2000, the infestation was initially believed to occur in only a small portion of the lagoon (Snug Harbor). In order to prevent further spread by boating activity and to allow the eradication crew to safely conduct their work, a boom was deployed around the infestation that excluded all boat traffic. Currently it is know that the infestation areas are much larger and widespread throughout the east basin of the lagoon. Further restriction of boating activity in this basin is currently being considered by the SCCAT and City of Carlsbad. At the current time, the lagoon is open to boat use with the exception of the area originally boomed-off in Snug Harbor.

In Huntington Harbour, homeowners living on the two infested ponds were asked by their homeowners association to not enter the water until the initial treatment was completed. The shallow ponds are closed to harbor traffic and are used only by a few paddle boats and swimmers. The infestation in the adjacent portion of the harbor that is accessible by boats occurred in much deeper water (about -10 to -15 ft MLLW) where boats leave their slips rarely and were considered less likely to spread *Caulerpa* with their propeller wash due to the depth. The treatment was conducted very quickly during the winter and no harbor closures were necessary.

As part of the eradication, all identified *Caulerpa* is currently contained by covering the patches with impermeable black PVC tarps. The tarps are then sealed to the seafloor by placing sandbags on the margins of the tarps. Following chemical treatment (see below), the tarps are left in place to discourage regrowth of any viable material that may remain in the sediment.

CHEMICAL TREATMENT

Caulerpa contained under the PVC tarps is further treated with the addition of chlorine. Chlorine is currently identified as the agent with the greatest potential to quickly kill *Caulerpa* (see document entitled Investigations of herbicides for treatment of *Caulerpa taxifolia*, Merkel & Associates, 2001). Two methods have been utilized to administer chlorine to tarped patches. During the summer of 2000 at Agua Hedionda, liquid chlorine (12.5 % Sodium Hypochlorite) was pumped under the PVC tarps from a container on shore. Following the initial eradication effort and discovery of additional patches further from the containment boom, solid chlorine (Trichloroisocyanuric acid) has since been used. Pucks of solid chlorine are placed by divers prior to covering a patch. Chlorine application is permitted for experimental use by the Department of Pesticide Regulation.

In Huntington Harbour, solid chlorine has been used for the duration of the eradication effort (October 2000 to present).

The determination as to what is the most appropriate course of action to follow after chemical treatment remains unclear. There is concern that chlorine will only be effective at killing plant material at the surface and thus viable rhizoids may persist in the sediments. For this reason, all tarps have been left in place to prevent regrowth of this material.

To explore this issue further, a research protocol has been developed by Lars Anderson (USDA). The research calls for the removal of sediment cores from previously treated patches of *Caulerpa* throughout the duration of the eradication program. Cores will be cultured at the University of California, Davis to determine the presence of any viable *Caulerpa*. If viable *Caulerpa* is found under treatments over one year old, then additional eradication options should be considered. A small-scale field investigation was conducted in Huntington Harbour that involved removing tarps after chlorine treatment. Notes on this work can be found in the document entitled Tarp Removal From Treated *Caulerpa taxifolia* in the Huntington Harbor Infestation, Merkel & Associates, 2001.

SURVEY RESULTS

As of October 2001, Agua Hedionda Lagoon has been completely surveyed with high-intensity surveillance or better. Currently, a fall survey is being performed with eradication area surveillance level throughout the western half of the east basin and within all infestation areas. A cumulative total of 15,611 ft^2 of *Caulerpa* has been discovered since summer 2000 within the east basin (Figure 3). Eradication has kept pace with surveillance such that once a patch of *Caulerpa* is discovered, it is immediately treated. Thus, all *Caulerpa* discovered to date has been treated.

The nearshore waters adjacent to Agua Hedionda Lagoon have been surveyed by divers on three occasions. Dives focused on sandstone reefs and suspect areas identified using side-scan sonar. Suspect targets generally turned out to be surfgrass, algae, or low relief sandstone reef. No *Caulerpa* has been discovered west of Interstate 5 (central or outer basin).

It has now been over one year since eradication work began in Huntington Harbour. Post-treatment surveys have revealed additional *Caulerpa* that has been treated (Figure 4). The additional growth was generally associated with the margins of the tarps. It is believed that

Cumulative Distribution of *Caulerpa taxifolia* in Agua Hedionda
November 2001
Carlsbad, CA

Figure 4

Merkel & Associates, Inc.

Infested/tarped area January 2001

Infested/tarped area August 2001

× *Caulerpa* detected and to be treated October 2001

Status of *Caulerpa taxifolia* in Huntington Harbour
October 31, 2001
Huntington Beach, CA

Figure 4

Merkel & Associates, Inc.

at the time of the initial treatment, which was conducted during the winter season, the patches of *Caulerpa* were reduced in size from their summer extent. During subsequent spring and summer surveys, algal material that was not detectable in the surrounding sediment during winter appeared to have sprouted up. The Fall 2001 survey found no new occurrences in the harbor area, which was the first occasion that an infested area at either site had been resurveyed and found to have no new growth. Each of the two ponds had about twenty small occurrences, most consisting of single small thallus. The area of *Caulerpa* totaled approximately 81 ft^2 in the east pond and 19 ft^2 in the west pond.

The full survey of Huntington Harbour in spring 2001 revealed no additional infestations of *Caulerpa*.

Regionally, no *Caulerpa* has been found outside of the previously reported occurrences in Agua Hedionda Lagoon and Huntington Harbour.

FUTURE REPORTING

Currently, there is no formalized written reporting format for the findings of the SCCAT. Information has been disseminated at regularly scheduled meetings of SCCAT as well as at public meetings, agency meetings, and conferences. However, it is recognized that a written format should supplement oral briefings and can be of use for public and agency members not able to attend meetings. Moreover, a formalized reporting process allows for easy evaluation of surveillance and eradication efforts through time.

FORMAT

The report format needs to be kept simple while including up-to-date information regarding new occurrences of *Caulerpa* along with treatment status. Moreover, the reports should cover both the Agua Hedionda and Huntington Harbour sites while presenting parameters that are useful for both sites. Finally, reports should be created quarterly following each surveillance effort.

REPORT PARAMETERS

Four parameters are currently used to evaluate the eradication effort: areal extent, number of major patches, debris field area, number of infestation areas. Each of these parameters is described in detail in the report, Defining, Describing, and Assessing Benchmarks for Success in the Eradication of *Caulerpa* taxifolia at Agua Hedionda Lagoon, Carlsbad California (M&A 2001). At each infestation site, parameters will be provided for each of the current management areas. For Huntington Harbour, the management areas include the west pond, east pond, and harbor. At Agua Hedionda the management areas are east basin within grid, east basin outside grid, middle basin, and west basin.

FIRST QUARTERLY REPORT (FALL 2001)

Following completion of the Fall 2001 survey, a quarterly report will be prepared by Merkel & Associates for review by the SCCAT, which may make recommendations to improve the format of the report as needed.

B. Agua Hedionda – Maps of *Caulerpa* Distribution (November 2001)

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LETTER OF TRANSMITTAL

Date: Oct. 15, 2002	M&A #: 00-088-01

TO: Marina Cazorla
California Coastal Commission
Energy and Resources Unit
45 Fremont Street, Suite 2000
San Francisco, CA 94105

We are sending you: ☒ Attached ☐ Under separate cover via _____ following items:

Copy of: ☒ Report ☐ Prints ☐ Plans ☐ Letter ☐ Other See Below

Copies	Description:
20	In Progress Review: Ancillary Data and Observations from Caulerpa taxifolia Eradication Efforts
	at Agua Hedionda Lagoon and Huntington Harbor of the Southern California Caulerpa Action
	Team (SCCAT) - January 2002

These items are transmitted as checked below:

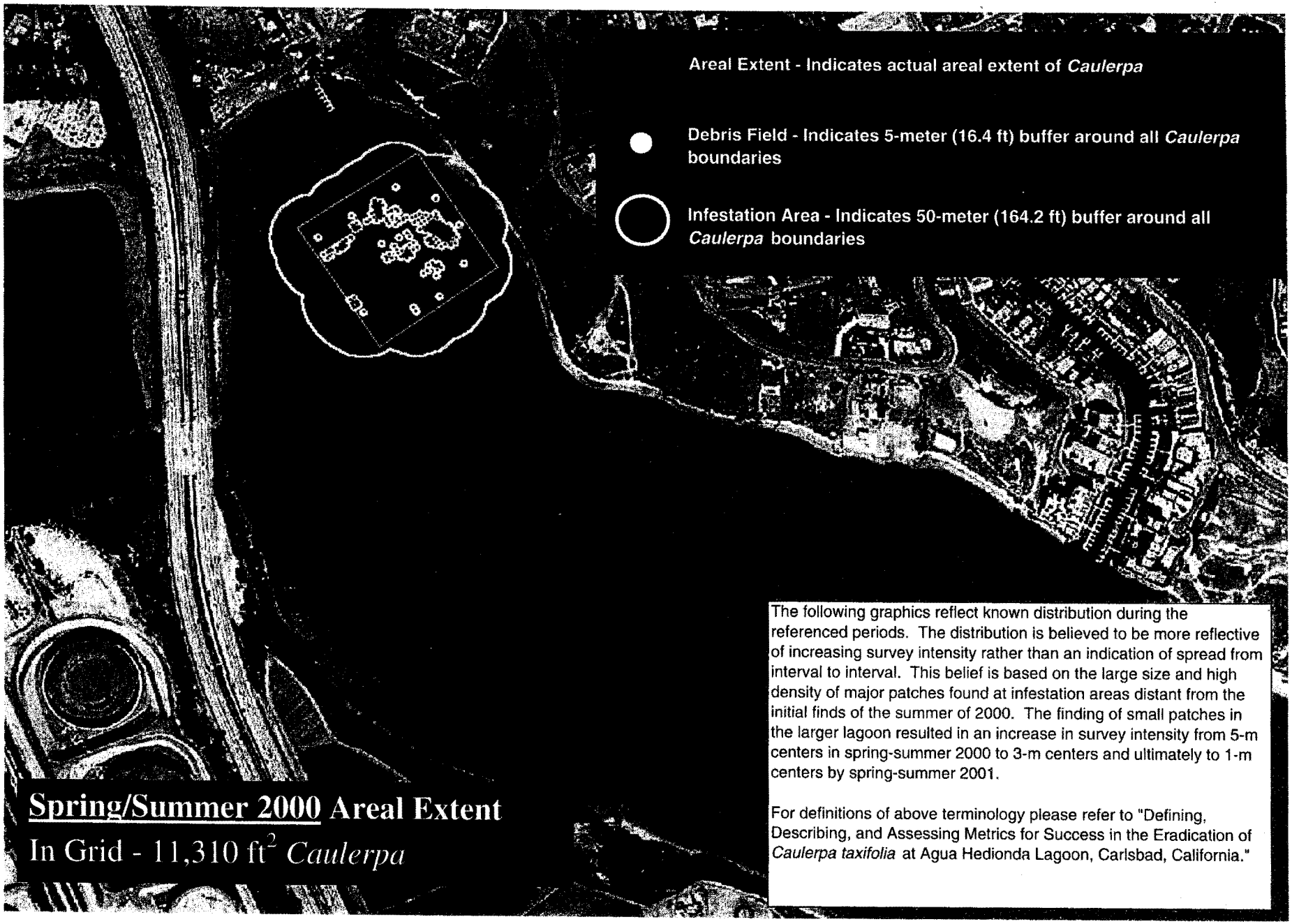
☐ For Approval ☒ As Requested ☐ For Your Use ☐ For Your Information ☐ For Review and Comment
☐ Other: _____

Remarks:

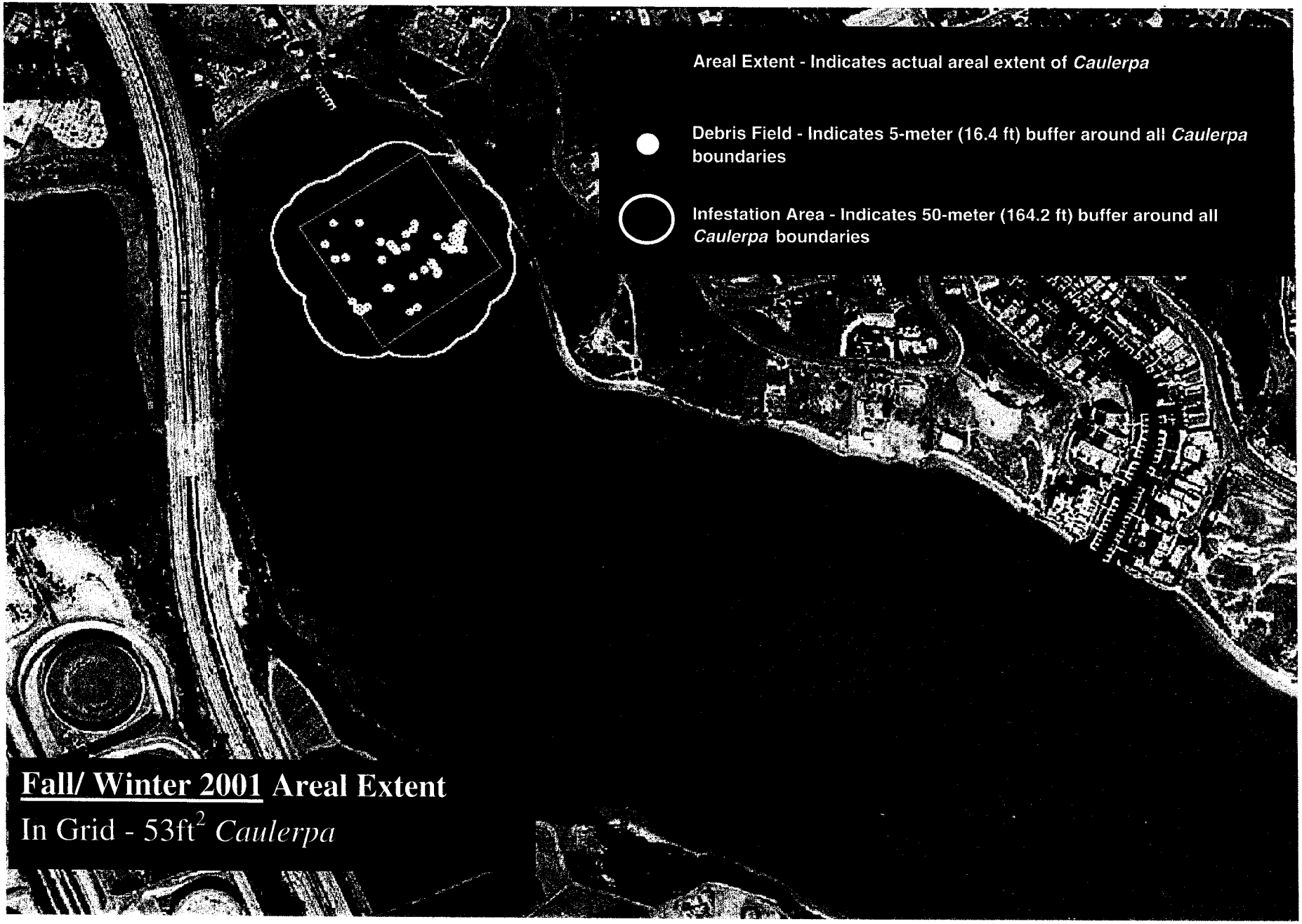
Copy to: _____

Signed: Collen Sheehan
Collen Sheehan, Administrative Assistant

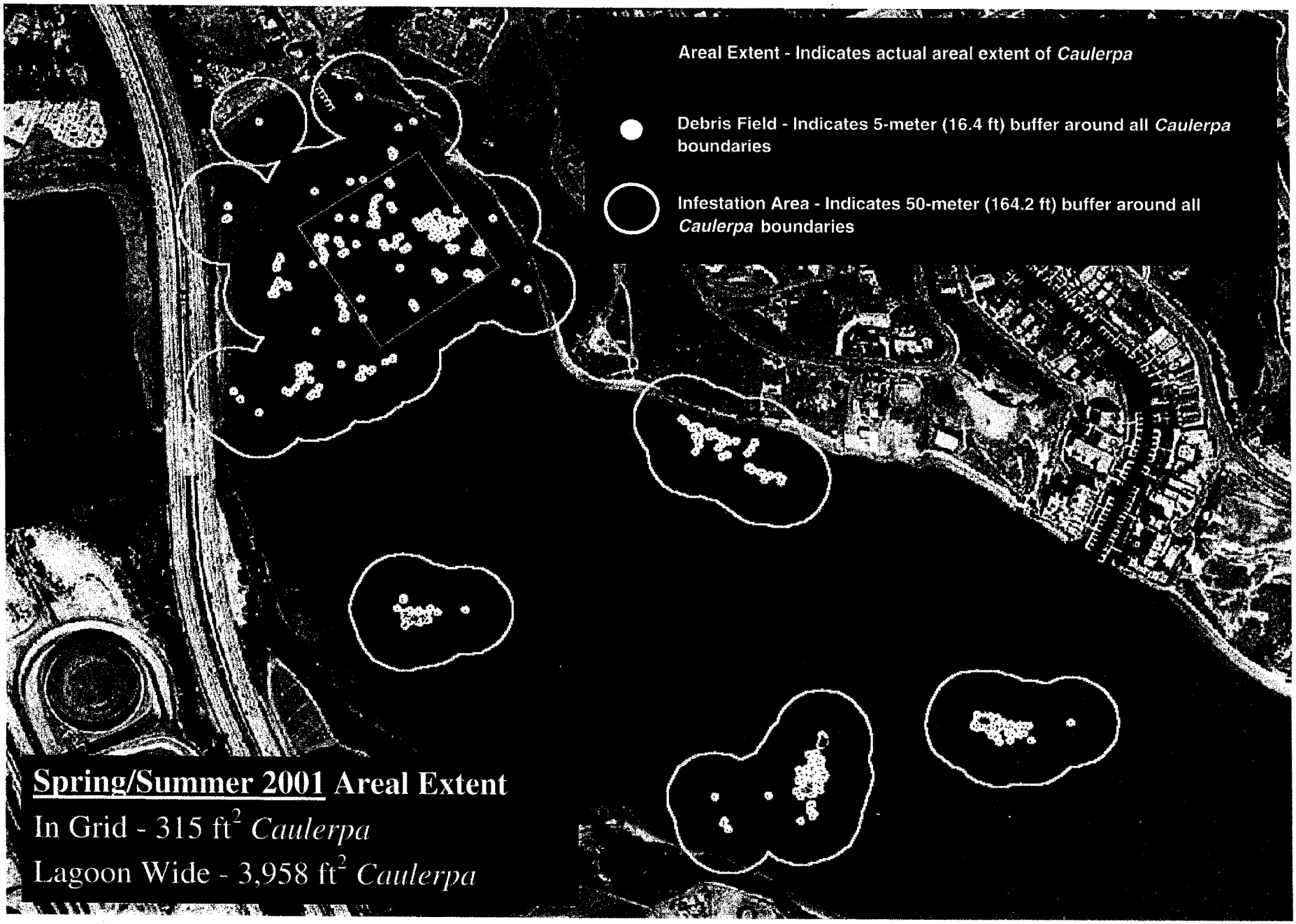
If enclosures are not as noted, kindly notify us at once.



