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CD-0002-19 (USFWS)

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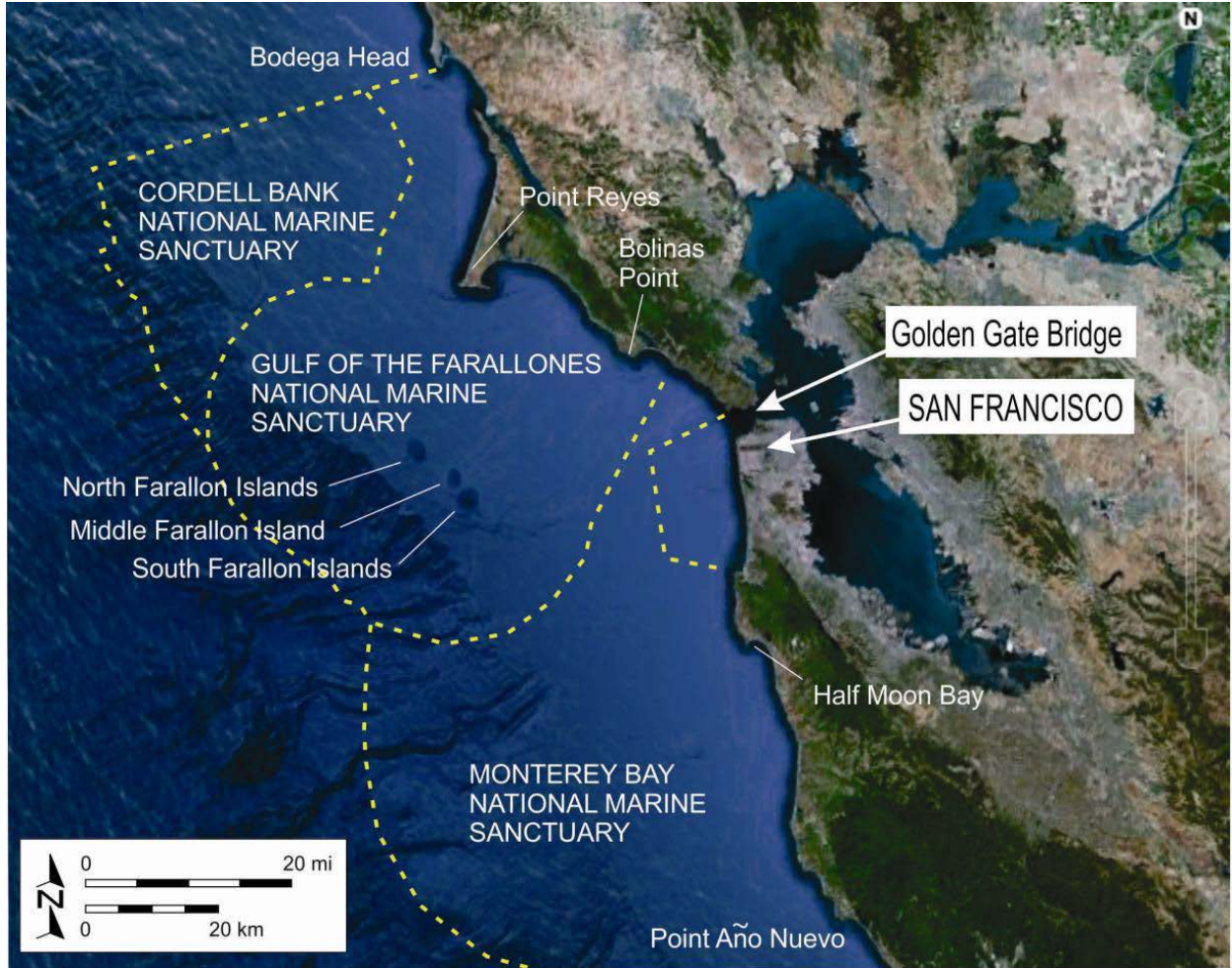
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