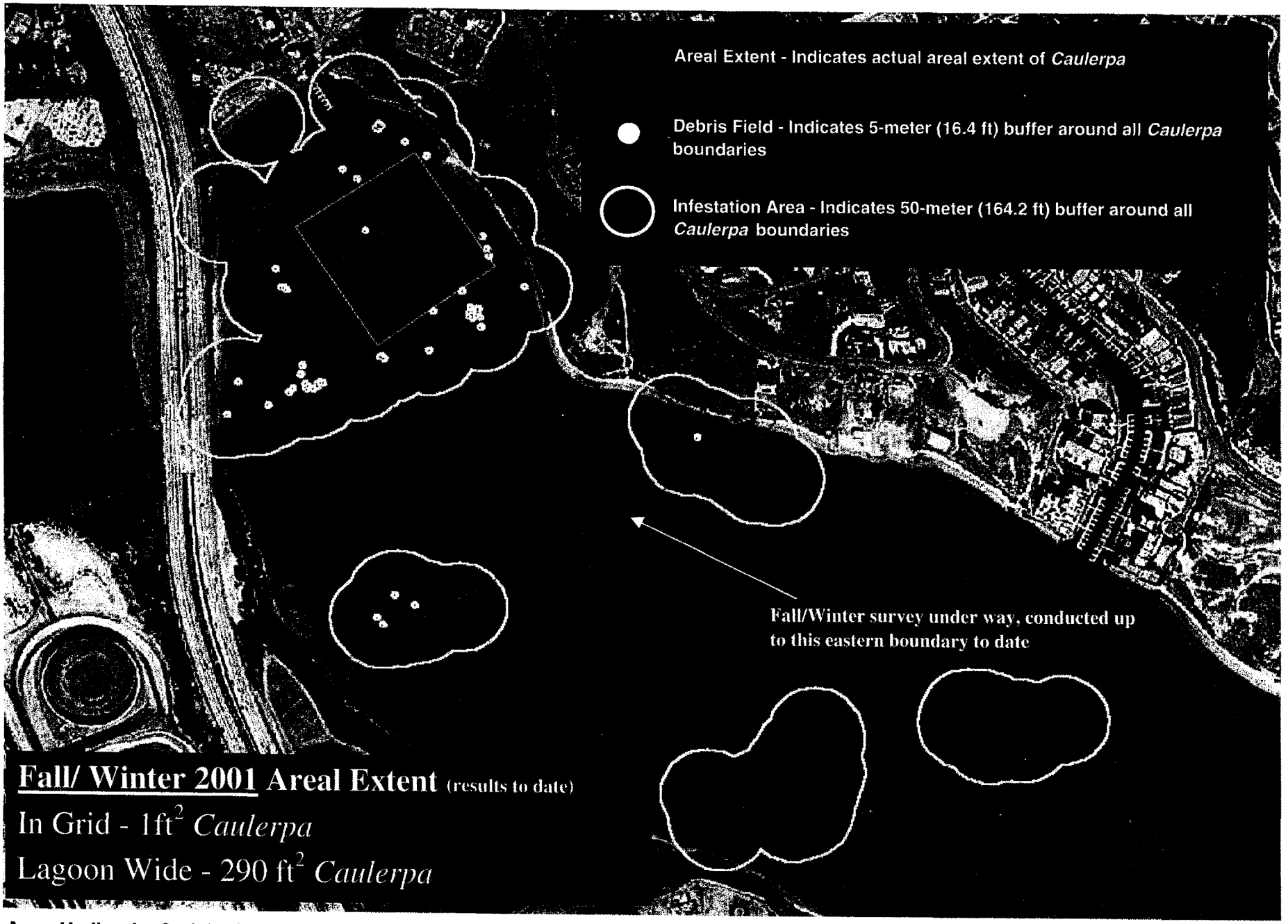
Agua Hedionda, Carlsbad California
December 2001



Agua Hedionda, Carlsbad California
December 2001



Agua Hedionda, Carlsbad California
December 2001



Agua Hedionda, Carlsbad California
December 2001

STATUS WITHIN GRID AREA

	2000		2001	
Parameter	**Spr/Sum**	**Fall/Win**	**Spr/Sum**	**Fall/Win**
Areal Extent (ft^2)	11,310	53	348	13
Number of Major Patches	13	0	0	0
Debris Field Area (ft^2)	63,032	27,716	49,261	3,809
Number of Dirty Cells	145	42	85	5
Number of Infestation Areas	1	1	1	1

STATUS OUTSIDE GRID

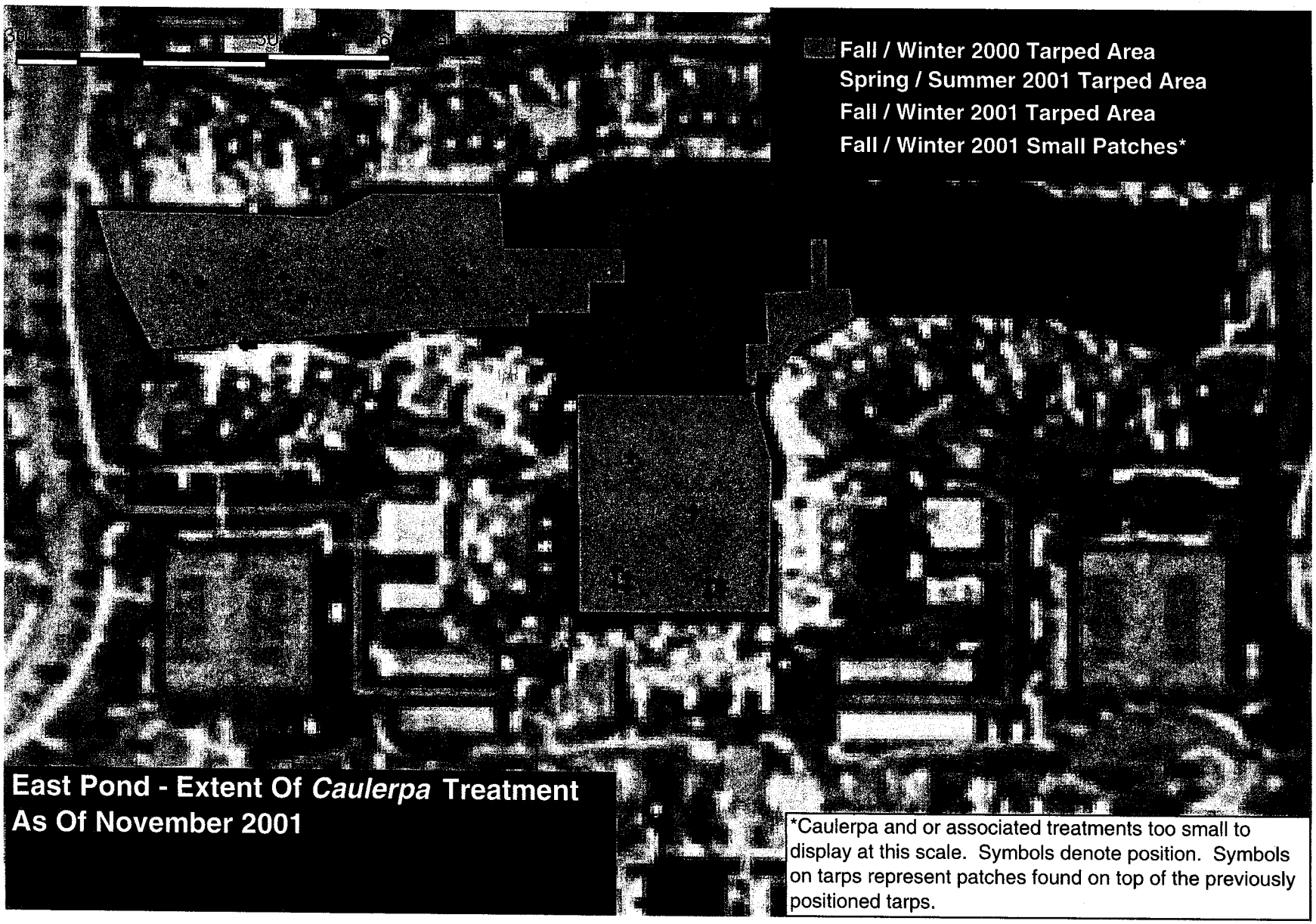
	2000		2001	
Parameter	**Spr/Sum**	**Fall/Win**	**Spr/Sum**	**Fall/Win***
Areal Extent (ft^2)	Unknown	Unknown	3,823	290
Number of Major Patches	Unknown	Unknown	7	1
Debris Field Area (ft^2)	Unknown	Unknown	117,026	49,866
Number of Infestation Areas	Unknown	Unknown	5	5

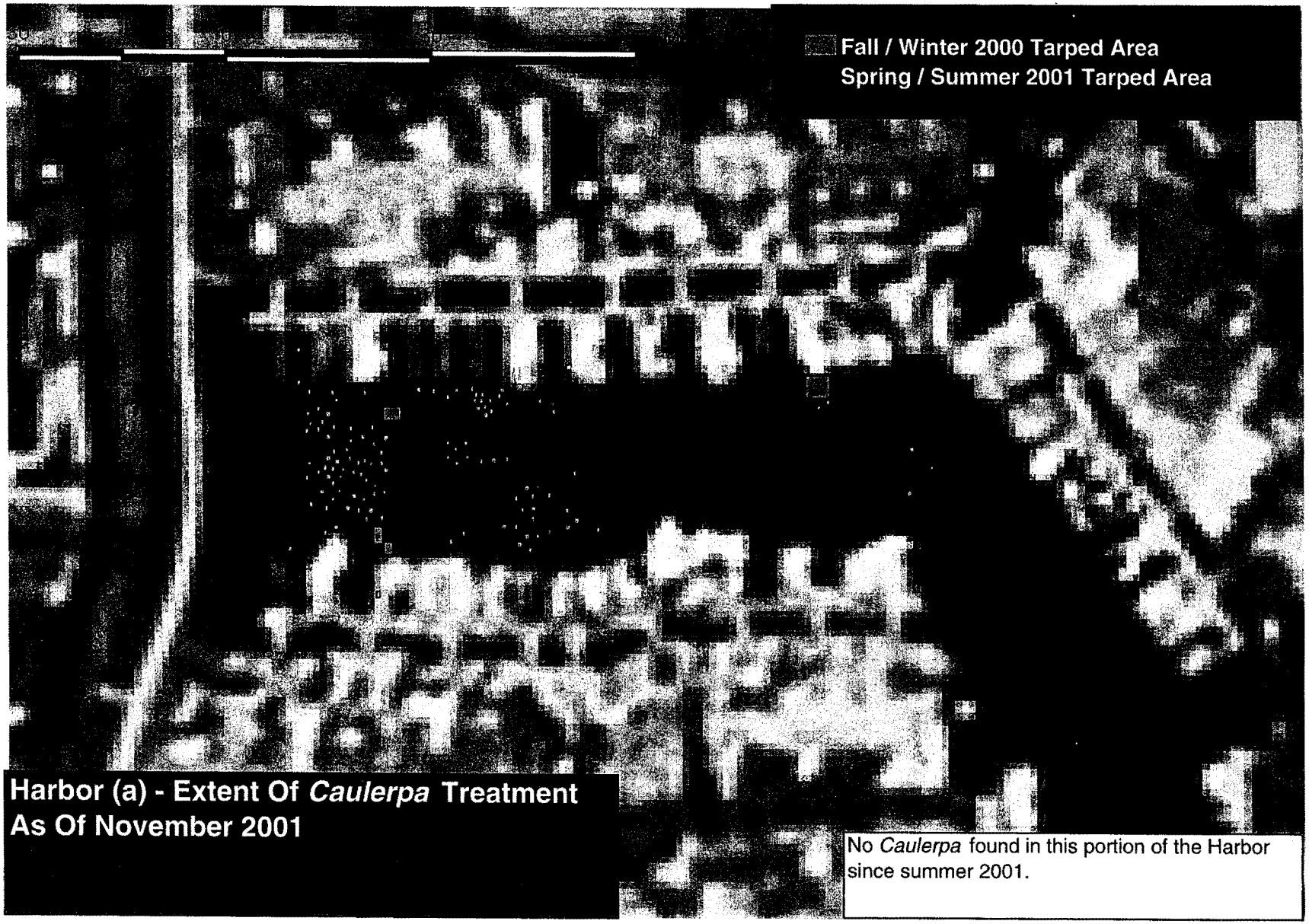
*Fall/Win 2001 Surveys Still In Progress As Of December 2001 (nearly complete).

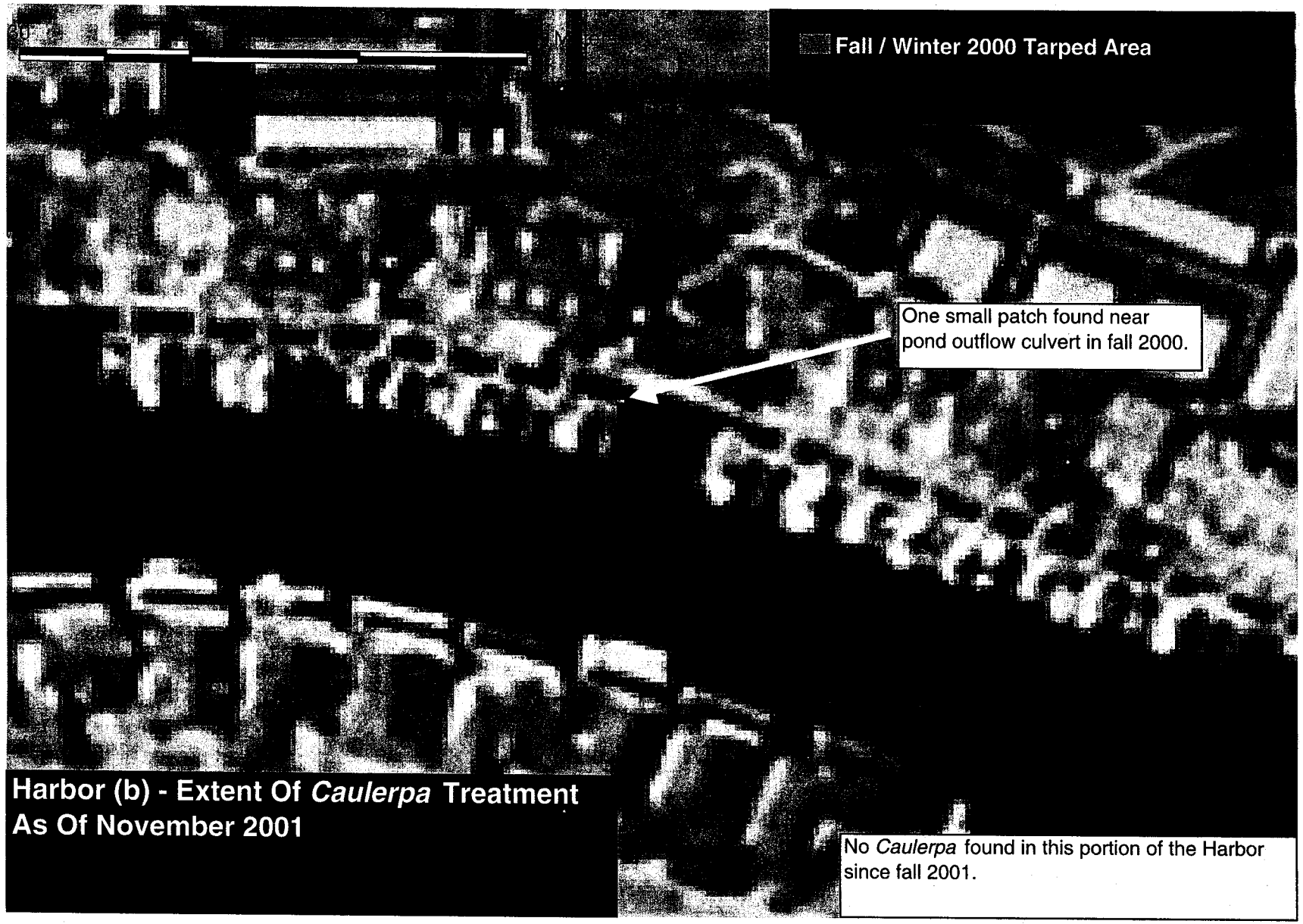
C. Huntington Harbour – Maps of *Caulerpa* Distribution (November 2001)


East Pond
West Pond
Harbor Unit 'A'
Harbor Unit 'B'
Huntington Harbour -
Caulerpa Management Units


30 0 30 60 Meters
Fall / Winter 2000 Tarped Area
Spring / Summer 2001 Tarped Area
Fall / Winter 2001 Tarped Area
Spring / Summer 2001 Small Patches*
Fall / Winter 2001 Small Patches*
West Pond - Extent Of *Caulerpa* Treatment
As Of November 2001
*Caulerpa and or associated treatments too small to display at this scale. Symbols denote position.


Fall / Winter 2000 Tarped Area
Spring / Summer 2001 Tarped Area
Fall / Winter 2001 Tarped Area
Fall / Winter 2001 Small Patches*
East Pond - Extent Of *Caulerpa* Treatment
As Of November 2001
*Caulerpa and or associated treatments too small to display at this scale. Symbols denote position. Symbols on tarps represent patches found on top of the previously positioned tarps.


Fall / Winter 2000 Tarped Area
Spring / Summer 2001 Tarped Area
Harbor (a) - Extent Of *Caulerpa* Treatment
As Of November 2001
No *Caulerpa* found in this portion of the Harbor since summer 2001.


Fall / Winter 2000 Tarped Area
One small patch found near pond outflow culvert in fall 2000.
Harbor (b) - Extent Of *Caulerpa* Treatment As Of November 2001
No *Caulerpa* found in this portion of the Harbor since fall 2001.

SUMMARY OF STATUS AT HUNTINGTON HARBOUR				
Parameter	Fall 2000/ Winter 2001	Summer 2001	Fall 2001	Year 1 % Reduction
Number of Infestation Areas	4	4	4	0%
Total Infected Area (sq.m.)	10,585	1,007	10	99.90%
Total Number Major Patches	9	1	0	100.00%
West Pond (sq.m.)	1,071	423	2	99.81%
East Pond (sq.m.)	7,743	583	8	99.89%
Harbor A (sq.m.)	1,771	1	0	>99.99%
Harbor B (sq.m.)	< 1	0	0	>99.99%

D. Defining, Describing, and Assessing Metrics for Success in the Eradication of *Caulerpa taxifolia* at Agua Hedionda Lagoon, Carlsbad, CA. (November 2001)

Defining, Describing, and Assessing Metrics for Success in the Eradication of *Caulerpa taxifolia* at Aqua Hedionda Lagoon, Carlsbad, California.

Robert Mooney, Keith Merkel, and Rachel Woodfield

Summary

On June 12, 2000 the first known infestation in the Western Hemisphere of the invasive strain of the tropical alga, *Caulerpa taxifolia*, was discovered in Agua Hedionda Lagoon, in Carlsbad, California. Eradication plans were immediately developed by the Southern California Caulerpa Action Team (SCCAT), a broad-based task force assembled from federal and state resource and regulatory agencies, exotic species experts and marine resource scientists. The SCCAT contracted Merkel & Associates, Inc. to implement the eradication plan.

The eradication program being employed within Agua Hedionda Lagoon consists of survey and treatment elements. Saturation surveys are used to seek out *Caulerpa. Caulerpa* is subsequently treated by the application of chlorine under vinyl containment tarps. Year 2000 surveys revealed the presence of slightly less than 75% of the *Caulerpa* believed to have been present within the lagoon during 2000. The summer and fall of 2000 was a period of aggressive treatment and high expenditures on treating large patches of *Caulerpa*. The largest single patch was estimated to have a biomass in excess of 20 tons of the alga. All of the 11,310 square feet of material known to exist in 2000 was treated, resulting in a 97.72% reduction of *Caulerpa* within the 2000 eradication area prior to 2001. Because of the significant reduction in the extent of the alga, in 2001 the focus shifted away from localized treatment and more towards heavy surveillance and treatment where previously undetected infestations were found. By the summer of 2001, the survey intensity was five times greater than in the summer of 2000. With this increased survey intensity, five additional infestation areas were identified and treated, totaling approximately 27% of the total algal cover as found and treated in 2000. In the first year of the program, approximately $1.1 million was spent on eradication at the lagoon.

While the extent of *Caulerpa* continues to be reduced as the second year of the eradication effort continues, the changing surveillance intensity and extent have meant that data collection techniques have been modified over time. For this reason, it is important to take time to determine appropriate metrics for tracking success of the eradication effort. These metrics or benchmarks need to offer standardized parameters that are meaningful at the lowest standard of data collection. Five metrics are defined and discussed in this document. Each has merits and limitations but in total they will allow for a complete picture of the infestation and the results of the eradication effort.

It is important to note that the metrics selected for use in the present effort have not been examined or considered for evaluation of more expansive infestations or more widely distributed occurrences.

Proposed Metrics

Areal Extent – *The bottom area over which Caulerpa was found.*

The value is the summation of diver-estimated patch sizes. Estimates are made visually for small patches (less than 6 ft in diameter) or with the aid of a fiberglass tape measure for larger patches.

This metric is typically the most sought after for agencies and press personnel attempting to evaluate the extent of infestation and the effectiveness of eradication. Although this estimate is intuitive and simple to report, it is difficult to obtain in the field without sacrificing time spent on eradication. Thus areal extent values are often not well standardized through the temporal and spatial scales of the eradication effort. An attempt has been made in the field to adequately assess areal extent for *Caulerpa* found within the original infestation area (in grid). This will allow this intuitive and simple metric to be used to assess eradication effectiveness within the grid throughout the eradication effort. Otherwise, this measure should be restricted in its general application. It should be noted that this parameter increases in accuracy as the eradication effort decreases the available *Caulerpa* making assessment easier.

Dirty Cells – *A count of the number of 5 x 5-m grid cells in the original infected area that contain Caulerpa within a given survey period.*

This parameter is created by simply designating cells within the survey grid as either clean or dirty.