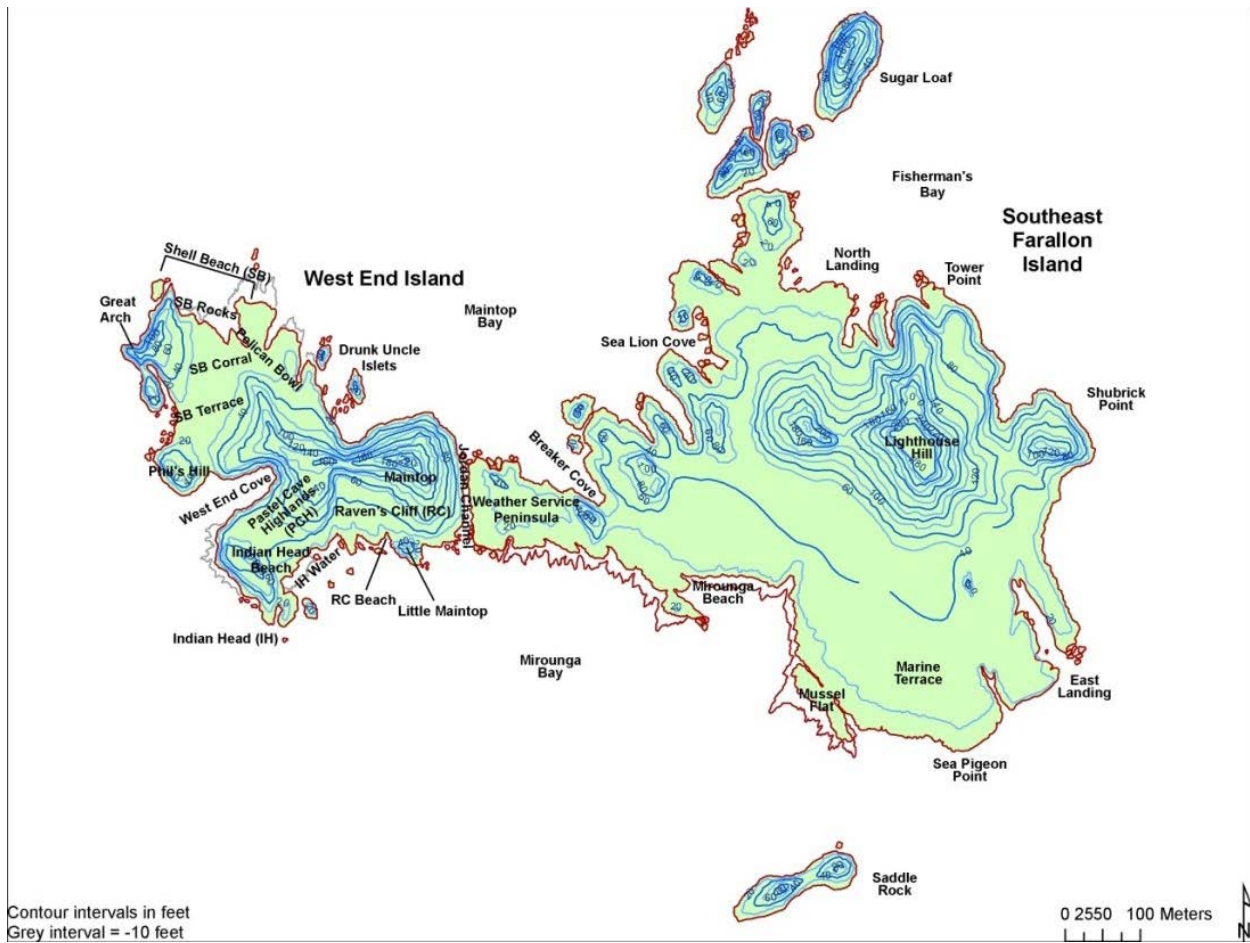
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Location of Farallon Islands National Wildlife Refuge, including South Farallon Islands (USFWS FEIS, March 2019).



Topographic map of the South Farallon Islands (USFWS FEIS, March 2019).

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South Farallon Islands, view to the east (USFWS FEIS, March 2019).

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South Farallon Islands, view to the west (USFWS FEIS, March 2019).

EXHIBIT 4
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MEMORANDUM

FROM: Lauren Garske-Garcia, PhD – Ecology Group, Technical Services Unit

TO: Larry Simon, Federal Consistency Coordinator - Energy, Ocean Resources and Federal Consistency Division
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Erin Chalmers, Senior Attorney – Energy, Ocean Resources and Federal Consistency Division

SUBJECT: **Ecological Resources and the South Farallones Mouse Eradication Project**

DATE: 27 June 2019

According to the [Final Environmental Impact Statement \(FEIS, March 2019\)](#), the [South Farallon Islands Invasive House Mouse Eradication Project](#) (“Project”) aims to eradicate the invasive house mouse (*Mus musculus*, of Asian origin) from the South Farallones within the Farallones National Wildlife Refuge. I have reviewed several sections of this document, including the Executive Summary and Chapters 1-4 (1: Purpose & Need, 2: Alternatives, 3: Affected Environment, and 4: Environmental Consequences) along with an assortment of the Appendices. Further, I joined staff from the US Fish and Wildlife Service (USFWS) for a field trip to South Farallon Island on May 7th, to understand the on-the-ground conditions and discuss concerns as well as opportunities for the project. During this visit, representatives from Point Blue Conservation Science (a key technical partner based on the Farallones continuously since 1968), the Greater Farallones National Marine Sanctuary, and the San Francisco Department of the Environment were also in attendance.

Approximately 27 miles from mainland California and the urban mosaic of the San Francisco Bay Area, the Farallon Islands are of tremendous ecological importance and support the **largest seabird breeding colony in the lower 48 states as well as one of only two rookeries for northern fur seals** (*Callorhinus ursinus*) south of Alaska. They also support an estimated 50% of the world’s ashy storm petrel (*Oceanodroma homochroa*) population, which is a California Bird Species of Special Concern,¹ and 13 seabird and 5 marine mammal species depend heavily on these islands for breeding colonies. In addition, the South Farallones are home to a unique plant community that includes the **largest known population of maritime goldfield** (*Lasthenia maritima*; see **Figure 1**), an annual plant endemic to islands along the California and Oregon coasts. The islands also harbor the Farallon camel cricket (*Farallonophilus caverniocolus*) and Farallon arboreal salamander (*Aneides lugubris farallonensis*), both of which are **endemic species** found nowhere else in the world. Under the Coastal Act, the South Farallones

¹ California Department of Fish and Wildlife (listed in 1978; continued in 1992 and [2008](#)) – in particular, breeding colonies are recognized as a priority and official management recommendations include eradication of invasive house mice from the South Farallones.

readily meet the definition of environmentally sensitive habitat (ESHA),² satisfying criteria for both rarity and special value as well as sensitivity to disturbance. Moreover, many of these species (*e.g.*, seabirds and marine mammals) are also recognized as **sensitive marine resources** given their inextricable roles within marine food webs.

Subsequent to the USFWS's successful eradication of European rabbits and domestic cats (*Oryctolagus cuniculus* and *Felis catus*, respectively) in the early 1970's, the house mouse remains the last non-native mammal to inhabit the South Farallones. Population estimates indicate that the mice reach densities of approximately 490 individuals/acre (1200 individuals/hectare) at their annual peak in October, which is considered to likely be the greatest of any house mouse-invaded island in the world.³ The house mouse imposes both direct and indirect impacts on native flora and fauna. Directly, they **prey on native plants** including the seeds of maritime goldfields **as well as on native invertebrates** like the Farallon camel cricket.⁴ There is also evidence that mice **feed on eggs**, including those of the Farallon arboreal salamanders and even the various seabird species including Cassin's auklet (*Ptychoramphus aleuticus*).⁵