The original infestation area had a grid with 5 x 5-m cells overlaid on it. Thus, the number of dirty grid cells can indicate eradication success within the original infestation area. This value does not require knowledge of areal extent, but can be used to complement areal extent estimates within the grid. The observation that areal extent within the grid was decreased by over 97% in the first eradication year while dirty cells decreased by only 52% displays a pattern that indicates great potential for re-growth of *Caulerpa* if left unchecked.

Major Patch – *An area of contiguous Caulerpa cover in excess of 9.3 m^2 (100 ft^2).*

The major patch designation is again an area estimate made by divers with the aid of fiberglass tape measures. A patch is deemed to be a "major" if it is in excess of 9.3 m^2 and there is little exposed bottom within the patch.

This metric is important because sizeable patches are often dense and thick. Thus major patches contain a significant portion of the total biomass (not directly measurable) present within the lagoon and therefore represent a great potential source of new patches via fragmentation. Because large patches garner much attention from the eradication team, this designation provides an easily standardized metric to follow through time. It's major drawback is that it is a categorical value and so patches within a mere square foot of cover can be deemed as "major" or not. Regardless, this measure in tandem with areal extent estimates can be used as an indicator of eradication efficacy. Decreases in both

values would imply a decrease in biomass and a lower probability for fragmentation and spread to distant habitats.

Debris Field – *An area-based parameter using Caulerpa location data plus a 5-m (16.3-ft) buffer.*

Debris field area is used to help remove variability in areal extent measures and to indicate that the area surrounding *Caulerpa* patches is often found to be supporting small fragments of *Caulerpa* even after successful treatment of the original patch. The relatively small buffer size (see "infestation area" below) is recognition that *Caulerpa* patches within a debris field are the likely result of localized passive dispersal from within the proximate patch. The density of Caulerpa often falls off with distance from the central patch.

This metric is important because it reduces the reliance on area estimates. By only needing to know the location of *Caulerpa* patches, this parameter can be standardized across patches where variable cover data exist or where cover area is unknown for some patches. Moreover, this value gives a realistic indication of the bottom area of greatest potential concern for future re-occurrence of *Caulerpa.*

Infested Area - *An area / numerical-based parameter using Caulerpa location data plus a 50-m (164.2-ft) buffer. This designation stays in effect until the infested area is designated clean for two years in a row.*

This metric builds upon the buffer approach used to determine debris fields. However, this parameter is intended to define the number of areas impacted by *Caulerpa* rather than the area impacted by *Caulerpa* (the latter being designated under debris field). An infested area can incorporate numerous debris fields. Infestation areas may not be reduced until full eradication is declared within the hydrographic system (defined by lagoon, harbor, bay, etc.).

This metric is important for three reasons. First it incorporates the temporal scale. By leaving the infested area designation in place even after initial eradication of *Caulerpa* we are recognizing the potential for re-growth of overlooked fragments and reminding ourselves to carefully monitor the area. Second, in tandem with the debris field parameter, the two parameters offer an effective means for monitoring the eradication effort. There are multiple combinations of situations where either of the parameters can increase or decrease, but only a decrease in debris field area with an ultimate decrease in the number of infested areas will indicate that the eradication plan is effective. Finally, the parameter creates large but defined areas within the scale of the lagoon that can be thought of and dealt with in a manner largely independent of each other. Much of the impetus for this and the debris field parameters was to display the pattern of infestation. By showing that multiple infestation areas exist at this scale we are recognizing that there must be variable degrees of dispersal with some being more common than others. For instance, the creation of infestation areas separated by more than 100 m (the combined buffers of two patches) indicates that a significant but rare dispersal event occurred (e.g. dispersal by strong currents or by boat anchor).

Use of Metrics

Figure 1 illustrates the use of the proposed metrics. The tabular data associated with the graphic are given in Table 1. Summer 2001 has been chosen to represent the metrics because an exhaustive high intensity (1 meter transect spacing) survey of the entire east basin was completed during this period. Fall 2001 data are included in Table 1 to illustrate the presentation of changes in metrics though time.

Figures 1 and 2 illustrate that *Caulerpa* tends to occur in clumped distribution patterns characterized by the boundary of the debris field buffer. There may be multiple debris fields within an infestation area, however two patches of *Caulerpa* must be separated by over 100 m before a new infestation is defined as existing. From the figures it is apparent that patches rarely occur singly within infestation areas. This indicates that the infestation areas have persisted for some amount of time following an initial establishment, thus providing time for *Caulerpa* to fragment and locally disperse and form numerous small patches within the debris fields.

Several hypotheses may be derived from the broader dispersal patterns observed in the infestation areas. First, the distance between the larger infestation areas might suggest that dispersal events able to move viable fragments greater than 100 m are relatively uncommon. Alternatively, it might be inferred that the ability for any given fragment to become established may be low and thus strongly dependent upon availability of parent stock biomass and fragmentation frequency. Once established in a new area, however, biomass increases, providing greater material availability for localized spread of fragments. This pattern of satellite colony establishment is common to many invasive species.

The data presented in Table 1 demonstrate trends not discernable in the figures. Most notably, the areal extent values are the best estimates of actual bottom area covered by *Caulerpa*. The number of major patches indicates the presence of those with the greatest potential to fragment and spread as well as identifies the older patches within an infestation area. The decrease in all metrics (with the exception of infestation area) between summer and fall 2001 shows that both the cover and biomass of *Caulerpa* are decreasing. Although it may seem inappropriate to make comparisons across different seasons, the illustration is still useful in tracking change over the short duration of the eradication effort, and absent more long-term data, provides the only comparisons available at the present time. Moreover, the trends are similar for data taken from the grid between the summer 2000 and summer 2001 indicating that *Caulerpa* cover and biomass are decreasing over time (refer to One Year Status Report – Eradication and Surveillance of *Caulerpa taxifolia* within Agua Hedionda Lagoon [M&A 2001]). It is important to recall that the number of infestation areas cannot be reduced by effective treatment efforts until full eradication within a system is declared. However, the number of infestation areas can grow by either spread of material or identification of previously un-identified patches well removed from known infestations. The reduction of infestation areas during the eradication effort is a counter-indicator of successful control because it indicates spread of Caulerpa that results in the joining of separate infestations.

Figure 1. Summer 2001 *Caulerpa* distribution. White box is the area shown in Figure 2.

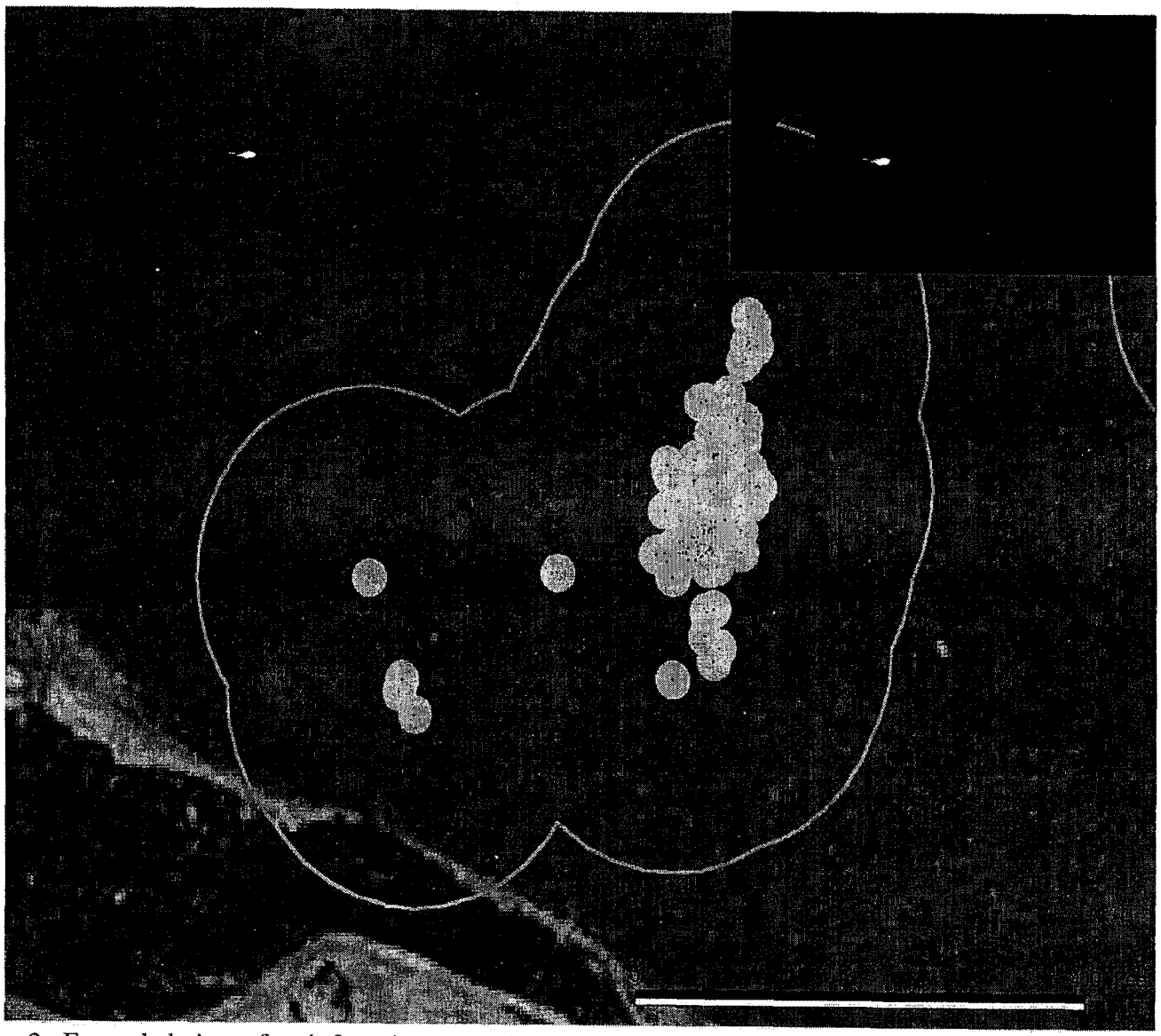


Figure 2. Expanded view of an infestation area with its associated *Caulerpa* and debris fields.

Table 1. *Caulerpa* status report for summer and fall 2001. Fall survey incomplete as of this writing.

TABLE 1. STATUS--ENTIRE LAGOON

Parameter	Summer 2001	Fall 2001	% Reduction
Areal Extent (ft^2)	3,322	290	91.3%
Number Major Patches	6	1	80.0%
Debris Field Area (ft^2)	151,092	50,707	66.4%
Number of Infestation Areas	5	5	0.00%

E. One Year Status Report – Eradication and Surveillance of *Caulerpa taxifolia* within Agua Hedionda Lagoon (September 2001)

One Year Status Report
Eradication and Surveillance of *Caulerpa taxifolia* within Agua Hedionda Lagoon, Carlsbad, California

September 2001

Executive Summary

On June 12, 2000 the first known infestation in the Western Hemisphere of the invasive strain of the tropical alga, *Caulerpa taxifolia*, was discovered in Agua Hedionda Lagoon, in Carlsbad, California. This document outlines the activities that have been undertaken during the first year of what is anticipated to be a five year program to eradicate this species from the lagoon system. It also outlines the anticipated future actions needed to effectively complete the eradication effort. Actions have been taken under the oversight of the Southern California Caulerpa Action Team (SCCAT), a broad-based task force assembled from federal and state resource and regulatory agencies, exotic species experts and marine resource scientists.

During the first year, much has been accomplished in the *Caulerpa* eradication effort, yet much still remains to be done. The eradication program being employed within Agua Hedionda Lagoon consists of survey and treatment elements in which saturation surveys are used to seek out *Caulerpa,* which is subsequently treated by the application of chlorine under vinyl containment tarps. Year 2000 surveys revealed the presence of slightly less than 75% of the *Caulerpa* believed to have been present within the lagoon during 2000. The summer and fall of 2000 was a period of aggressive treatment and high expenditures on treating large patches of *Caulerpa*. The largest single patch was estimated to have a biomass in excess of 20 tons of the alga. All of the 11,310 square feet of material known to exist in 2000 was treated, resulting in a 97.72% reduction of *Caulerpa* within the 2000 eradication area prior to 2001. Because of the significant reduction in the extent of the alga, in 2001 the focus shifted away from localized treatment and more towards heavy surveillance and treatment where previously undetected infestations were found. By the summer of 2001, the survey intensity was five times greater than in the summer of 2000. With this increased survey intensity, five additional infestation areas were identified and treated, totaling approximately 27% of the total algal cover as found and treated in 2000. In the first year of the program, approximately $1.1 million was spent on eradication at the lagoon.

While the extent of *Caulerpa* continues to be reduced as the second year of the eradication effort continues, the intensity of surveys used to locate remaining patches is rising, increasing effort and cost. As a result, surveillance is replacing treatment as the most costly element of the eradication program. During the ensuing years, it is anticipated that a comparable annual budget to that invested in the first year's program will be required to continue to locate and treat remaining patches of *Caulerpa*. Early results from the eradication efforts are promising, but it is imperative that the program be completed in order to ensure effectiveness.

Background

The highly invasive Mediterranean strain of the tropical alga, *Caulerpa taxifolia*, has become established in Agua Hedionda Lagoon, Carlsbad, California. This site, identified in June 2000, represents the first known occurrence of this strain within the Western Hemisphere and is a major threat to coastal ecosystems and recreational and commercial uses dependent upon coastal resources. While the species has now been identified at a second site in California, Agua Hedionda represents the larger of the known infestations and has likely been in the lagoon for at least four years prior to its discovery. It is not known whether other infestations also exist and the continued wide availability of this species on the commercial aquarium market is of high concern.

Caulerpa taxifolia has been banned from international import or interstate commerce since 1999 through the Federal Noxious Weed Act. Legislation banning the transport, sale, and possession of several potentially invasive species of *Caulerpa* was recently approved by the California State Legislature and was signed into law by the Governor on September 24, 2001.

Since the discovery of *Caulerpa* in Agua Hedionda in June 2000, eradication, surveillance, public outreach efforts, eradication research, and legislative efforts have been initiated and are on-going. The primary, but not the sole, focus of SCCAT has been on eradication of the known infestations. However, given that there may be other infestations that have yet to be identified, that the alga is still commercially available and there is a high risk of new introductions, and that no current effective eradication mechanisms in high-energy areas have been identified in either Europe or the U.S., resources have been allocated to a diverse range of needs as best seen fit within the mandates of the funding and supporting agencies.

Caulerpa taxifolia eradication efforts within Agua Hedionda Lagoon are currently underway. These efforts include both survey and treatment components. Using the present resources available through state and federal agency funding, and funds previously committed by Cabrillo Power I LLC (Cabrillo), work has been underway for one year in contemplation of a five-year program for eradication of *Caulerpa* from Agua Hedionda Lagoon.

This document provides a synopsis and retrospective on the first year's efforts and identifies what can be expected over the future years with respect to the eradication program. It outlines how the program has evolved over the past year and outlines a course for the future with a goal of full eradication of *Caulerpa* from Agua Hedionda Lagoon.

2000-2001 Eradication Program

Early Actions Taken

Development of a program to eradicate the *Caulerpa* infestations began in June 2000, within a week of identifying the species. The first actions taken were: 1) assembly of a multiple agency task force (the Southern California Caulerpa Action Team (SCCAT)); 2) continued assessment of the magnitude of the infestation in the lagoon; and 3) identification of effective treatment options through review of European efforts to combat this species and laboratory testing of a variety of treatment options. This work was outlined in the Rapid Response and Eradication Program for the Invasive Green Alga, *Caulerpa taxifolia*, at Agua Hedionda Lagoon, Carlsbad, California.

The eradication program being employed within Agua Hedionda Lagoon is comprised of both survey and treatment components. Extensive diver surveys are employed to locate *Caulerpa* and treatment involves applying chlorine under vinyl tarps that cover the substratum.

Based on the initial actions outlined for the eradication, an estimated 5-year program to eliminate *Caulerpa* from the lagoon was established. The eradication treatment efforts were initiated in July 2000. Throughout the second half of 2000, the extent of the infestation was believed to only occupy large portions of Snug Harbor within the easternmost of three lagoon basins (Inner Lagoon). The approximately 5.7 acre area within Snug Harbor was bounded by a boom and a grid was established over the infestation area to facilitate systematic surveys and treatment. Of the 1,024 grid cells, 145 were found to contain *Caulerpa*. A debris field in which small patches of the alga were present occupied approximately 1.45 acres. In total, 11,310 square feet of *Caulerpa* was identified within the grid, including 13 major patches (over 100 square feet each).

Initial efforts during the late summer and fall of 2000 were focused principally on treatment of the *Caulerpa* known to be present within Snug Harbor. While treatment was taking place within Snug Harbor, other portions of the Lagoon were being surveyed using diver transects spaced at 5 meters on center. Within the westernmost basin (Outer Lagoon), comprehensive surveys were conducted on two separate occasions prior to the completion of maintenance dredging by Cabrillo Power's Encina Generating Station. By the end of September 2000 all of the *Caulerpa* known to exist at the time had been treated.

Through monitoring surveys conducted in the Lagoon, areas of *Caulerpa* not discovered during summer and fall 2000 surveys were found. Fall 2000/Winter 2001 surveys were hampered in November 2000 by massive natural diebacks of eelgrass that matted down over the bottom making it nearly impossible to locate any of the shorter *Caulerpa* that may have been present. By the next quarterly survey, conducted in February 2001, the eelgrass had fully shed dead blades, exposing the bottom throughout most of the lagoon. At this time, it became clear that previously undetected *Caulerpa* had over-wintered and

that more intensive surveys were necessary to detect all of the infestation areas, especially considering the fact that smaller patches were now being sought. It also became clear that the extent of the infestation area identified in 2000 was an underestimate and that patches of *Caulerpa* actual occurred throughout the of entire Snug Harbor and even occurred further east in the Inner Lagoon. As a result of these findings, surveys were intensified to 3-meter center transects and were ultimately shifted to 1-meter center transects by early summer 2001.

Second High Growth Season

While the initial efforts in the eradication program were principally reactive and focused on the treatment of extensive occurrences of *Caulerpa* found in the Inner Lagoon, the greater focus on intensive survey during the second high growth summer season revealed additional *Caulerpa* that had been overlooked in 2000. In total, six centers of infestation were noted within the Lagoon, with all locations occurring within the Inner Lagoon. High turbidity within the easternmost portion of the Inner Lagoon may screen additional sites that remain undetected at the present time. Surveys have continued to focus on this area during summer and fall of 2001.

During spring and summer of 2001 a total of 315 square feet of *Caulerpa* was detected within 69 of the original grid cells identified in 2000. This algal material was spread over a 40,885 square foot debris field. Preliminary estimates outside of the grid for summer 2001 have identified a total of 3,040 square feet of *Caulerpa*, including five major patches in five infestation areas as of September 25, 2001. The debris fields for these infestations occupied 101,828 square feet. Final estimates for the lagoon are anticipated to be available by October 15, 2001.

Through the spring and summer of 2001, eradication treatment efforts continued on newly identified sites and within areas surrounding previous treatment areas. Refinements of the treatment approach were made to expand treatment beyond limits of detected *Caulerpa* to include a minimum buffer of 3 meters when treating large patches. This was done based on the findings of the prior year that indicated very small and easily overlooked fragments were common in close proximity to detectable patches. Patches identified during the spring and summer 2001 were treated using the techniques outlined for the overall program.

Eradication Status Report

Because only a portion of the infestation was detected during 2000, it is not possible to fully evaluate the change in *Caulerpa* status from summer 2000 to summer 2001 throughout the entire lagoon. However, it is possible to examine changes within the infestation area that was known to exist in 2000 and to establish a 2001 baseline against which future changes throughout the entire lagoon may be evaluated.

Caulerpa infestations can be characterized both by areal coverage (quantitative extent) and dispersion (spatial distribution patterns). Lacking sexual reproduction, this strain of *Caulerpa taxifolia* only spreads by fragmentation or growth. Over the course of the year, it has been determined that the *Caulerpa* infestations typically exhibit a clumped distribution pattern where a central core patch is surrounded by fragments that initiate new patches that can also fragment and spread. As a result, infestation areas are defined by a number of closely associated patches. These are commonly made up of major patches, if they have been present for over a year, and debris fields of associated small patches and fragments. *Caulerpa* can move greater distances through dispersal of fragments by means that are not quite fully understood. In the Mediterranean Sea, it has been noted that *Caulerpa* is moved long distances by vessel anchors. At Agua Hedionda Lagoon, this mechanism, along with fishing, was identified as the primary controllable risk of spreading *Caulerpa.* As a result the City of Carlsbad was requested by the SCCAT to assist in the control of spreading the alga by banning fishing and anchoring around the infested area. The City took this action and provided their Police Department with the authority to enforce and expand the ban where necessary. This ban is now being enforced by the Carlsbad Police Department and the California Department of Fish & Game. Within the most significant area of infestation, all boating and access has been temporarily eliminated to aid in the eradication efforts.

Within the infestation area that was known to exist in 2000, the results observed from the eradication efforts have been very positive. All major patches have been eliminated and the total areal coverage of *Caulerpa* is down by 97.3%. Lesser, but still significant, reductions have occurred with respect to the area of the debris field around patches and the number of cells in the grid that were found to support *Caulerpa* (see Table 1). An area of infestation cannot be considered eliminated until there has been no *Caulerpa* detected for a period of two or more years with intensive searches.

TABLE 1. STATUS WITHIN GRID AREA

Parameter	2000	2001	% Reduction
Areal Extent (sq.ft.)	11,310	315	97.3%
Number Major Patches	13	0	100.0%
Debris Field Area (sq.ft.)	63,032	49,261	21.8%
Number of Dirty Cells (1024 total)	145	85	41.4%
Number of Infestation Areas	1	1	0.00%

Outside of the grid, *Caulerpa* was discovered during the 2001 surveys and thus no data on the size or extent of the infestation that was present in these areas in 2000 are available. However, it is believed that these *Caulerpa* patches were present in 2000 and were missed in the earlier, lower intensity surveys of the lagoon. All of patches were treated by the end of the summer 2001. Data for 2001 therefore reflect a baseline against which future eradication progress can be judged. *Caulerpa* found outside of the initially identified infestation area comprises approximately 27% of the total found in 2000 although the area over which this material was distributed included approximately 161% of the total area known to exist in 2000 (see Table 2).

TABLE 2. STATUS LAGOON-WIDE (EXCLUDING GRID)*

Parameter	2000	2001	% Reduction
Areal Extent (sq.ft.)	unknown	3,040	NA
Number Major Patches	probably 5	5	NA
Debris Field Area (sq.ft.)	unknown	101,831	NA
Number of Infestation Areas	5	5	0.00%

* Preliminary data as of September 23, 2001

The grid-survey results suggest that the eradication approach is effective in treating Caulerpa with the goal of full eradication. However, this report only addresses year-one in a long-term program and diligence in implementation will be essential in order to avoid backsliding. The following section outlines future program plans and needs.

Future Actions in the Eradication Program

Expectations of a 5-year Program

The first year of eradication work provides insight into what can be expected over the course of future eradication efforts. The first year data also indicate that the initial action plan contemplation of a 5-year eradication program was not unfounded. The reappearance of *Caulerpa* within the grid was expected. The propensity for *Caulerpa* to vegetatively disperse through fragmentation means that regardless of initial successes, multiple years of surveillance and eradication are necessary to find and address very small fragments as they grow to a detectable size. While the precise length of time it may take to rid the lagoon of *Caulerpa* may vary from the 5-year estimate, the general schedule fits well with observed reductions in 2000-2001.

As the eradication program continues, it is anticipated that surveillance efforts will dominate over treatment efforts in terms of both costs and time. With the biomass and areal coverage of *Caulerpa* significantly reduced, efforts are now focused on seeking smaller patches over larger areas. Intensive surveys seeking the earliest possible detection of newly colonizing patches will be the focus during the subsequent year (2001-2002) and possibly a third year. The large reduction in patch cover since the inception of the eradication effort means that patches can now be treated within 48 hours of discovery. Such a rapid response ensures minimal fragmentation and will help to ensure that the program timeline is kept to a minimum. Given the progress that has been made, it is hoped that by the end of the third year no new occurrences are identified and surveys would be performed for the purpose of designating areas as non-infested. Two additional years (years 4 and 5) would be used to conduct surveys to ensure that no remaining *Caulerpa* exists. Only after at least two years of surveillance without detection would the lagoon be declared free of *Caulerpa*.

Enhancing the Caulerpa Detection and Eradication Efforts

While it is essential that the present program be maintained to effectively eradicate *Caulerpa* within the lagoon, there are also opportunities to enhance the program by increasing the intensity of surveys. This enhancement of the program is currently limited by available funding and conflicts of safety and efficiency between the eradication efforts and recreational uses within the lagoon.

The present eradication program includes two surveillance levels. The first is a high intensity surveillance that is being used in regions of the lagoon where *Caulerpa* has not previously been identified. The second is an even higher intensity eradication area survey. Although survey intensity has increased five-fold (greater diver density) since initiating work on the eradication program, still higher intensity would be helpful. The present program calls for quarterly surveys of the entire lagoon. This program is proposed to continue in the future. If additional resources were available, it would be preferable to conduct monthly surveys of the lagoon during the period of highest growth (May through September) and to intensify and expand survey areas around eradication sites. Such actions would allow more rapid identification and treatment of patches and would ensure that the rate of elimination of alga from the lagoon was increased.

F. Tarp Removal From Treated *Caulerpa taxifolia* in the Huntington Harbour Infestation (December 2001)

Tarp Removal From Treated *Caulerpa taxifolia* in the Huntington Harbour Infestation
Summary of Field Notes to Date
Rachel Woodfield
December 2001

Introduction

An infestation of *Caulerpa taxifolia* was identified in Agua Hedionda Lagoon in Carlsbad, California in June 2000. Preliminary investigations conducted in June, July, and August 2000 tested the efficacy of various herbicides at killing *Caulerpa taxifolia* samples collected at Agua Hedionda. Chlorine was determined to be the most effective and practical agent for use in treating the infestation in the field. Liquid chlorine was injected under PVC tarps that had been placed over patches of *Caulerpa* in Agua Hedionda. In October 2000, treatment of a second infestation in Huntington Harbour in Huntington Beach, California involved a similar methodology, but with the application of solid pucks of chlorine.

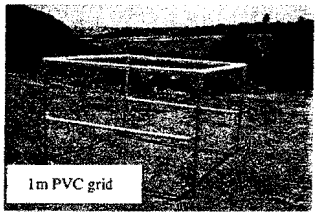
While the chlorine treatments clearly kill the aboveground biomass, it is not known how well the chlorine penetrates the *Caulerpa* biomass buried in the sediment. While *Caulerpa* does not grow back in areas where tarp and chlorine have been placed, it is not known if this is simply because of the continued presence of the tarp, or if the below-ground biomass was effectively killed by the treatment. To date, all tarps have been left in place in Agua Hedionda and Huntington Harbour.

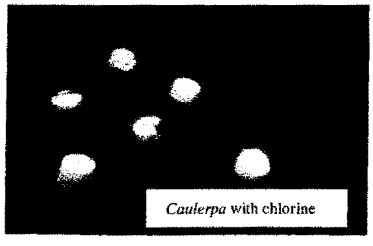
However, if *Caulerpa* were to be discovered in a high energy environment, offshore for example, it may not be feasible to leave tarps on the bottom for long periods of time. To determine the minimum time a chlorine/tarp treatment must stay in place over a chlorinated *Caulerpa* treatment in order to render the alga non-viable, a brief investigation was conducted in Huntington Harbour where tarps were removed from eighteen small treatment plots at varying intervals following treatment.

This investigation was intended to collect useful information without interrupting the eradication process, and was not intended to constitute a complete research program. Work was completed when permitted by the demands of the eradication effort; a strict experimental design was not adhered to. It was understood that study plots might have to be sacrificed prior to the end of the investigation if the needs of the eradication effort conflicted with the placement of the study plots.

Methods & Results

In March 2001, small patches of *Caulerpa* that covered an area of less than one square meter were identified in the West Pond of Huntington Harbour (Figure 1). A one-meter square PVC grid with legs was placed over each patch to mark its location and form the structure over which the treatment tarp would be placed. The exact location of the *Caulerpa* was marked with pin-flags. Twenty one-inch chlorine pucks were distributed within the one-meter square and an approximately 2.5 x 2.5-meter


1m PVC grid


Caulerpa with chlorine

Location of West Pond in Huntington Harbour
Huntington Beach, CA

Figure
1

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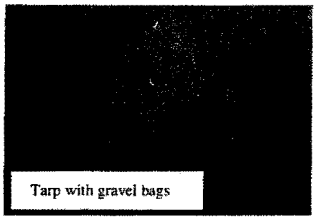
20mil black PVC tarp was laid over the grid. The tarp was secured to the substrate with steel rebar and held in place with heavy gravel bags. The grid stood approximately 0.25-meter tall, creating a volume under the tarp of approximately 0.25-m^3. There were three additional plots that were tarped without an application of chlorine underneath. The locations of the study plots are indicated in Figure 2.


Tarp with gravel bags

Tarps were to be removed at designated intervals following the complete bleaching of the *Caulerpa* under the tarp. Because solid chlorine was used, which dissolves slowly, the immediate bleaching of all material under the tarp that had been observed at Agua Hedionda when using liquid chlorine was not seen. It took five weeks for all *Caulerpa* to be bleached under the tarps (April 2001). At that time, the tarps were pulled back from plots 1A, 3D, 4A, and 7B. Some of the *Caulerpa* was no longer detectable under the tarps, with only the pin flags indicating the original location of the thalli. In other cases the *Caulerpa* thalli were clearly bleached and transparent. The diver teased a few of these thalli partially out of the sediment and found the vertical (buried) portions of the stolon to also be bleached and transparent. (Multiple attempts to regrow bleached thalli such as these in aquaria in Summer 2000 resulted in no growth and eventual disintegration).

In May 2001, the eight-week treatment tarps were uncovered. Treatments 1B, 3B, 7C, and 8C were each completely bare and blackened under the tarps. No *Caulerpa* was detectable. The five week treatments were all revisited and found to have no regrowth of *Caulerpa* (plot designated as "clean").

In June 2001, all uncovered treatment plots were checked. No regrowth of *Caulerpa* was detected.

In September 2001, the twenty-week treatment tarps were uncovered. Treatments 1C, 6A, 7A, and 8B were each completely bare and blackened under the tarps. No *Caulerpa* was detected. All previously uncovered study plots were revisited and were found to be clean.

At that time it became apparent that the study plots in the center of the West Pond (tarp group 3) had been established in an area that had considerable scatterings of *Caulerpa* which, while not evident in March, had sprouted up to detectable size between plots by September. In order to effectively treat the area, a larger tarp had to be placed over the entire area, including over the five study plots in the vicinity. Plots 3A, 3C, and 3E were all uncovered for examination prior to the laying of the large tarp. All were found to be completely bare and blackened and have been designated as "lost".

Also at that time, the three plots that were tarped but received no chlorine were also uncovered (8A, 8D, and 2A). All three were bare and blackened.

All uncovered study plots were revisited in October 2001 and found to contain no *Caulerpa*. A summary of the results described above is provided below in Table 1.

Location of Study Plots in West Pond (small plots adj
Huntington Harbour
Huntington Beach, CA

TABLE 1		Observation Interval and Plot Status					
Tarp Duration	Plot ID	5 weeks (April 01)	6 weeks (April 01)	8 weeks (May 01)	12 weeks (June 01)	20 weeks (Sept 01)	24 weeks (Oct 01)
5 weeks	1A	Uncovered	Clean	Clean	Clean	Clean	Clean
	3D	Uncovered	Clean	Clean	Clean	Clean/covered	Plot lost
	4A	Uncovered	Clean	Clean	Clean	Clean	Clean
	7B	Uncovered	Clean	Clean	Clean	Clean	Clean
8 weeks	1B			Uncovered	Clean	Clean	Clean
	3B			Uncovered	Clean	Clean/covered	Plot lost
	7C			Uncovered	Clean	Clean	Clean
	8C			Uncovered	Clean	Clean	Clean
20 weeks	1C					Uncovered	Clean
	6A					Uncovered	Clean
	7A					Uncovered	Clean
	8B					Uncovered	Clean
24 weeks	3A					Clean/covered	Plot lost
	3C					Clean/covered	Plot lost
	3E					Clean/covered	Plot lost
No chlorine (24 weeks)	8A					Uncovered	Clean
	8D					Uncovered	Clean
	2A					Uncovered	Clean

Discussion

As mentioned above, this investigation should be treated strictly as a pilot study which may guide the development of an appropriate experimental protocol to test for the efficacy of the chlorine treatment. Observations were made throughout this work that allow for recommendations to be made for future investigations. It is suggested that the initial treatment be applied as liquid chlorine, which has an immediate effect (within hours). This will allow for the immediate initiation of the investigation of tarping durations. Because all tarping durations investigated here have resulted (to date) in no regrowth, it would be useful to explore much shorter times, such as a few hours, one day, two days, three days, or one week.

If *Caulerpa* had been detected growing in the study plots following treatment, it could not be established for certain that the material had not been introduced from outside of the plot from a nearby patch of *Caulerpa*, as small occurrences continue to be found in the pond. As the eradication effort progresses and there continues to be a diminished amount of *Caulerpa* in the pond, the risk of external infection of the study plots will be continually reduced. Future experiments of this sort might consider screening the edges of the study plots to discourage dispersal of *Caulerpa* into the plot from other sources.

It is important to note that although the *Caulerpa* growing in Huntington Harbour and Agua Hedionda have been identified as clones of one another, the *Caulerpa* has been observed to behave radically differently at the two sites (growth rates, seasonal variation, distribution, etc.). In addition, the two sites are physically very different (circulation, substrate, dispersal agents, other plants and animals, water quality, depth, etc.). Any

conclusions drawn or suggested from observations made in Huntington Harbour should be applied only to the Huntington Harbour eradication.

All study plots will continue to be revisited to check for regrowth of *Caulerpa* throughout the length of the eradication effort (a minimum of 4 more years). It is possible that some plots may again have to be sacrificed in order to effectively treat an infested area. Of interest is the coming spring and summer 2002 season, when water quality is likely optimal for growth of any *Caulerpa* material that may be resting in the sediment of the study plot in Huntington Harbour. Finding regrowth at that time or even appearing several years later would not be of great surprise due to several observations made previously in Agua Hedionda. In several cases, observations suggested that there may have been undetected *Caulerpa* material present in the sediment throughout the warm summer season, a time that would seem to be optimal for regrowth, yet *Caulerpa* did not sprout up. However, it did sprout up in these same plots either during the following winter or summer, suggesting algal material may be able to lie dormant in the sediment for extended periods of time, reminiscent of seed banking commonly seen in higher plants. For this reason it is prudent to watch the uncovered study plots in Huntington Harbour for several years to determine if they in fact remain clear of *Caulerpa*.

G. Investigation of Eradication Treatments of *Caulerpa taxifolia* in Agua Hedionda (December 2001)

INVESTIGATION OF ERADICATION TREATMENTS OF *CAULERPA TAXIFOLIA* IN AGUA HEDIONDA

Summary of Field Notes and Preliminary Calculations
Rachel Woodfield
December 2001

INTRODUCTION

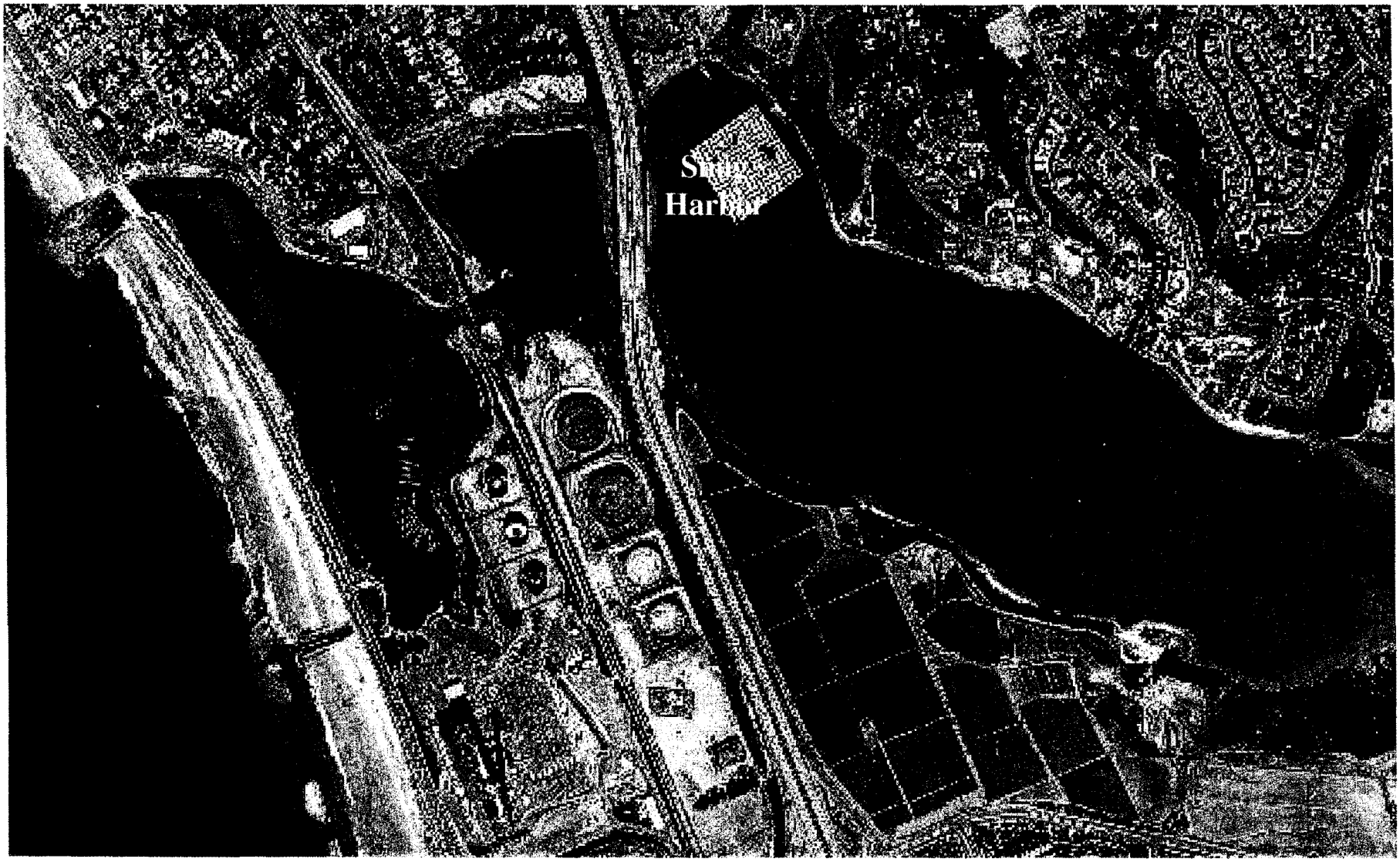
An infestation of *Caulerpa taxifolia* was identified in Agua Hedionda Lagoon in Carlsbad, California in June 2000. Preliminary investigations conducted in June, July, and August 2000 tested the efficacy of various herbicides at killing *Caulerpa* samples collected from Agua Hedionda. Chlorine appeared to be the most effective and practical agent for use in treating the infestation in the field. The main focus of the Southern California *Caulerpa* Action Team was an immediate eradication effort, however it was recognized that some useful information might be collected concurrent with, but not hindering, the eradication effort that was under way. In order to look at other potential treatment options in the field, a small investigation was set up using a variety of treatment methods. The effect of the various treatments was assessed by comparing the growth rates of the treated *Caulerpa*. This was not the ideal indicator of treatment efficacy, as the only acceptable outcome of eradication is to have no growth, but the intention was to collect as much data as possible during the brief duration of the investigation.

This investigation was intended to collect useful information without interrupting the eradication process, and was not intended to constitute a comprehensive research effort. Work was conducted concurrently with the eradication effort and a strict experimental design was not adhered to. It was understood that study plots might have to be sacrificed prior to the end of the investigation if the needs of the eradication effort conflicted with the placement of the study plots.

METHODS & RESULTS

In August 2000, thirty small patches of *Caulerpa* that covered an area of less than one square meter were identified in Snug Harbor at Agua Hedionda (Figure 1). A one-meter square PVC grid with legs was placed over each patch to mark its location and form the structure over which the treatment tarp would be placed. Several steps were taken to prepare each study plot. In each, the amount of eelgrass growing in a plot was assessed and assigned a value of sparse, moderate, or dense. Five thalli of *Caulerpa* in each plot were selected for monitoring. Landscaping pin-flags, with trimmed flags, were numbered and placed in pairs on either side of, but not touching, the growing tip of the stolon. A frond from the same thallus was selected for elongation monitoring and marked with a small cable-tie, looped into a circle 3-4 cm wide and loosely collared around the base of the frond. This did not appear to impair the growth of the frond or stolon.