Indirectly, the impacts of the house mouse on the South Farallones ecosystem is particularly expansive and complex. For example, they **compete with native salamanders for insect prey** and facilitate dispersal of non-native plant seeds, which **contribute to the proliferation of invasive vegetation** on the islands. The increase in non-native vegetation has **reduced the availability of preferred nest material** for ground-nesting species (*e.g.*, gulls using native vegetation), **limited the ability of underground-nesting species to safely enter and exit their burrows** (*e.g.*, petrels and auklets; see **Figure 2**), and **limited resources for native pollinators** that have evolved to depend on the native plant species. Among the most interesting impacts of the mouse is that of **hyperpredation**,⁶ where elevated populations of mice in the fall have facilitated the transition of migrating burrowing owls (*Athene cunicularia*) from that of a seasonal stopover species in the Farallones to that of an established overwintering and recurring population. While burrowing owls are themselves a protected species,⁷ and their foraging on the invasive mice is not problematic in and of itself, the timing of mouse population cycles and coincidence of migratory owl arrivals to the islands sets up a predicament for native species. The initially abundant house mouse population attracts owls into overwintering rather than continuing their migration, even while the house mouse enters its seasonal decline, resulting in a diminished food source and requiring owls to significantly increase search time and energy to hunt. Subsequently, the **owls switch to preying on other, more readily available and energetically-affordable native island species**. In particular, it has been shown that owls prey on native beetles, the endemic Farallon cricket, and on ashy storm petrels as they emerge from their underground burrows, thus

² California Coastal Act §30107.5 reads: "Environmentally sensitive area" means any area in which plant or animal life or their habitats are either rare or especially valuable because of their special nature or role in an ecosystem and which could be easily disturbed or degraded by human activities and developments.

³ By contrast, house mouse densities typically range from 10-50 individuals/ha though have been reported as high as 800 individuals/ha during episodic population spikes (Pearson (1963); Mackay *et al.* 2011).

⁴ Jones and Golightly (2006) documented that house mice largely consume Farallon camel crickets and other native terrestrial invertebrates, including pollinators. In addition, they found that house mice prey heavily on native plants.

⁵ Point Blue Conservation Science, unpublished data

⁶ Hyperpredation refers to increased levels of predation on a secondary prey species due to an increase in the population of a predator, or a sudden decline in abundance of the predator's principal prey species.

⁷ California Department of Fish and Wildlife, California Bird Species of Special Concern (listed in 1978; continued in 1992 and [2008](#))

disproportionately affecting the native species populations. During our site visit, near one of the remnant owl burrows from the previous winter, we **observed evidence of such hyperpredation** in the form of scattered ashly storm petrel carcasses and owl pellets (see **Figure 3**) that emitted the petrel's characteristic musky scent. Decades of research in the South Farallones have clearly documented such indirect effects of the house mouse invasion, including since the [Draft Environmental Impact Statement \(2013\)](#) and in response to comments thereof.

Just as islands facilitate the evolution of disproportionately unique ecosystems across the globe and yet are especially vulnerable to disturbance and extinction, they also present important opportunities and priorities for conservation. Introduced species have been repeatedly documented as having disproportionately adverse impacts on island ecosystems, contributing to at least 54% of the 170 extinctions of island species for which the cause of extinction is known.⁸ Importantly, the discrete bounds of islands allow for the use of management strategies that may not be feasible in mainland ecosystems and provide an avenue for conservation. **In this case, eradicating the invasive house mouse from the South Farallones through a focused and strategic effort is not only feasible, but in-line with the conservation goals for this special place.**⁹

The proposed Project will employ a rodenticide (Brodifacoum 25D-Conservation) and primarily deliver it through two consecutive aerial applications of low-dosed grain-based pellets with the goal of achieving eradication in only a few months.¹⁰ While there is concern with the use of toxic materials in any system, this **Project would use a targeted conservation approach to eradicate the house mouse through acute exposure as opposed to the chronic dosing frequently used to control pest populations on the mainland.** This distinction is crucial to recognize and consider when evaluating the many alternatives that have been suggested elsewhere, as the FEIS discusses. By applying rodenticide in November, when the fewest non-target animals (including breeding species and their numbers) occupy the island, when mouse populations are naturally beginning their seasonal decline due to limited food resources and reduced breeding rates, and when favorable environmental conditions for aerial bait dispersal and subsequent degradation occur, the proposed Project (along with additional precautions and mitigation measures proposed¹¹) can minimize impacts to non-target species and the environment while achieving important conservation goals. Building on a substantial body of island conservation work,¹² the proposed Project follows similar rodent eradication efforts that have been successfully implemented while also