All study plots were mapped and randomly assigned one of the following six treatments, with five replicates of each: 1) PVC grid, open with no tarp or chemicals (control) 2) PVC grid, black PVC tarp (dark) 3) PVC grid, clear plastic tarp (clear) 4) PVC grid, black PVC tarp, chlorine application 5) PVC grid, black PVC tarp, acetic acid application 6) PVC grid, hand pick all *Caulerpa*. The locations of the study plots are mapped in Figure 2.



Location of Survey Grid in Snug Harbor at Agua Hedionda
June 2000
Carlsbad, CA

Figure 1

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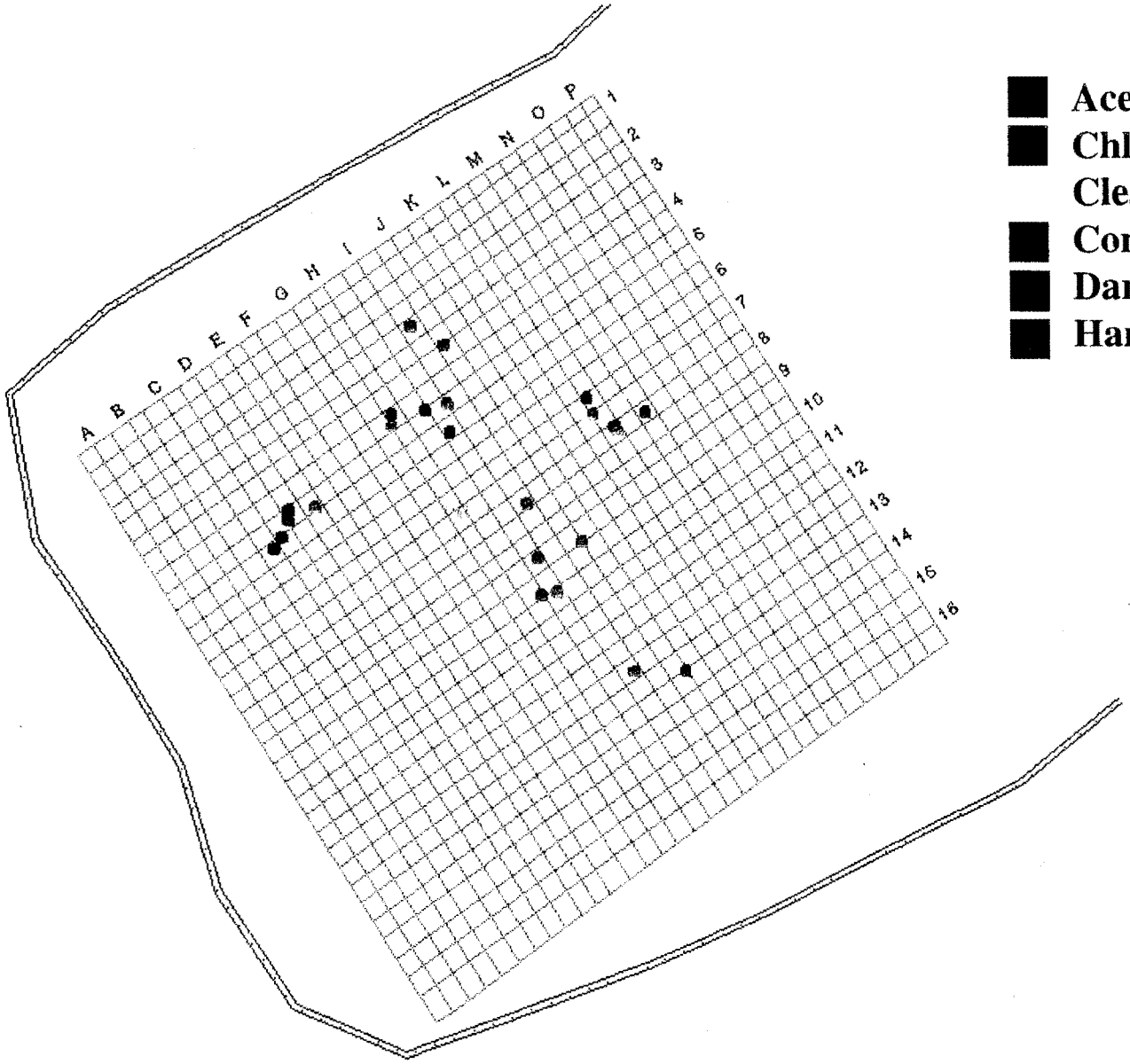

N

Location of Treatment Study Plots within the *Caulerpa* Survey Grid in Snug Harbor, Agua Hedionda, Carlsbad, California

Figure 2

Merkel & Associates, Inc.

All study plots were treated between August 8 and 11th, 2000 as described below. Prior to treatment of the study plots the initial measurements were recorded. For each plot, an initial percent cover of *Caulerpa* was recorded by placing a one-meter quadrat divided into 100 sub-cells over the plot. Presence or absence of *Caulerpa* in each of the 100 cells was used to assign a percent cover. The lengths of the marked fronds were recorded, while the stolon elongation measurements were all zero.

The control plots received no tarps or chemical treatment and were simply to be monitored for growth. The dark treatments were each covered by a 2.5 x 2.5-meter sheet of 30mil black PVC tarp, which was secured with rebar and sealed to the substrate with a perimeter row of sand bags. The tarp prevented light penetration and water flow. The volume of the tarped treatment was approximately 220 liters. The clear treatments were set up similar to the dark treatments, using clear Visqueen tarp of similar thickness, which permitted light penetration but not water flow.

The chlorine study plots were set up just as the dark plots, with the exception of a port installed in the top of the tarp to allow the introduction of liquid chlorine from shore and allow for collection of water samples from under the tarp. Preliminary investigations in buckets using 5% sodium hypochlorite (household bleach strength) had suggested that a 100 to 1 ratio of seawater to chlorine was lethal to two thalli in approximately 6 liters of seawater. Considering the density of *Caulerpa* in the study plots, a ratio of 10 to 1 (seawater to chlorine) was applied by injecting 22 liters of the 5% solution under the tarp. The acetic acid study plots were similar to the chlorine plots, with acetic acid injected as the treatment. With a goal of a 49 to 1 ratio of seawater to acetic acid, 4.4 liters of glacial acetic acid were injected under each of the five treatments to make a 2% acetic acid treatment.

The hand pick plots were treated by harvesting by hand all of the *Caulerpa* from the plot along with 10cm of the underlying sediment. Pin flags were inserted to mark where the *Caulerpa* had been, in order to aid in monitoring for regrowth. At the field station, the harvested *Caulerpa* was extracted from the sediment. The wet weight was measured and the total number of thalli and fronds was counted and recorded. Although these data did not relate directly to treatment efficacy, they were collected for general interest to compare to the recorded percent covers recorded in each plot.

Following initial treatment, each plot was revisited from three to five times within the next nine to twenty days to monitor the status of each plot. At the control plots, growth data were collected and percent cover was measured. At the clear, dark, and acetic acid treatments, the tarps were folded back so that percent cover and growth measurements could be made. Notes were taken on the health of the *Caulerpa*, eelgrass, and fauna as well. At the chlorine treatments, a water sample was collected by inserting a syringe with an extension tube on it into the tarp through the port. The sample was tested by support staff in the boat for the presence of residual chlorine. No chlorine was detectable under any of the treatments within 24 hours of the application. Tarps were folded back and observations were recorded. The hand picked treatments were all visited and inspected for missed *Caulerpa* or evidence of regrowth.

The small patches selected for use in this investigation were all on the periphery of much larger adjacent patches. As these larger patches were tarped for the eradication effort, most of the study plots fell within the buffered treatment area and were tarped over and not

accessible for further observation. The last observations were made on August 29, 2000. By that time, all control plots had been covered by larger tarps; no *Caulerpa* was left untreated.

RESULTS

The control study plots all grew vigorously for the nine to twenty days that they were monitored (some longer than others). The mean stolon elongation was $7.2 \pm 5.3_{s.d.}$ mm/day (n=63), with some observed to grow up to 27.0 mm/day. The mean frond elongation was $4.2 \pm 3.5_{s.d.}$ mm/day (n=63) with rates observed up to 13.0 mm/day. Percent cover increased in all five replicates: from 13% to 22% in nine days (rep 1), from 30% to 35% in eight days (rep 2), from 57% to 77% in fifteen days (rep 3), from 55% to 64% in nine days (rep 4), and from 96% to 98% in eight days (rep 5). The initial eelgrass density was reported as moderate for all five replicates. The expanding *Caulerpa* grew into the surrounding eelgrass.

The *Caulerpa* in the dark study plots continued to increase in size for the first two to three days of being covered, but became reduced in size in nearly all samples over the next five days. At that time, the *Caulerpa* under the tarps was losing turgor, appearing gelatinous and limp, with an olive green color. Conditions under the tarp appeared anoxic, with dark black substrate, blackening of the eelgrass, dead invertebrates (primarily ghost shrimp and razor clams) and a dead blenny in one replicate. By the twentieth day, the *Caulerpa* was collapsing and dissolving when touched in four of the five replicates, and completely undetectable in the fifth.

While the mean stolon elongation during the nine days that the *Caulerpa* in the dark plots held enough shape to be measured was $1.6 \pm 3.3_{s.d.}$ mm/day (n=47), the rate can be more interesting looked at during the first three days of treatment when stolons increased at a mean rate of $3.7 \pm 3.1_{s.d.}$ mm/day (n=24), but then shrunk during the following five days at a mean rate of $-0.6 \pm 1.6_{s.d.}$ mm/day (n=23). The fronds generally continued to grow or stay at the same length over the nine days with a mean frond elongation of $0.5 \pm 2.6_{s.d.}$ mm/day (n=46) and exhibited less of the shrinking that was seen in the stolons. Percent cover increased slightly in three replicates: from 26% to 27% in eight days, from 20% to 21% in eight days, from 20% to 29% in nine days, remained at 100% in one replicate and in the fifth was reduced from 72% to 64% in nine days.

The *Caulerpa* in the clear tarp study plots continued to grow after tarping, but visibly slower than in the control. The new fronds that sprouted at the growing tips were fewer and more narrow and short than those in the control. Interestingly, nearly every frond sprouted a stolon at its tip rather than continuing growth in the form a frond. Over the sixteen days of measurements, the tarps became fouled by settling silt and algal growth, which caused some shading in the plots. There were dead scallops, razor clams, and bubble snails under each tarp.

The mean stolon elongation in the clear plots was $4.7 \pm 3.4_{s.d.}$ mm/day (n=72). The mean frond elongation was $3.5 \pm 2.6_{s.d.}$ mm/day (n=73). By August 24, all five plots had been incorporated into larger treatment tarps, preventing further monitoring.

The chlorine test plots started with percent covers ranging from 58 to 99% with moderate eelgrass density. Plots were visited in the days following treatment and tested for residual chlorine under the tarp. None was detected. The tarps were pulled back on the fifth day to

examine the plot. All invertebrates were dead, with the *Caulerpa* appearing to not have been completely bleached in the four replicates with 71% cover or more. The midribs of the fronds were still slightly green in a portion of the material. A fifth replicate (58% cover) was completely bleached, with no green color detectable in the *Caulerpa*. No growth was detected in any of the plots. Samples of the *Caulerpa* were collected from each of the five plots and placed in aquariums at the field station for observation. None exhibited viability and after several days dissolved and were undetectable. The tarps were put back on the plots following the initial check. Later visits to the plots found the *Caulerpa* to be undetectable, apparently having disintegrated away. The tarps were replaced and in most cases the plots were incorporated under larger treatment tarps.

The acetic acid treatment also appeared to take immediate effect, with no growth detectable when the plots were revisited six days after treatment. With percent covers ranging from 12 to 94%, the treatment had in effect pickled the *Caulerpa*, leaving it essentially intact but with a dark olive green color and limp structure. Samples were taken out of each plot and monitored in aquaria. No growth was ever detected and all samples were considered unviable. Dead ghost shrimp, scallops, razor clams and fish were observed in the plots.

The hand picked plots were all monitored for regrowth. There were only four replicate plots due to the loss of the fifth to the concurrent eradication effort. One of the replicates was found to have a single frond growing in it nine days after being picked. This was most likely a piece that was missed and left behind during the picking. Once the removal is initiated, the entire area becomes very turbid and it is easy to miss small fragments. The other replicates were found to be clean and continue to be monitored today, and continue to be found clean. The measurements of the harvested *Caulerpa* found that three replicates which all had about 15% cover had wet weights of about 50g. The replicate with 25% cover had a wet weight of 112g.

Water temperatures in the lagoon were moderate in June 2000, with a bottom temperature of 17°C on June 15, quite a bit higher throughout July, with a bottom temperature of 25°C on July 26. The warm temperatures persisted until August 9, when temperatures dropped dramatically to 19°C and remained low for several weeks, warming back up to around 22°C throughout September.

DISCUSSION

These were brief summaries of the results of this investigation, which would ideally have been monitored for a much longer time and involved further treatment, such as removing the tarps completely and watching for regrowth. There are a few interesting observations though that can be made from this work. Because I was not able to assess the viability of any plant material that may have remained untreated in the sediment, I can only discuss treatment effectiveness on above-ground biomass. It appears that tarping alone is not enough to kill *Caulerpa*, as evidenced by the clear tarping, while using a black tarp is effective through a combination of lack of light and restricted water flow. The loss of circulation appeared to lead to a build up of inhospitable conditions as material under the tarps rotted, as evidenced by the dead invertebrates seen in all tarp treatments.

Although black tarps alone appeared effective, there were two main rationales for continuing with an eradication plan that combined the exclusion of light by black tarping with the application of chlorine. Primarily, the goal was to make the *Caulerpa* non-viable as quickly as possible after tarping. There was a concern that placing just the tarp over the *Caulerpa* would encourage it to bolt for the edges of the tarp while seeking light and possibly escape undetected from the edges. Additionally, with placement of a large sheet of plastic in a dynamic, tidal water body comes the risk of it becoming dislodged for any of a variety of reasons. If this were to occur there would be less risk of additional spread if the *Caulerpa* underneath were already not viable.

The other reason for applying chlorine also highlights one of the major questions yet to be answered regarding eradication of *Caulerpa* in California. It is not known what the status is of the sub-surface biomass of the *Caulerpa* in the substrate following any treatment (dark tarp, chlorine, hand pick). The assumption was made however that the application of chlorine, which is considerably more dense than sea water, was more likely to have a lethal effect on the sub-surface stolons and rhizoids by penetrating into the sediment.

Four of the five chlorine treatments most likely needed to receive more chlorine in order to bleach the *Caulerpa* completely. Although the *Caulerpa* did not show viability in the aquarium or after continued tarp time, greater confidence can be placed in the efficacy if the *Caulerpa* is completely bleached of all color. The fifth plot, which had a smaller percent cover, seemed to have received an appropriate dose. Future applications of chlorine to large eradication tarps were adjusted based on these findings.

The acetic acid treatment was very interesting. The treatment appeared to be effective by pickling the *Caulerpa.* Again, there is no information on whether *Caulerpa* would have regrown from untreated sub-surface biomass had the tarps been removed. The limitation of using this treatment on a large scale is the difficulty and hazard of application. To treat even the small study plots with a safe concentration of acetic acid such as table vinegar would have required the application of 88 liters. Aside from being cumbersome to move around that much liquid, the space under the tarp could not contain such a big volume. Using a more manageable volume requires the use of glacial acetic acid, which is highly concentrated and must be handled very carefully. The risks of injury to the applicators are considerably greater that those of applying the liquid chlorine that has been favored for the current eradication effort.

As was suggested by the hand-pick treatments and has been made clear by addition field work and reports from others, hand picking is not an effective method of removing *Caulerpa* on a large scale. It can be effective on a very small scale for removing single, small thalli. Once more than one thallus is targeted, it becomes very difficult to remove all of the plant material. As discussed above, visibility is lost once the work is initiated. The thalli often break while being removed and leave small fragments behind. A vigorous plant also often has segments of frond that appear to be preparing to fragment, with a small ball of rhizoids and short stolon tip evident at mid length on a frond. When disturbed, these pieces have been observed to readily break off and are easily lost track of. For these reasons, hand picking is now done only on a very limited basis, typically with very small occurrences or fragments that are found loose on the substrate or in the eelgrass.

Clearly, this work is very cursory and there are many questions still to be answered. As well as experimenting with post-treatment tarp removal to watch for regrowth, it would also be of interest to monitor the recovery of the treated areas. When tarps that have been down for more than a few weeks are pulled up, the substrate is always completely bare, whether it has been treated with chlorine or not. This condition could provide an ideal study area for observing recovery of a tarped area. While tarping of any sort is lethal to the biota under the tarp, there may be interesting variations in the recolonization rates depending on the chemical treatments that were or were not applied under the tarps. An estimate of the biological cost of treatment of *Caulerpa* could be useful for making future management decisions regarding additional infestations of *Caulerpa* that may be discovered.

H. Timeline of Events Relative to *Caulerpa taxifolia* Infestation in California (September 2001)

TIMELINE OF EVENTS RELATIVE TO *CAULERPA TAXIFOLIA* INFESTATION IN CALIFORNIA

DATE	LOCATION	DESCRIPTION
1996	Carlsbad, CA	*C. t.* likely introduced into Agua Hedionda Lagoon through discharge from an aquarium. Reports of collections by private citizens that emerged after *C. t.* was identified in 2000 will support this belief. The severity of this introduction will go unrecognized until June 12, 2000
1998	United States	Andy Cohen spearheads effort with over 100 prominent scientists petitioning Interior Secretary Bruce Babbit to add *C. t.* to the import-banned invasive species under the Federal Noxious Weed Act
1998	Huntington Beach, CA	*C. t.* known by residents to occur in Huntington Harbour but not recognized for its infamous invasive nature
November 1998	United States	National Aquatic Nuisance Species (ANS) Task Force begins working on A Prevention Program for the Mediterranean Strain of *Caulerpa taxifolia* focusing on prevention of introduction of *C. t.* to U.S. waters
March 16, 1999	United States	*C. t.* added to the Federal Noxious Weed Act resulting in a ban on international import and interstate trade of the species. Intrastate sales and private exchanges over the internet continue.
August 3, 1999	United States	ANS Task Force publishes "A Prevention Program for the Mediterranean Strain of *Caulerpa taxifolia*"
June 12, 2000	Carlsbad, CA	*C. t.* discovered in Agua Hedionda Lagoon during eelgrass surveys. This is the first verified occurrence of *C. t.* in the Western Hemisphere
June 13, 2000	Carlsbad, CA	Surveys in Agua Hedionda Lagoon commence to assess the magnitude of *C. t.* infestations while identification is confirmed
June 15, 2000	United States, Europe	*C. t.* identification confirmed based on morphology by Paul Silva, Curator of Phycology, Berkeley Herbarium and Alex Meinesz, University of Nice, France
June 17, 2000	Carlsbad, CA	Field and laboratory investigation to test and develop treatment methods for Agua Hedionda Lagoon commence
June 26, 2000	Carlsbad, CA	Field investigations of growth parameters and control efficacy of differing treatments initiated to support eradication efforts
June 28, 2000	San Diego, CA	First meeting of the Southern California Caulerpa Action Team (SCCAT) to review field and treatment data, contemplate actions, and structure eradication program
July 4, 2000	San Diego, CA	Draft Rapid Response and Eradication Program for the Invasive Green Alga, *Caulerpa taxifolia* , at Agua Hedionda Lagoon., Carlsbad, California submitted to SCCAT for review and adoption.
July 5, 2000	San Diego, CA	Immediate Action Plan adopted by SCCAT calling for contained treatment with chlorine. SCCAT holds back to back briefings of environmental community leaders and media on the *Caulerpa* situation and planned response. Coordinated *Caulerpa* information outlet established through NMFS.
July 6, 2000	Carlsbad, CA	Water surface navigation in Agua Hedionda realigned to isolate Snug Harbor to facilitate treatment of known infestation areas. Carlsbad PD assists SCCAT by revising uses to separate boat traffic from divers conducting survey and treatment efforts within known infestation areas
July 27, 2000	Huntington Beach, CA	SCCAT notified that *C.t.* exists in a pond in the back part of Huntington Harbour. The notification comes as a result of press coverage on the issue.
July 28, 2000	Huntington Beach, CA	M&A confirms *C.t.* occurrence and prepares a preliminary briefing on the site conditions and layout for SCCAT
August 2, 2000	Huntington Beach, CA	Surveys of Huntington Harbour commence using M&A and CDFG staff
August 2000	Huntington Beach, CA	Surveys in Huntington Harbour ultimately reveal that Caulerpa exists not only in two isolated ponds, but also in the adjacent harbor areas.