⁸ Ricketts *et al.* (2005)

⁹ The Farallones National Wildlife Refuge Comprehensive Conservation Plan (2009) identifies protection of native bird habitat as a principal goal and aims to restore breeding seabird populations to historic breeding population levels. Additionally, the Plan aims to improve degraded habitat and reduce the prevalence of non-native vegetation in an effort to restore historic native plant species' abundances and distributions.

¹⁰ The preferred alternative in the FEIS and proposed for the Consistency Determination (Alternative B) would deliver a total of approximately 2,917 lbs (1323 kg) of bait to 121 ac (49 ha) in the South Farallones over the course of two applications timed 10-21 days apart; the total amount of brodifacoum delivered would be 1.16 oz (33 g). The other alternative considered in-depth in the FEIS (Alternative C) would use a different rodenticide, diphacinone, requiring application of a total of approximately 4,482 lbs (2032 kg) of bait and require three applications in total, each timed 7 days apart; in this case, the total diphacinone delivered to the South Farallones would necessarily be 3.6 oz (101.6 g).

¹¹ Including, for example: relocation of migrant raptors (including burrowing owls) to mainland habitat; temporary captive holding of any resident raptors (such as peregrines) and a proportion of the endemic arboreal salamander population; the use of bait stations in locations that cannot be reached via aerial bait drops; continued monitoring for residual mouse presence; mouse carcass collection; and a gull hazing program over the term of potential threat from bait pellets, to reduce ingestion.

¹² For example, see Horn *et al.* (2019), Mackay *et al.* (2011), and Newton *et al.* (2016).

benefiting from the lessons learned through experience and incorporation of even more refined methodologies.¹³ Further, the USFWS has been responsive to the many concerns raised through comments on the earlier draft, conducting additional research to understand risks to non-target species (e.g., Farallon arboreal salamander) and adding precautions to minimize risks that cannot be altogether eliminated (e.g., a hazing program to minimize gull and migrant raptor exposure). Of the two rodenticides proposed for potential use in the FEIS, there are **clear advantages to Alternative B, which would use Brodifacoum 25D-Conservation**, including the relative success of its use in mouse eradications,¹⁴ it requiring less rodenticide to be consumed per individual mouse and fewer total dose events to be effective,¹⁵ and that it breaks down faster with the onset of the rainy season, thus altogether limiting exposure risk to non-target species as well as abbreviating the operational period that would necessarily disturb wildlife. This alternative was selected due to these and other advantages.

Key questions (or challenges) concerning the Project are **related to the steep and rugged terrain of the South Farallones**: in particular, whether aerial bait drops can achieve sufficient cover to reach all of the mice, and what are the risks associated with bait drift into the marine environment? Regarding **bait cover**, there are two large caves that we observed during our site visit (see **Figure 4**), for example, where aerial bait application is not feasible and thus, it would be necessary to implement **concurrent on-the-ground baiting efforts** in these select, difficult to aerially-access areas. This is already part of the proposed Project, and while it will be operationally intensive, it will be critical to the Project's success and is being committed to along with the necessary monitoring to ensure complete mouse eradication. **Bait drift** from above the mean high tide line seems inevitable due to the potential for it to roll down steep slopes and for encroaching waves to reach some bait, despite ever-improving guidelines for aerial bait application.¹⁶ Although the bait is formulated to dissolve and diffuse quickly following precipitation events - there does appear to be some uncertainty as to how the bait and rodenticide will behave in the marine environment, including whether the pellets will float or sink, how quickly they will dissolve and/or concentrate, and what environmental conditions might control all of this; however, data suggests that both rodenticides considered in the FEIS will degrade rapidly in aqueous environments with ultraviolet exposure.¹⁷ These points on drift are equally pertinent to any potential spill events during bait transport to the islands over/through coastal waters and the Greater Farallones National Marine Sanctuary, as it would inform both risk and clean-up measures. The proposed Project does include **commitment to develop a Spill Response Plan**, which should fully consider these aspects in the marine environment. On land, bait degradation is expected to be rapid following significant rain events (estimated at up to 5 weeks for Brodifacoum 25D-Conservation versus up to 15