DATE	LOCATION	DESCRIPTION
August 25, 2000	Fresno, CA	*Caulerpa taxifolia* from Agua Hedionda and Huntington Harbour are confirmed by Dr. Rick Zechman of CSU Fresno to be genetically identical to the Mediterranean strain of *C.t.*
August 25, 2000	San Diego, CA	First of many public outreach coordination meetings hosted by RWQCB to coordinate resources available through public, private, and institutional interests.
September 20, 2000	Carlsbad, CA	Treatment completed on 11,310 ft^2 of *C. t.* known to exist in Agua Hedionda Lagoon during the summer of 2000. In 2001 it will later be found that some infestation areas went undetected through 2000.
November 2000	Carlsbad, CA	Fall quarterly surveys were largely in effective due to massive natural dieback of eelgrass that matted down across the bottom making it nearly impossible to survey significant portions of the lagoon floor.
February 2001	Carlsbad, CA	Early spring surveys were aided by the exposure of lagoon floor prior to the regrowth of eelgrass. Detection of *Caulerpa* patches that were clearly present in 2000 but which were missed in prior surveys resulted in a five-fold increase in survey intensity during the subsequent spring and summer surveys
June 26, 2001	Carlsbad, CA	Carlsbad City Council approves a ban on anchoring and fishing within infested areas of Inner AH Lagoon. Carlsbad PD and Cabrillo post lagoon signage. Enforcement is provided by Carlsbad PD and CDFG Wardens
July 2001	Washington D.C.	GAO report to congress on a national review of federal response to invasive species identifies the *Caulerpa taxifolia* eradication efforts in Southern California as an exemplary model of public-private partnership to respond to invasive species threats.
Summer 2001	Carlsbad, CA	Known 2000 coverage of *C. t.* in Agua Hedionda Lagoon reduced to 258 ft^2 (97.7% reduction where infestations were known in 2000). All other metrics also indicate a decline in *C. t.* is occurring.
Summer 2001	Carlsbad, CA	3, 040 ft^2 of *C. t.*, not detected in 2000, discovered in multiple patches in Agua Hedionda Lagoon outside original infestation area. Increased intensity of surveys during 2001 greatly aided in detection but increased eradication effort costs.
September 24, 2001	California	Governor Gray Davis signs AB 1334 (Harman) banning the intrastate sale, possession, importation, transportation, transfer and release of *C. t.* and similar *Caulerpa* species within California
September 30, 2001	Carlsbad, CA Huntington Harbour, CA	$1.1 million spent in eradication efforts at Agua Hedionda Lagoon, $400,000 spent on eradication within Huntington Harbour.
Present	Carlsbad, CA Huntington Harbour, CA	Ongoing survey and treatment of *C. t.* in Agua Hedionda and Huntington Harbour
Present	Southern California	Ongoing surveillance for *C. t.* lagoons, bays, and high risk coastlines including offshore of known infestation areas

I. Rapid Response and Eradication Program for the Invasive Green Alga *Caulerpa taxifolia* at Agua Hedionda Lagoon – ORIGINAL DRAFT (July 2000)

RAPID RESPONSE AND ERADICATION PROGRAM FOR THE INVASIVE GREEN ALGA, *CAULERPA TAXIFOLIA* AT AGUA HEDIONDA LAGOON, CARLSBAD, CALIFORNIA

Prepared for:

Southern California *Caulerpa* Action Team

- Regional Water Quality Control Board – San Diego Region (RWQCB-SD)
- California Department of Food and Agriculture (CDFA)
- U.S. Department of Agriculture (USDA)
- California Department of Fish and Game (CDFG)
- National Marine Fisheries Service (NOAA-NMFS)
- U.S. Fish and Wildlife Service (USFWS)
- Cabrillo Power I, LLC (Cabrillo)
- Merkel & Associates, Inc. (M&A)
- San Diego County Department of Agriculture (SDCDA)
- Environmental Protection Agency (USEPA)
- San Francisco Estuary Institute (SFEI)
- Aquatic Nuisance Species Task Force (ANSTF)

Prepared by:

Keith Merkel, Merkel & Associates, Inc.
Rachel Woodfield, Merkel & Associates, Inc.

July 12, 2000

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PREFACE

WRITTEN DECEMBER 2001

THE FOLLOWING DOCUMENT IS THE IMMEDIATE ACTION PLAN ADOPTED BY THE SOUTHERN CALIFORNIA CAULERPA ACTION TEAM (SCCAT) ON JULY 5, 2000, INCORPORATING EDITS MADE IN THAT ADOPTION. SUBSEQUENT TO ADOPTION OF THIS PLAN, ADDITIONAL MODIFICATIONS HAVE BEEN MADE TO THE METHODOLOGY APPLIED TO ERADICATION EFFORTS INCLUDING TREATMENT, SURVEY, SURVEILLANCE, AND REPORTING APPROACH. THESE CHANGES ARE REFLECTED IN THE **REVISED ERADICATION PLAN FOR *CAULERPA TAXIFOLIA* IN CALIFORNIA: SURVEILLANCE, ERADICATION, AND CURRENT STATUS (MERKEL & ASSOCIATES, NOVEMBER 2001).**

IN ADDITION CHANGES IN THE STRUCTURE OF THE SCCAT HAVE BEEN MADE AS AGENCY ROLES AND MANDATES WERE SORTED OUT IN THE MONTHS FOLLOWING THE INITIATION OF ACTION. THE STRUCTURE OF THE SCCAT IS NOT ADDRESSED IN THE REVISED DOCUMENT.

THIS DOCUMENT IS PROVIDED AS BACKGROUND TO THE INITIAL EFFORTS UNDERTAKEN IN SUPPORT OF THE INITAITON OF AN IMMEDIATE ERADICATION PROGRAM.

RAPID RESPONSE AND ERADICATION PROGRAM FOR THE INVASIVE GREEN ALGA, *CAULERPA TAXIFOLIA* AT AGUA HEDIONDA LAGOON, CARLSBAD, CALIFORNIA

INTRODUCTION

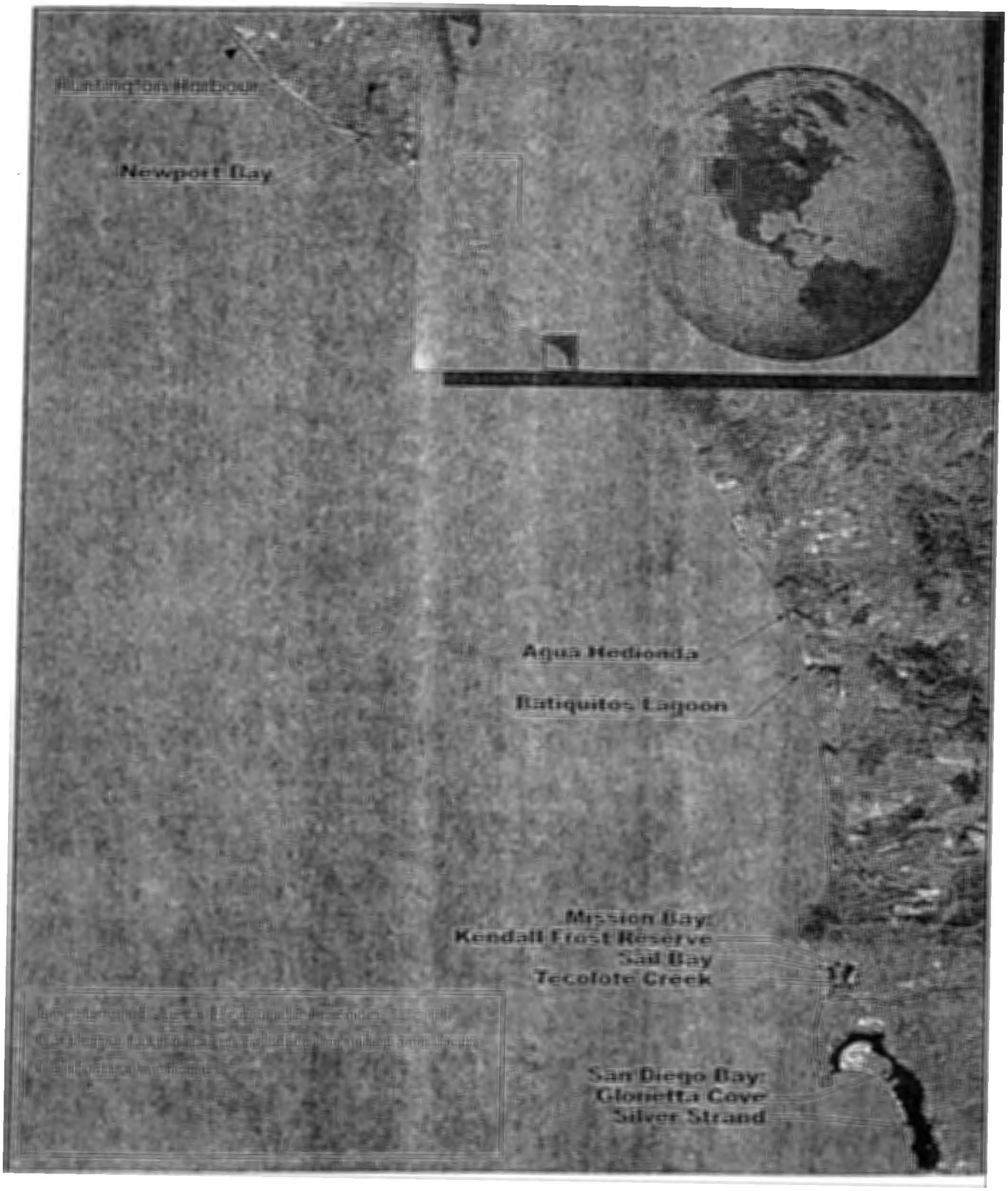
Caulerpa taxifolia (Mediterranean form), an extremely invasive green alga that is presently destroying the ecosystems of the northern Mediterranean Sea was banned from importation into the United States under the federal Noxious Weed Act. While the devastation this species could bring to the United States' shorelines has been previously noted both in the scientific journals and popular press, it has previously not previously been identified in the waters of the Western Hemisphere. However, on June 12, 2000 an apparently localized infestation of *C. taxifolia* was identified in Agua Hedionda Lagoon in Carlsbad, California in San Diego County (Figure 1).

With the identification of the Agua Hedionda Lagoon infestation, a number of actions have been put in motion to eradicate this local infestation and prepare for potentially more expansive occurrences that may already exist in other coastal waters. Included among the first elements to controlling the infestation, an action committee has been established from those entities with relevant authorities, expertise, resources, and/or vested rights and interests in the lagoon and its resources. The Southern California *Caulerpa* Action Team (SCCAT) is the group assembled to address the present infestation issues. It is a public/private partnership established with the sole purpose of completing activities related to the eradication of *Caulerpa* in an efficient and well-devised manner.

On August 3, 1999 the Aquatic Nuisance Species Task Force received a Prevention Program for the Mediterranean Strain of *Caulerpa taxifolia* prepared by Sandra Keppner and Russell Caplen, ANSTF members. This prevention program includes applicable guidance for the preparation of an eradication program. This guidance, along with an outline of an action plan prepared by Nate Dechoretz, CDFA, SCCAT technical program supervisor, form the basis for the plan that has been prepared and presented herein.

This document serves as the guidance document for the implementation of a rapid response and eradication program for the known Agua Hedionda Lagoon infestation. This plan further provides direction for immediate actions in the form of surveillance in other waters and limited public outreach. It does not address the needs to develop a long-term comprehensive control plan for *Caulerpa taxifolia* that will now be required given the knowledge that this species is now present in the southern California region.

Figure 1. Locator map for of Agua Hedionda Lagoon.



PLAN PURPOSE AND GOALS

This document addresses numerous elements essential to effective eradication of the present incipient occurrence of *Caulerpa*. The major components of this plan are:

1. Leadership and Organization
2. Coordination, Cooperation and Partnership
3. Survey and Detection
4. Eradication Implementation
5. Monitoring and Restoration
6. Public Outreach and Information
7. Applicable Regulatory Elements
8. Resources and Funding

Each of these components is expounded upon in the sections that follow. This plan is designed to aid in governing all aspects of the eradication effort from communications to eradication, to follow-up requirements. It is also designed to be a living document that may be amended to address program changes or new issues as they arise. Plan amendments are to be made through a formal process described herein and will be distributed to the SCCAT within 48 hours of any significant changes.

The principal goal of this plan is to provide a guide for the implementation of a rapid, multiple element action program to eradicate *Caulerpa taxifolia* from Agua Hedionda Lagoon and protect against the spread of this noxious weed to other areas of the coastline.

The program has the following objectives:

1. Establish the specific roles of SCCAT members and other agencies and organizations relative to the activities being undertaken through this plan;
2. Establish processes for coordination and communications between SCCAT members and partners;
3. Identify the actual extent of infestation both within and outside of the lagoon;
4. Determine the best course of action for control of *Caulerpa* using existing data, and completing further testing;
5. Outline a program for eradication that employs the selected defensible methods that are best suited to the specific conditions of Agua Hedionda Lagoon and level of infestation present;
6. Characterize the extent and permanence of anticipated collateral damage to lagoon resources that are contemplated with the proposed eradication methods and discuss these in the context of the level of risk of less aggressive controls or a non-action alternative;
7. Identify the post-eradication monitoring and restoration requirements;
8. Outline the specific public outreach and information dissemination activities to be completed by the SCCAT and the methods to be used in such communications;
9. Outline the applicable regulatory programs that affect the eradication and control efforts and identify means of compliance with programs;
10. Identify the short-term and long-term resources available to implement the eradication and surveillance efforts, and;
11. Identify any gaps in the control program and means to fill any voids in the program in advance of the need.

LEADERSHIP AND ORGANIZATION

The SCCAT is comprised of a number of federal, state, and local agencies as well as private organizations. Many of the SCCAT members have independent and overlapping authorities, jurisdictions, and expertise that may be either complementary or dysfunctional under varying circumstances. To ensure that the SCCAT functions effectively and efficiently this section of the plan establishes the roles and responsibilities of the SCCAT members relative to the key actions to be taken under the plan. The individuals and organizations represented on the SCCAT are indicated in the organizational chart presented in Figure 1. The technical advisory direction of the eradication effort rests with the California Department of Food and Agriculture (CDFA), however, the lead agency for the eradication efforts has been identified as the Regional Water Quality Control Board, San Diego Region (RWQCB-SD). Key roles in the program are:

- **Technical Program Supervisor** - Nate Dechoretz, CDFA, Integrated Pest Control

This program is being conducted under the technical advisory direction of the California Department of Food and Agriculture (CDFA). The CDFA, through its technical program supervisor provides guidance to the various aspects of the program playing both the key advisory role in the immediate action program for the Agua Hedionda Lagoon incipient infestation as well as the preparation of a long-term regional control program for the species (not addressed in this action plan). CDFA has been requested to serve in this role due to this agency's direct relevant experience in implementing eradication efforts for agricultural pest species.

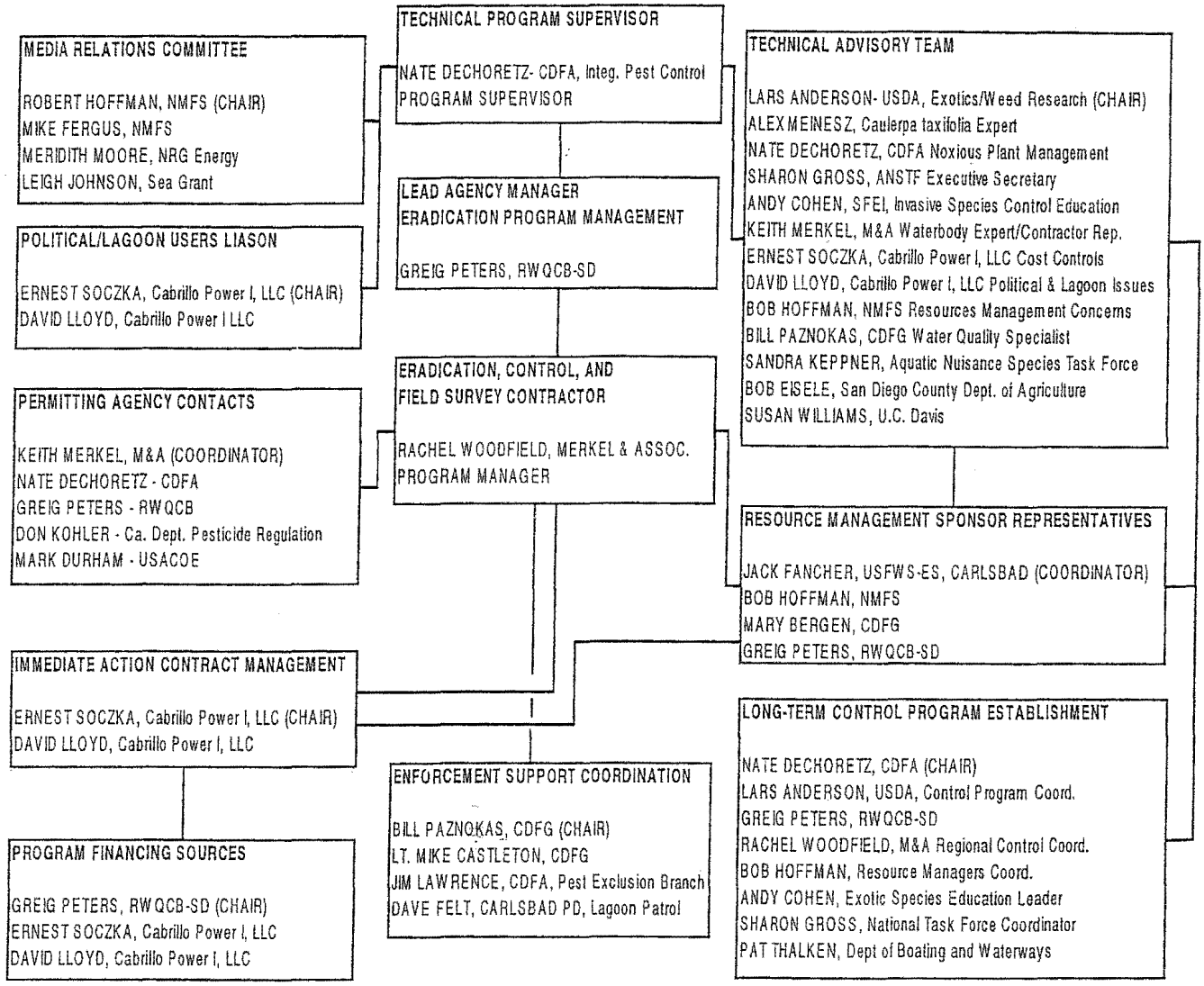
- **Lead Agency Manager** – Greig Peters, RWQCB-SD

As the lead agency representative for the implementation of the immediate action program, the Regional Board has the authority to direct contractor activities in the eradication efforts. Because of the overall greater experience of CDFA in addressing exotic pest infestations, the RWQCB will seek and use, to the greatest extent practicable, the advise and counsel of the technical program supervisor. However, the lead agency manager shall ultimately be responsible for directing the on-site eradication efforts under the auspices of the Clean Water Act and the Porter-Cologne Act.

- **Technical Advisory Team** – Chair: Lars Anderson, USDA, Invasive and Exotic Weed Research

The technical advisory team is to serve as an advisory body to assist the program supervisor by providing constructive and pertinent information useful in making informed decisions on the eradication program approach. The advisory team is comprised of experts in pest species research and control methods, *Caulerpa taxifolia* infestations, invasive species education, the human uses, the physical, chemical, and biological environment of the infested waterbody, natural resource management issues, and cost concerns relative to the eradication program. To provide a focused conduit for information assimilation, a chair for this committee has been designated. All information and recommendations from the advisory team shall be provided through the chair, who will serve to assimilate information for the program supervisor and will also be responsible for dissemination of information to technical advisory team members.

Figure 2. SCCAT Organization Chart For Immediate Action Program



- **Media Relations Committee** – Chair: Robert Hoffman, National Marine Fisheries Service

The media relations committee is responsible for coordination of all outside communications to be broadcast to the general public or focused constituent groups. This group is responsible for preparation of any update material and dissemination of materials as directed by the program supervisor. All information or statements to the public, media, or constituent groups regarding the efforts of the SCCAT shall be confirmed with the media relations chair prior to general release. As an additional effort of this group, a public information effort is to be developed to enlist the aid of target groups (recreational divers, boaters, and fishermen) in identifying any other outbreaks and controlling the spread.

- **Eradication and Survey Contractor** – Program Manager: Rachel Woodfield, Merkel & Assoc.

Merkel & Associates, Inc. is serving as the contractor for completion of the required eradication and survey work and is also providing technical and other support services to the SCCAT and its various committees, as required through the completion of the immediate action plan. M&A will be conducting or coordinating all elements of the field operations both inside and immediately outside of Agua Hedionda Lagoon. M&A has been offered agency staff and equipment resources to supplement its own resources. These agency resources will be useful in expanding the rate of work completion and controlling private party costs. As such these agency resources are very welcome. However, it must be noted that while M&A will coordinate the efforts of non-staff labor and equipment, no legal employee/employer nor contractor/subcontractor relationship exists between M&A and assisting agencies. M&A shall not insure, nor an any way be held liable for the actions or safety of agency staff and equipment. M&A will determine where and when support resources would be best applied and will instruct agency staff on methods and participate with agency staff in completing tasks, however, work by agency staff shall be deemed to be under the direction of the particular agencies and their representatives.

All field operation are to be completed under the direction of the program manager. The program manager shall designate task managers to assist in completing all of the require field works

- **Immediate Action Contract Management** – Chair: Ernest Soczka, Cabrillo Power I, LLC

At the present time, all work is being completed under contracts to Cabrillo Power I, LLC. To date, work has been fully funded by Cabrillo Power I, LLC and as such, authorization for any work effort must be given by Cabrillo. While Cabrillo Power I, LLC has been generous enough to willingly fund all control activities thus far, it is envisioned that some of these expenses may be reimbursed by state, federal, or local governmental funding sources in the future. It is further anticipated that Cabrillo Power I, LLC will transition out of the lead contract manager position as the immediate action program at Agua Hedionda Lagoon is completed and the focus moves towards a long-term control program development.

- **Program Financing Sources** – Chair: Greig Peters, RWQCB-SD

In order to adequately fund the completion of a comprehensive eradication and surveillance program for *C. taxifolia* in Agua Hedionda Lagoon, it is preliminarily anticipated that immediate action work may range between $800,000 and $1,300,000, depending upon the full magnitude of the infestation, the degree of success of initial eradication efforts, and the specific approach applied in the work. Costs do not fully contemplate the public agency and private party staff time also committed to the effort. While Cabrillo Power I, LLC has initiated efforts, it is fully intended that, at least some major portion of the total program cost will be borne by governmental funding sources. The program

financing committee has been established to aid in identifying and acquiring money, agency staff, or other resources that can be used in the effort to help defer costs.

- **Political/Lagoon User Liaison** – Chair: Ernest Soczka, Cabrillo Power I, LLC

The successful eradication of *Caulerpa* from Agua Hedionda Lagoon will require some levels of disruption to uses on the lagoon. These range from relatively minor watercraft inspection efforts to ensure that the species is not inadvertently spread to other waterbodies, to closures of various portions of the lagoon while eradication efforts are underway. Through this effort, it is essential that the impacts of the eradication efforts on the public and lagoon user groups be fully considered. It is also imperative that the users and controlling political bodies be coordinated with so that the program needs are identified, and reasonable alternatives to high impact actions may be fully explored. This group is charged with assisting the SCCAT in identifying program concerns of the lagoon users and working with the lagoon groups, controlling public and private entities, and SCCAT to seek resolution to conflicts which arise during the eradication efforts. It is also the mission of this group to seek to foster assistance and support from the lagoon users in effectively implementing the eradication through education, self-inspection of boats, and maintenance of safety around the work efforts.

- **Enforcement Support Coordination** – Chair: Bill Paznokas, CDFG

Site containment and enforcement is being facilitated by a multiple agency support effort. The CDFG wardens are handling the principal site control with other support coming from the Carlsbad Police Department and CDFA. Tools available to control access include the issuance of a Hold Notice by the CDFA, police authorities of the Carlsbad PD and CDFG wardens to enforce various statutes for protection of public health and safety, and ecological resources within the state.

- **Resource Management Sponsor Representatives** – Chair: Jack Fancher, USFWS

Sponsoring resource management agencies include the USFWS, NMFS, CDFG, and RWQCB. This group represents resource and regulatory agencies that are generally charged with natural resource management of ecological and water quality resources within the lagoon and other areas potentially effected by the spread of *Caulerpa*. This group is charged with conducting rapid response evaluations of potential collateral damage concerns associated with proposed eradication efforts and offering recommendations to minimize the extent of damage in the context of the needs for successful eradication. To the extent necessary, this group shall provide written, verbal, or other forms of program impact and risk evaluation to permitting or oversight agencies in order to expedite any regulatory or funding program requirements.

COORDINATION, COOPERATION AND PARTNERSHIP

The immediate action program being undertaken at Agua Hedionda Lagoon is an effort initiated by a private user and resource steward for Agua Hedionda Lagoon, Cabrillo Power I, LLC. The initiation of this effort within the privately owned lagoon has allowed immediate actions to be taken without the delays inherent in assembling large governmental eradication efforts. However, it is recognized that the expertise with eradication of pest species rests within governmental agencies charged with this mission. For this reason, Cabrillo Power I, LLC has joined forces with various governmental agencies in a partnership to eradicate *Caulerpa taxifolia* from Agua Hedionda Lagoon in a swift and effective manner. The partnership has been organized to be directed by the State Department of

Food and Agriculture and integrates expertise from numerous individuals and organizations necessary to address the program needs.

The Southern California *Caulerpa* Action Team is presently contemplated to be assembled for the specific purpose of directing and implementing work necessary to eradicate *Caulerpa* from Agua Hedionda Lagoon. The SCCAT is considered to be an interim organization to serve as an action committee only until such time as a formally adopted long-term control program may be prepared and adopted by state and federal agencies charged with this role.

This document serves to outline the areas of responsibility and cooperative roles of the SCCAT members. It is understood that the SCCAT will function under the guidance of this document and the overarching authorities of their individual agencies. It is further understood that the SCCAT will be coordinated with prior to individual agency actions as a courtesy, and to ensure that actions taken by individual agencies do not impair the overall eradication objectives. Given this simple understanding and the intended interim nature of the team, it is not believed that a formal memorandum of understanding or cooperative agreement would be justified, nor an effective use of agency and private party resources.

The agency and private party representatives of the SCCAT include:

- California Department of Food and Agriculture (CDFA)
- U.S. Department of Agriculture (USDA)
- California Department of Fish and Game (CDFG)
- National Marine Fisheries Service (NOAA-NMFS)
- U.S. Fish and Wildlife Service (USFWS)
- Regional Water Quality Control Board – San Diego Region (RWQCB-SD)
- Cabrillo Power I, LLC (Cabrillo)
- Merkel & Associates, Inc. (M&A)
- San Diego County Department of Agriculture (SDCDA)
- Environmental Protection Agency (USEPA)
- San Francisco Estuary Institute (SFEI)
- Aquatic Nuisance Species Task Force (ANSTF)

PUBLIC OUTREACH AND INFORMATION

MEDIA RELATIONS

Media relations for the SCCAT is under the control of a media relations committee that shall take its lead from the committee chair who will work directly with the program supervisor. As a matter of policy, the SCCAT shall seek to keep the interested public informed as to activities underway, studies being conducted, or issues that arise during the course of the program. Public information dissemination will be a critical component to insuring the implementation of an effective surveillance and control program for *Caulerpa*.

Conflicting information, premature statements, speculation, or sensationalism will result in wastes of time and resources responding to alarm and confusion and will ultimately only damage opportunities to effectively use the media as an effective tool to aid in the control and eradication program.

SCCAT members and their representatives are instructed to be helpful to the media or public, provide any information that has already been published through the media relations committee, but do not provide further information or offer speculation relative to the program or other activities. Please direct inquiries back to the media relations committee.

Ultimately, specific questions may come back to members of the SCCAT via the media relations committee chair and you may be asked to further pursue discussions within your specific areas of expertise and role on the SCCAT.

Public Outreach Program

In the short-term, public outreach will be managed through the media outlets, coordination with constituent group representatives, and the political/lagoon liaison committee. A public internet web page for the SCCAT efforts will be established on the NOAA web site and a public information number will be provided both on the web site and to SCCAT members for the purpose of giving the public a location where they can obtain information.

As the immediate eradication efforts get underway, more attention will be given to expanding the outreach program using local user group direct mailers and preparation of brochures targeting focused groups that may assist in expanding effective surveillance and controlling spread if the species has already escaped from the lagoon. Target audience outlets for information such as dive shops, boat clubs, and boater registration mailers will likely be used for this effort.

SURVEY AND DETECTION

Survey Program

Inside Lagoon Survey Efforts

Lagoon surveys are being completed in two phases. Phase 1 surveys are designed to provide a reconnaissance-level review of all portions of the lagoon as a rapid assessment tool to determine the magnitude of infestation. Phase 2 surveys concentrate on lagoon regions that are identified as having *Caulerpa* during the initial survey work and are comprehensive survey and mapping efforts.

Phase 1 surveys within the lagoon are principally being completed using tightly spaced diver transects with divers being towed along straight parallel transects by a small skiff navigating a course using dGPS. An initial survey is to be completed using transect spacing of 5 meter centers in Snug Harbor, 10 meter centers in the Outer Lagoon, and 10 meter spacing in the Middle Lagoon. Inner Lagoon surveys are to be accomplished using combinations of diver transects, video surveys, and side-scan sonar. The ability to ensure full coverage of survey efforts is dependent upon water clarity. For this reason, survey intensity will be adjusted as needed to obtain adequate reliability.

Phase 2 comprehensive surveys are to be completed in areas where infestations have been identified. At present, the only area where phase two surveys are proposed is Snug Harbor. Because of the potential for fragmenting plants, no physical gridlines are to be placed on the bottom. In this area, additional diagonal transect surveys oriented approximately 45 to 60 degrees from parallel to the initial phase survey transects will be surveyed. These surveys are to be completed at the same 5 meter spacing as the initial surveys. At each identified *Caulerpa* patch, divers will survey and map the perimeters of each patch and will search the adjacent eelgrass beds for any satellite patches. Additional diver searches are to be completed in defined areas with divers working areas as teams to cover broad swaths of the bottom.

Outside Lagoon Survey Efforts

Surveys are to be completed outside of the lagoon with the assumption that any *Caulerpa* that has been freed in the lagoon could be transmitted out of the lagoon either by tidal action, or through the power plant cooling system. The power plant cooling water system has a mechanical travelling screen that captures and rejects most drift debris prior to it being passed through the plant to the ocean discharge. Any rejected material is disposed of in an upland landfill.

Outside of Agua Hedionda Lagoon, surveys are to be conducted by a combination of video surveys, side-scan sonar, and diver transects surveys. Where no vegetation is present, side-scan sonar will allow large areas to be effectively surveyed. Any features could then be spot surveyed with divers or video to determine if the material is drift kelp, rocks, old lobster pots, or *Caulerpa* patches.

Regional Surveillance Efforts

Regionally, several efforts are to be conducted to identify other potential occurrences of *Caulerpa* away from Agua Hedionda Lagoon. These include focused searches around all launching facilities in southern California bays and harbors, searches of specific areas that have been visited by boats licensed for use in Agua Hedionda Lagoon. This information is to be collected through direct mail and phone contacts with registered boaters identified by City of Carlsbad records.

In addition to the specific survey efforts of the SCCAT, the SCCAT is to prepare information advisories for public dissemination through outlets such as dive shops, boat ramps and clubs, internet web sites, bait and tackle shops, newspapers, focused journals, etc.

Find Confirmation and Mapping Program

The SCCAT shall develop and implement a program for completing confirmations of reported finds of *Caulerpa* and maintaining maps of any confirmed finds. This is to be accomplished by providing a designated contact and call number in all prepared literature and making use of SCCAT agency staff to confirm finds. All confirmed finds will be mapped and treated in a manner described for the Agua Hedionda patches, until such time as a final program is developed.

SURVEY RESULTS

With approximately 50% of the lagoon having been surveyed in phase 1 surveys, *Caulerpa taxifolia* infestations are known from approximately 20 distinct patches ranging from less than one square meter to over 500 m^2. All of the identified clumps of *Caulerpa* are located within eelgrass beds in Snug Harbor along the northern shoreline of the Inner Lagoon. Phase 2 surveys have delimited the specific locations and extent of these patches (Figure 3).

Surveys are to continue in all areas of the lagoon and areas outside of the lagoon until the entire survey areas have been covered with phase 1 surveys. Phase 1 and phase 2 surveys will be completed regularly for a period of three years following initial eradication efforts.

Figure 3. Known distribution of Caulerpa in Agua Hedionda Lagoon (July 8, 2000).

ENFORCEMENT AND COMPLIANCE

MATERIAL CONTAINMENT

The CDFA has issued a Hold Notice for *Caulerpa taxifolia* at Agua Hedionda Lagoon. This notice prohibits the removal of any of this alga from the system except as related to the active efforts of the current eradication program. For this reason, at the present time no authorization exists for removal of any kind for other purposes, even if it relates to research, herbarium collections, or other legitimate uses. As the eradication program is developed, research associated with the present control and ecological damage will continue and enough live material will be retained by the SCCAT to meet long-term control research needs. This material will be collected and held by Merkel & Associates until such time as CDFA determine the appropriate distribution of materials under the auspices of a formal research program.

Vessels leaving the lagoon via boat ramps are being inspected to ensure that they are not carrying any fragments of plants in their bilges, or on motors, hulls, or water sports equipment. Information is to be collected as to where vessels used in Agua Hedionda are also launched. This information will aid in focusing regional survey efforts.

SITE CONTROL

The current site control needs are being coordinated by the SCCAT Enforcement Support Coordination Chair drawing on resources of the CDFG, CDFA, and Carlsbad Police Department. The shoreline work area adjacent to infested areas of Snug Harbor has been closed down except for the eradication team efforts. All shoreline areas of Snug Harbor have been closed to fishing to avoid snagging and spreading the alga to other areas both within and outside of Snug Harbor. Water uses including jet skiing and boating have been excluded from Snug Harbor except along the western shoreline where a 5 mph controlled speed exists for transiting through the area to get to other use areas. This corridor does not support any *Caulerpa* and is essential to maintaining viable lagoon use by commercial operations in the northern portion of Snug Harbor.

The SCCAT has opted to work cooperatively with lagoon user groups to attempt to accommodate on-going uses to the greatest extent practical by realigning activities within the various areas of the lagoon rather than applying more exclusionary authorities. This has been done for several reasons. First, it presently appears that the infestation is relatively localized and general public activities may be excluded from the affected area while work is being completed. Second, maintaining good relations with lagoon user groups is believed to be an essential element to achieving long-term eradication and completing the necessary work over the next several years. Finally, it is waterbody users that are likely to play the greatest role in future surveillance for this species throughout southern California and it is the experience in Agua Hedionda that will determine how cooperative people are in the future.

While the program being employed is designed to protect as much of the lagoon use as practical, it should be noted that the level of disruption to the lagoon users is subject to change if circumstances warrant. Factors to be considered that could effect the program include identification of additional infestations elsewhere in the lagoon, inadequate safety of eradication team members, or chronic enforcement difficulties with the limited controlled areas.

ENVIRONMENTAL REGULATIONS

Under this immediate action program, environmental regulatory elements are to be coordinated by Merkel & Associates. Regulations addressed include those under the federal and state Endangered

Species Acts (ESA, CESA), Clean Water Act (CWA), Rivers and Harbors Act (RHA), and California Coastal Act (CCA). To be efficient in this effort agencies on the SCCAT will need to assist in facilitating the regulatory processes to the greatest extent practical.

Herbicide Application Regulations

Merkel & Associates, Inc. will seek to obtain a Pesticide Research Authorization for *in situ* trials involving treatments showing promise under laboratory conditions. For long-term treatment program needs herbicide application authorizations are to be facilitated by the California Department of Food and Agriculture. This may require coordination with the California Department of Pesticide Regulation to seek area specific authorizations.

PRE-TREATMENT CONTROL METHOD INVESTIGATIONS

To aid in the design of an effective eradication strategy for this immediate action program, information has been collected from eradicative efforts in the Mediterranean Sea and has been blended with expertise on the infested system and other aquatic pest eradication methods. Investigations that have been undertaken include those examining treatment options as well as trials to perfect methods for implementing treatments. These efforts have been documented for later use to support development of eradication methods for a larger-scale program.

Herbicide Treatment Studies

To evaluate the potential herbicide control agents that may be used in the eradication efforts, several replicated herbicide treatments and controls were established in an outdoor laboratory setting. Tests included various chemical agents tested in light and dark environments and at graduated concentrations ranging from label recommended application rates to mega-doses at many times the recommended application rates.

Of the tested herbicides and other biocide treatments, few met with any substantive results. Test results are summarized in Table 1. Over short durations, mega-doses (5.0 and 10.0 ppm) of Cutrine were successful in generating some die-back in plants, however this was not sustained. Diquot, Hydrothol 181, and Simazine resulted in no significant response over the first 4 days and only a slight loss of turgor in later periods of the test. Better results were observed in tests of light exclusion than were seen in most herbicide treatments. The most significant treatment effect was observed with sodium hypochlorite (chlorine bleach) treatments. Concentrations of 1.5 ppt and 3.0 ppt of hypochlorite solution both proved equally lethal overnight with full bleaching of tissues being observed well before the 4 day report period.

Reports on the Mediterranean infestations have suggested that copper sulfate may be effective in treatments. However, no information has been located that provides an indication of treatment concentrations that have been applied. Cutrine used in the present study would effect the alga in similar ways as copper sulfate, suggesting that effective doses may be very high.

Table 1. Summary of results for *in vitro* chemical control investigations

		RESPONSE							
Treatment	**Conc.**	**4 DAYS**	**New growth ?**	**8 DAYS**	**New growth ?**	**12 DAYS**	**New growth ?**	**24 DAYS**	**New growth ?**
Control (no treatment)	___	none	N	none	Y	none	Y	none	Y
Diquot	0.75 ppm	none	N	*	Y	*	Y	recovered	Y
	1.5 ppm	none	N	*	Y	*	Y	recovered	Y
Hydrothol 181	1.0 ppm	none	N	none	Y	*	Y	recovered	Y
	2.5 ppm	none	N	none	Y	*	Y	recovered	Y
Cutrine (Copper)	0.5 ppm	none	N	none	Y	none	Y	none	Y
	1.0 ppm	none	N	**	Y	*	Y	recovered	Y
	5.0 ppm	***	N	**	Y	**	Y		
	10.0 ppm	***	N	**	Y	**	Y		
Simazine	1.0 ppm	none	N	none	Y	none	Y		
Bleach (5% Cl)	1,500 ppm	****	N	dead		dead		dead	
	3,000 ppm	****	N	dead		dead		dead	
Light Exclusion	___	none	N	**	Y	**	Y	***	Y

* slight loss of turgor in fronds
** slight die-off at tips
*** slight bleaching of fronds
**** full bleaching of thallus, dead

MECHANICAL EXTRACTION TESTS

The mechanical removal of *Caulerpa* has been contemplated as a means to reduce the biomass requiring herbicide treatment and protect against potential discharge of viable fragments that may be liberated by dying plants after herbicide treatment. Tests have included manual collection of alga using divers and two efforts using different suction dredging technologies (aspirator and centrifugal pumps) to remove plants and sediments.

Diver *Caulerpa* harvesting was determined to be moderately successful at removing experimental volumes of material, however considerable plant breakage occurs where rhizoids are firmly anchored in sediments or are intertwined with eelgrass rhizomes. In a large-scale removal operation, a clear potential for freeing small plant fragments from rhizoids or fronds would exist by hand extraction.

To test the efficacy of suction dredging small portions of an eelgrass bed were extracted by marine contractors using two different dredge types. Dredging was directed by Merkel & Associates to excavate all plant materials and sediments to a depth of 10 inches, a depth adequate to extract the rhizoids of any *Caulerpa.* The test was deemed to be a reasonable way of evaluating the performance of dredge equipment in mixed beds of algae and eelgrass as well as sediments underlying monotypic *Caulerpa* patches. *Caulerpa*, being more significantly more fragile than eelgrass was expected to be aspirated relatively efficiently by pumps when present in pure stands.

Suction dredging operations have a significant benefit over hand extraction in that smaller fragments of damaged algae are generally vacuumed up around the dredge nozzle and few escape the immediate vicinity of the nozzle. However, the dredging approach also has several drawbacks relative to hand harvesting. First, the suction nozzle is not as controlled as hand harvesting and many more very small fragments would be generated by suction dredge harvesting than by hand extraction as long rhizoids are stripped through the intertwining mass of rhizoids and fronds. Some of these fragments would be released far beyond the influence of the suction head and it would be necessary to collect these particles as the dredge moves into the areas where fragments are broken off and, hopefully, settle.