¹³ See Chapter 4 in the FEIS for detailed discussion as well as Keitt *et al.* 2015

¹⁴ Samaniego 2016 determined that of 61 successful island mouse eradication efforts, one relied on diphacinone and 48 relied on brodifacoum. In addition, they found that all 30 such eradication attempts between 2005 and 2015 used brodifacoum and of these, 93% were successful in removing mice from the islands. This includes the success with black rat removal from Anacapa Island in California's Channel Islands in November 2002.

¹⁵ Unlike rats, a species for which diphacinone has been frequently used, the house mouse is a selective and intermittent forager with a relatively small home range (estimated 0.62 ac/individual versus 2.47-27.2 ac/individual for rats) so bait cover is necessarily high to reach all mice. In some locations, mice have demonstrated resistance to diphacinone and while USFWS preliminary studies at South Farallon Island suggest this resistance is not an issue here, there is a possibility that it may. In addition, for diphacinone to be fully effective, mice would need to consume more pellets per individual than with bait using brodifacoum.

¹⁶ Will *et al.* (2019)

¹⁷ [National Library of Medicine HSDB Database](#), accessed for environmental fate information on brodifacoum and diphacinone (June 2019)

weeks for Diphacinone-50 Conservation under typical precipitation conditions¹⁸) and because the rodenticides bind tightly to organics in the soil, stormwater runoff is not likely to contribute significantly to secondary marine exposure. Once on/in the soil, the rodenticides should break-down with exposure to further oxygenation, sunlight, and microbial activity and thus, have limited persistence in this environment. It is worth noting that brodifacoum is formulated to target vertebrates specifically so invertebrate and plants species are not considered at-risk to direct impacts. While these non-target organisms could potentially transfer residual amounts of rodenticide up the food web to susceptible vertebrates, it is notable that the majority of vertebrate species in the South Farallones primarily feed on marine species that should be significantly less exposed. And while scavengers such as gulls may potentially consume mouse carcasses, mice typically retreat into their burrows as they are dying,¹⁹ and carcasses are not typically consumed beyond a week or so following death, so **bioavailability to scavengers would be relatively limited even before implementing best management practices.**

Overall, I find that the proposed Project has the potential to greatly benefit the native island flora and fauna, and to advance critical conservation goals in the South Farallones. The project is **consistent with Coastal Act Section 30240** in that the goal is to eradicate a human-introduced threat, the house mouse, thereby protecting a native ecosystem that is both rare and especially valuable ecologically.²⁰ Although, as described in the FEIS, the Project will cause some short-term impacts to individuals of various native species, the Project will not significantly disrupt any species (except the target mice) at a population level and will not significantly disrupt the sensitive habitat over the short or long-term. Marine resources, including significant populations of seabirds, will also be maintained and restored, **consistent with Coastal Act Section 30230.**²¹ While the likelihood of short-term adverse impacts is not to be ignored, including the potential for those to coastal water quality, these will be minimized through proposed mitigation measures, including a spill plan. Overall, marine resources will be maintained and restored, despite minor, short-term effects, and the biological productivity and quality of coastal waters will also be maintained, **consistent with Coastal Act Sections 30231 and 30232.**²² Recognizing the breadth of lessons, advances, and successes that have been made over the past decade (in particular) of island conservation efforts using rodenticides such as brodifacoum, and appreciating the cautious, deliberative, and well-researched nature of this effort in particular, **I support the Project as proposed, though make two additional recommendations:** First, the **potential use of passive sampling devices (PSDs) to monitor** low levels of environmental exposure to rodenticides over time should be explored. Over the past two decades, tools such as polar organic chemical integrative samplers (POCIS), semi-permeable membrane devices (SPMDs), and diffusive gradient thin-films (DGTs) have been used by environmental chemists to study pollutant exposure over extended time periods (typically weeks to months) where traditional methods such as grab samples may contain contaminant levels

¹⁸ Annual average rainfall at the Farallones is 20 inches, with nearly 90% of that falling between November and April.