The two dredges evaluated were substantially different in their effectiveness. The aspirator type dredge lacked adequate power to efficiently extract eelgrass and sediments. When the dredge plugged, it would frequently backwash a large plume of sediment, water, and eelgrass into the dredge area. This burping would cause substantial resuspension of small fragments and could aid to spread rather than collect *Caulerpa.* The second dredge was a centrifugal pump type dredge that was substantially more powerful than the aspirator and never burped during the period of testing. The dredge did plug up on occasion and required cleaning of the intake nozzle. The efficiency of this dredge was substantially higher than that of the aspirator type pump. However, this dredge was also not fully capable of collecting all plant debris and video tapes of the nozzle illustrates that portions of plant matter frequently floated away from the dredge. The divers were able to remain relatively stationary while working and generated less turbidity than anticipated. However, levels of turbidity around the work area still exceeded any level that would allow a secondary diver to collect freed plant fragments and prevent their escape from the area or resettlement on the bottom.

Perhaps the largest impediment to dredging of the *Caulerpa* is the need to efficiently treat very large volumes of water to remove potentially viable plant material and either dispose of clean water or return it to the lagoon. It is estimated that as much as 11,000 gallons per minute may be generated by the dredging operation and the total liquid volume may top several million gallons. Various options for handling this water have been contemplated. These include: 1) the establishment of a small

filtering facility on the lagoon shore and releasing water back to the lagoon or sewering the clarified water; 2) steaming or chlorinating the dredged water to kill any residual tissues, or; 3) pumping the mud/plant/water slurry to the empty power plant 12 million gallon oil tank. This would require significant post-dredging cleaning cost to restore the tank conditions and dispose of hydrocarbon contaminated waters and sediments.

Liner Containment Trials

Perhaps the most difficult issue to address in the eradication effort is how to effectively apply chemical control agents at effective dosages while minimizing collateral damage in surrounding areas. Because the area is tidal, water flushes through the infested region twice daily replenishing the area with new oceanic water at high tides and eastern bay waters at low tides. To address this issue, a containment program has been developed to effectively isolate the *Caulerpa* patches and surrounding native eelgrass beds under liners which trap adequate volumes of water for treatment with chemical herbicides while protecting surrounding areas from collateral damage. Further, this approach prevents fragmentation of dying plants from spreading viable fragments to surrounding areas.

The 35mil PVC liners have been fitted with gas release valves. Several trials have been conducted in eelgrass beds to practice placing the liner to determine the most efficient manner for placing liners to avoid disturbing *Caulerpa* patches when ultimately placed for isolation purposes. Trials dictated a technique for placing the liner materials using divers and a surface support boat. Seams between liners and gas release valves were inserted both prior to liner deployment and with liners in place on the bottom. While labor intensive, the placement of liners by divers and boat crews has been demonstrated to be achievable when placed with care.

ERADICATION IMPLEMENTATION

Containment

All identified *Caulerpa* patches have been isolated by realigning lagoon uses to areas away from infestations and covering patches with materials that prevent the spread of plant fragments away from the infested locations.

The realignment of lagoon uses has effectively meant: 1) isolation of the area by buoy lines; 2) exclusion of boat and jet ski traffic from the waters in the infestation area, and; 3) rearranging watercraft uses elsewhere in the lagoon to accommodate all uses. This effort has been completed under the direction of the Carlsbad Police Department and is illustrated in Figure 4.

Chemical Control Treatment

Patches are to be covered with impermeable PVC liners that enclose the patches, a buffer of surrounding eelgrass beds, and an adequate volume of water to ensure full distribution of chemical control agents (Figure 5).

Prior to treatment of contained plots, all pretreatment notifications are to be made as dictated by regulatory requirements. Detailed records are to be kept with respect to the applications made to allow preparation of required reports and to facilitate future design of eradication efforts for this species.

Figure 4. Lagoon use realignment to isolate infested areas for treatment actions

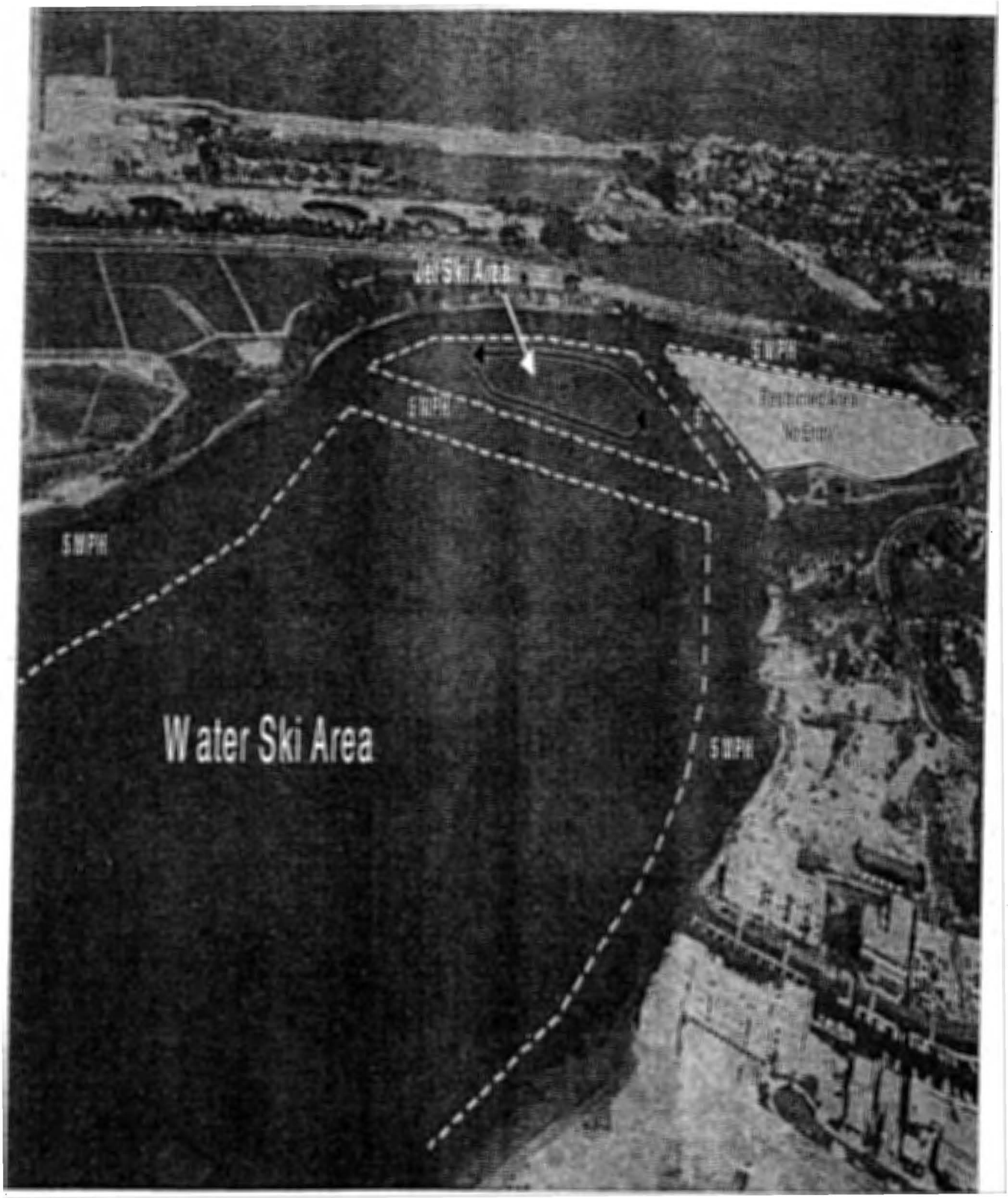
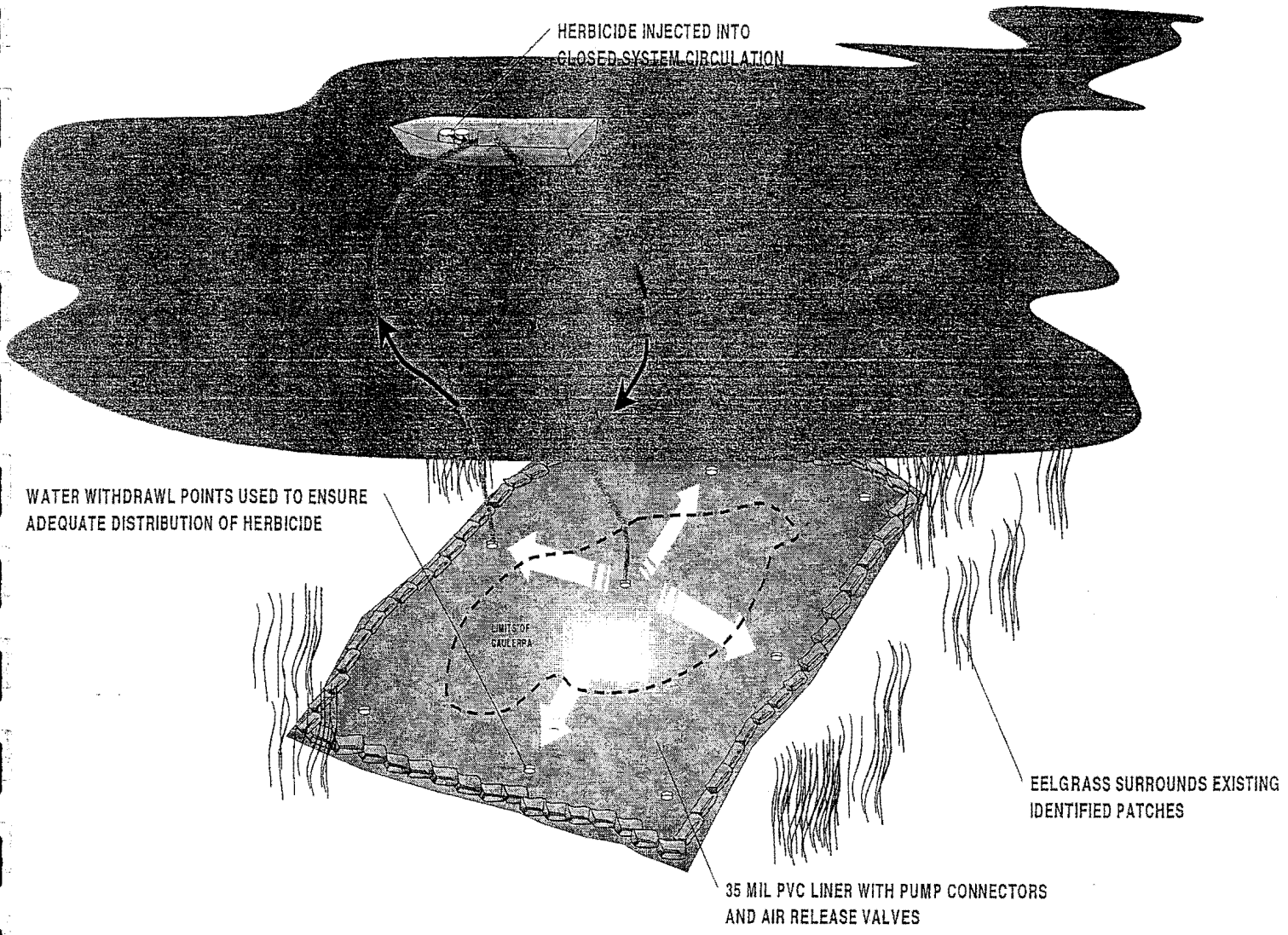


Figure 5. Containment schematic for herbicide application approach.



For the purpose of the immediate response eradication program, a treatment of chlorine is to be used. This treatment is anticipated to result in a rapid and complete kill of all surface plant material however, it may not be successful in penetrating the sediments and reaching all rhizoids. To address regrowth, the liner is proposed to remain in place and subsequent treatments are to be conducted over the subsequent two months. While hypochlorite treatments are anticipated to be effective under the contained conditions present at Agua Hedionda Lagoon, investigations on control chemicals will continue since no highly efficient algaecide has yet been identified and future control areas may not be as well defined or readily confinable for treatment.

Experimental chlorine treatments are to be conducted using both a solid puck form of chlorine and an injected liquid solution. The treatments will be repeated until such time as a residual chlorine within the contained area is maintained at 150 ppm for a period of not less than 72 hours. The same sustained residual chlorine concentration as the initial treatment will be used in the subsequent monthly treatments.

Containment of the treated area is not to be removed until chlorine residual has dropped below 5 ppm, however the desired target is <0.1 ppm residual chlorine.

Post-application Treatment

The determination as to what the most appropriate course of action to follow after chemical controls are effected remains unclear. There is concern that chlorine will only be effective at killing plant materials at the surface and thus viable rhizoids may persist in the sediments. Repeated treatments with hypochlorite would be expected to reduce the number of viable starts, however it is not safe to assume that a complete kill will occur. For this reason, some post application treatment is warranted.

Dredging of the patches would entail enclosing the site with silt-screens and operating a suction type dredge to extract sediment and plant material to a depth of approximately 20 cm. This material would be pumped to storage areas on shore where material could be treated or extracted for upland disposal. The remaining water would need to be returned to the lagoon or otherwise disposed. There is a concern that this approach may be logistically or cost prohibited due to the difficulty in handling approximately 11 million gallons of water contaminate with algal fragments and the potential for releasing viable material to the water column either at the dredging site or when water is discarded.

A second alternative treatment under consideration is a capping program using a geosynthetic liner and a sediment cap for a year or more following treatment. This alternative has proven successful in other areas and is being further explored.

A final option for post-application treatment is to conduct intensive monitoring and spot eradication treatments as needed to control resurgence from residual rhizoids. This option would provide significant information on efficacy of initial treatments. While such data may be very valuable in the long-term control efforts, it would be less desirable than a capping program relative to local eradication.

In any case, extensive monitoring of the treatment area is proposed to continue the search and eradication efforts.

POST-ERADICATION MONITORING AND RESTORATION

POST-TREATMENT MONITORING PROGRAM

Monitoring following the immediate action eradication efforts is to continue for a period of three years following the last detected occurrence of *Caulerpa* in the lagoon. This program is to include a combination of Phase 1 and Phase 2 surveys as described above. The use of these surveys is to both monitor the status of treatment areas as well as completing surveillance for potential additional outbreaks.

Survey schedules to be followed are outlined in Table 2. Additional surveys and spot eradication efforts conducted on a biweekly basis would be required in treatment areas if no subsequent post-application treatment is to be used following removal of PVC liners.

Table 2. Schedule of post-eradication survey efforts

SURVEY AREA	YEAR 1	YEAR 2	YEAR 3
Treatment Area	Monthly (May-Oct) Bimonthly (Nov-Apr)	Biannual (Sept, Mar)	Biannual (Sept, Mar)
Non-infested Lagoon Basins	Biannual (Sept, Mar)	Annual (June)	Annual (June)
Lagoon-region Ocean Shoreline	Biannual (Sept, Mar)	Annual (June)	Annual (June)
Other Waterbodies	As Determined By Long-term *Caulerpa* Control Plan		

The monitoring program outlined provides an adequate period of time to ensure that any residual patches can expand to a size required to be readily detectable by survey methods. However, if any additional incidents are detected, it will be necessary to reinitiate eradication and survey efforts as if the program were just beginning.

RESTORATION OF TREATMENT AREAS

The eradication program is anticipated to result in collateral damage to eelgrass habitat and benthic communities within the immediate vicinity of targeted alga. This damage will effectively result in a temporary loss of habitat that extends to the size of the treatment containment limits. The resultant cleared areas are considered a benefit to conducting effective surveillance during monitoring years. For this reason, no directed actions are proposed to restore native eelgrass to these areas. However, given the prolific rate of eelgrass expansion into small areas within existing established beds, no restoration of these small treatment areas is anticipated to be necessary to ultimately recover from treatment damage.

ADDITIONAL RESEARCH AND DOCUMENTATION EFFORTS

While the present program is clearly focused on the direct and immediate eradication of this invasive species from Agua Hedionda Lagoon, the high potential that southern California and the Western Hemisphere as a whole will be facing this species in months or years to come dictates that as much information as is practical be collected from the infestation prior to its eradication. For this reason, data collection has been on-going coincident with survey and eradication efforts. While information has not yet been worked up, data collection has included work on growth parameters of the species, ecological impact on benthic communities, epiphytic communities, and environmental characteristics of the infestation area.

Eradication program documentation is also being completed using video, still cameras, detailed notes, and archival of other records so that a future retrospective may be prepared to aid in application of information learned during the present efforts.

Following completion of more pressing eradication efforts, data will be analyzed and reports will be prepared for use by others in characterizing the threat and confronting the problems of controlling this species.

SCHEDULE OF ACTIVITIES

The numerous elements of the eradication program are to occur over a brief time period through parallel tracking of the work efforts. This allows the program to be completed with minimum delay while ensuring adequate attention is given to the individual element requirements. A rough schedule of activities being undertaken is provided in Table 3. The schedule is principally contingent upon timing related to herbicide authorization and rates at which effective surveys may be completed. Survey effectiveness is largely dependent upon water clarity and tidal conditions. Long-term monitoring assumes that initial eradication efforts are successful. Subsequent identification of more *Caulerpa* would reset the monitoring schedule such that the three year monitoring period is driven by the last identified infestation.

Table 3. Schedule of immediate action eradication program.

ACTION	START	END
Caulerpa taxifolia located in Agua Hedionda Lagoon	June 12	June 12
Caulerpa taxifolia ident. confirmed (Mediterranean strain suspected)	June 12	June 15
Initiate eradication and control method planning and research	June 17	July 30
Restrict access into first known patch of *Caulerpa*	June 19	June 20
Phase 1 (recon-level) surveys of lagoon	June 19	July 15
Identify immediate action program funding sources	June 19	July 30
Ecological impact study data collection efforts	June 26	July 15
Physical containment of *Caulerpa* patches	July 1	July 15
Environmental leaders and environmental reporters notifications	July 5	July 5
Surveys of off-shore reefs, ebb-tide delta, and power plant discharge	July 5	July 30
Phase 2 (comprehensive) surveys of infested areas	July 5	July 30
Realign uses in lagoon to eliminate all access to infested area	July 6	July 8
PVC liner placement for chemical treatment	July 10	July 22
Permitting and exemptions	July 6	July 19
Chemical treatment of patches	July 19	August 30
Long-term regional control program development	July 15	Oct. 30
Under liner examination and testing of chemical residuals	July 19	Sept. 30
PVC liner removals	Sept. 30	Oct. 30
Post-application treatment activities	Sept. 30	Oct. 30
Long-term surveillance and monitoring	Oct30,'00	Oct30,'03

RESOURCE AND FUNDING

Cabrillo Power I, LLC, has committed to financing of the initial activities under the immediate action program. This commitment has been made as a good corporate citizen and management steward interested in seeing the health of Agua Hedionda Lagoon maintained both as a resource to the community and as a resource to the Encina power plant operated by Cabrillo Power I, LLC. While the power plant has pushed forward to insure that appropriate actions were not impaired by the lack of adequate initial funding, it is the desire of Cabrillo Power I, LLC to ultimately be a minority financing partner in the overall effort. The plant has committed resources in the form of contract services and a significant amount of staff time and expertise to keep the eradication efforts moving forward, however, this commitment will not carry the program through fruition considering the high cost of conducting surveys and the required meticulous underwater work. To effectively keep the program active, it will be necessary to supplement and hopefully reimburse some of the funds allocated by Cabrillo with other public agency funds.

To date such public relief has been provided in the form of agency staff and equipment support donated by the SCCAT member agencies and City of Carlsbad. Lagoon user groups and property owners surrounding the lagoon have also accommodated eradication efforts by providing free access to use shoreline staging areas and to assist in implementing containment and surveillance efforts to inspect watercrafts leaving the lagoon.

To address financing needs for the program, other sources of funds are being sought to implement both the immediate action program as well as the longer-term official *Caulerpa* control program. The long-term program needs are not discussed in this document as they are the subject of other work efforts. The immediate action-financing program is being addressed by a committee of the SCCAT that is chaired by Mr. Greig Peters, RWQCB-SD. It is anticipated that some funding will be available through the RWQCB Clean-up and Abatement Funds. Additional monies are expected to be available through NMFS-NOAA. Other agencies have indicated the possibility for funding to be available, however the full potential has not yet been fully explored.

The full extent of program costs will not be known until such time as all surveys are completed and control efforts are fully defined. However, it is presently estimated that the cost of the entire immediate action program is likely to range between $800,000 and $1.3 million depending upon post-chemical treatment actions taken to address residual living plant material.

As presently predicted, existing allocated resources for the program implementation are likely to be exhausted in early to mid-September. As the eradication efforts are intensified the anticipated resource consumption rate will be refined.

APPENDIX A: NOXIOUS ALGAE FOUND IN SOUTHERN CALIFORNIA COASTAL WATERS