¹⁹ Buckelew *et al.* 2008

²⁰ California Coastal Act §30240(a) reads: *“(a) Environmentally sensitive habitat areas shall be protected against any significant disruption of habitat values, and only uses dependent on those resources shall be allowed within those areas.”*

²¹ California Coastal Act §30230 begins: *“Marine resources shall be maintained, enhanced, and where feasible, restore. Special protections shall be given to areas and species of special biological or economic significance...”*

²² California Coastal Act §30231 begins: *“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...”* and California Coastal Act §30232 reads: *“Protection against the spillage of crude oil, gas, petroleum products, or hazardous substances shall be provided in relation to any development or transportation of such materials. Effective containment and cleanup facilities and procedures shall be provided for accidental spills that do occur.”*

below instrument detection limits, and/or there is interest is in exposure integrated over time rather than at some particular moment. These devices can be used in soils as well as in aqueous environments, so may be suitable for monitoring at the South Farallones as they would offer an integrated measure of residual rodenticide in the environment and provide means to evaluate its degradation. Second, I would suggest that the Commission be included in the **review of the detailed operations, spill, and monitoring plans that will be developed as the effort progresses towards implementation**, and subsequently, **included as a recipient of all monitoring reports** so that the Commission can continue to provide guidance and track the success as well as any adverse impacts of the Project.

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FIGURE 1. Above and upper right: Maritime goldfield (*Lasthenia maritima*) is the primary native species across the South Farallones landscape – it is a small annual plant with shallow roots suited to the islands along the California and Oregon coasts. The population at South Farallon Island is the largest known. Lower right: Goldfield is also a preferred nesting material for gulls and other seabirds; note the gull eggs perched on a cliff amidst a bed of recently-harvested plant material.



FIGURE 2. Above: Invasive non-native vegetation is proliferating across the South Farallon Island landscape. Here, a variety of European grasses New Zealand spinach (*Tetragonia tetragonioides*), and cut leaf plantain (*Plantago coronopus*) are shown encroaching on the native goldfields towards the background. Among their adverse impacts, these invasive species outcompete native flora, alter soil conditions, and create an unnaturally dense cover of vegetation that limits available space and alters ground conditions needed for seabird nesting. The presence of house mice, which suppress native plant populations via seed consumption as well as acting a dispersal agent for non-native plant material, is likely playing a significant role in the continued loss of the native island plant community at the South Farallones. Right: Another example of how non-native vegetation is altering the Farallones landscape – an assortment of taller-growing European grasses, mallow (*Malva* spp.), curly dock (*Rumex crispus*), sweet fennel (*Foeniculum vulgare*), and other species create thicket-like conditions that can severely limit wildlife agility in when entering and returning to their underground burrows. This renders them vulnerable to predators such as overwintering burrowing owls.



FIGURE 3. *Above:* A shallow cave dwelling used by a burrowing owl the previous winter, littered with feathers and bones from its prey. The majority of these appear to be the remains of ashy storm petrels. *Upper left:* A largely-intact wing left from an ashy storm petrel carcass. *Lower left:* An owl pellet containing bones and feathers was identified to consist of ashy storm petrel remains on the basis of the petrel’s characteristic musky scent, which was still present at the time of our site visit to South Farallon Island on May 7th, 2019.



FIGURE 4. View of the eastern side of South Farallon Island with Sugarloaf [islet] to the right. Two caves can be seen on the right end of South Farallon, including Great Murre Cave, which is the taller of the two and is primarily used by Common Murres (*Uria aalge*). These caves are examples of areas where aerial bait dispersal will not be feasible and house mouse eradication operations will instead have to rely on concurrent use of bait stations and other on-the-ground operations to ensure full coverage for the target species.