House Mouse Eradication from the South Farallon Islands
Draft Environmental Assessment

May 2009

Lead agency:
U.S. Fish and Wildlife Service
San Francisco Bay National Wildlife Refuge Complex

Abstract
The United States Fish and Wildlife Service proposes to protect and restore the ecosystem of the South Farallon Islands, particularly seabirds and other native biological resources, by eradicating non-native house mice and preventing their future reintroduction. In accordance with the National Environmental Policy Act (NEPA) and its associated regulations, the Service has prepared this Environmental Assessment (EA) to determine whether mouse eradication on the South Farallones would have significant impacts on the quality of the human environment. The Service has considered three alternatives for addressing the problem of non-native mice on the South Farallones:

A. Taking no action, which in this case would be a continuation of the island's status quo;
B. Mouse eradication with an aerial broadcast of toxic bait as the primary technique; or
C. Mouse eradication with toxic bait delivery using bait stations as the primary technique.

The Service is soliciting comments from the interested public on this Draft EA. If no significant impacts to the human environment are identified, and public comments do not warrant major changes in the proposed action, the Service will then issue a Final EA and a Finding of No Significant Impact, and implement the action.

Public Comment Period:
September 8, 2009 through October 23, 2009

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Executive Summary

The Farallon Islands, or Farallones, are about 28 miles west of the Golden Gate and the city of San Francisco, California. This group of islands is managed by the U.S. Fish and Wildlife Service as the Farallon National Wildlife Refuge. The Farallones' isolated nature, varied and extensive habitats, and adjacent productive marine environment makes them an ideal breeding and resting location for wildlife, especially seabirds and marine mammals. The Refuge comprises the largest continental U.S. seabird breeding colony south of Alaska, and supports the world's largest breeding colonies of ashy storm-petrel, Brandt's cormorant, and western gull.

The South Farallon Islands, the island cluster within the larger Farallones group that contains the vast majority of the land area, have sustained ecological damage over many years from the presence of non-native house mice. Mice eat invertebrates, seeds and other plant matter, and possibly the eggs of nesting seabirds (mice have even been found to prey on seabird chicks in the nest on other islands). On the South Farallones, mice also artificially sustain burrowing owls that arrive from the mainland and prey heavily on small seabirds.

The purpose of the proposed action is to meet the Service's management goal of protecting and restoring the ecosystem of the Farallones, particularly seabirds and other native biological resources, by eradicating non-native house mice. Eradicating house mice would prevent burrowing owls from staying on the islands to prey on seabirds. Mouse eradication would also directly improve nesting and chick-rearing conditions for seabirds, and would likely benefit native amphibians, invertebrates, and plants as well.

In accordance with the National Environmental Policy Act (NEPA) and its associated regulations, the Service has prepared this Environmental Assessment (EA) to determine whether mouse eradication on the South Farallones would have significant impacts on the quality of the human environment. Using the guidelines set by NEPA, the Service has considered three alternatives for addressing the problem of non-native mice on the South Farallones:

A. Taking no action, which in this case would be a continuation of the island's status quo;
B. Mouse eradication with an aerial broadcast of toxic bait as the primary technique; or
C. Mouse eradication with toxic bait delivery using bait stations as the primary technique.

Within this EA, the parameters of each of these alternatives are described and their potential impacts to the environment are considered. The environmental issues discussed include:

- Impacts to physical resources including water resources, geology and soils, and wilderness character;
- Impacts to biological resources including impacts from toxin use and impacts from disturbance;
- Impacts to the social and economic environment, including Refuge visitors, fishing resources, and historical and cultural resources

The Service is soliciting comments from the interested public on this Draft EA. If no significant impacts to the human environment are identified, and public comments do not warrant major changes in the proposed action, the Service will then issue a Final EA and a Finding of No Significant Impact, and implement the action.

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1. Purpose and Need

1.1. Introduction

The United States Fish and Wildlife Service ("USFWS" or "the Service") proposes to undertake the following actions on the South Farallon Islands, part of the Farallon National Wildlife Refuge ("FNWR" or "the Refuge"):

1. Eradication of the non-native house mouse (*Mus musculus*); and
2. Prevention and emergency response plan for dealing with re-introduction of mice, other non-native rodents, and other animals to the islands.

In accordance with the National Environmental Policy Act of 1969 (NEPA) (42 USC 4321 *et seq.*, as amended), and Council on Environmental Quality (CEQ) regulations for implementing NEPA (40 CFR 1500 *et seq.*), Federal agencies must consider the environmental impacts of actions – projects, programs, policies, or plans that are implemented, funded, permitted, or controlled by a federal agency or agencies – they propose to undertake. Specifically, Federal agencies must consider the environmental impacts of a reasonable range of alternatives for implementing an action, and make the public aware of the environmental impacts of each of the alternatives presented. If adverse environmental impacts are identified, NEPA requires an agency to show evidence of its efforts to reduce these adverse impacts through mitigation. An environmental analysis, such as this Environmental Assessment (EA), documents that an agency has considered and addressed these impacts.

This EA will be used by the Service to solicit public involvement and to determine whether the implementation of either of the action alternatives presented within would have a significant impact on the quality of the human environment.

1.2. Purpose of the Proposed Action

The purpose of the proposed action is to meet the Service's management goal of protecting and restoring the ecosystem of the Farallones, particularly seabirds and other native biological resources, by eradicating non-native house mice.

The South Farallones have sustained ecological damage over many years from the presence of mice. Prior to the introduction of non-native mammals, the South Farallones provided seabirds with breeding and roosting habitat nearly devoid of land-based predatory threats. Introduced rabbits (*Oryctolagus cuniculus*) and cats (*Felis catus*), which were later removed, and mice, which remain on the South Farallones today, have had noticeable negative impacts on native species. Eradicating mice would improve the breeding conditions and may increase the local population size for at least two seabird species, the ashy storm-petrel (*Oceanodroma homochroa*) and Leach's storm-petrel (*Oceanodroma leucorhoa*), and may also benefit other seabirds

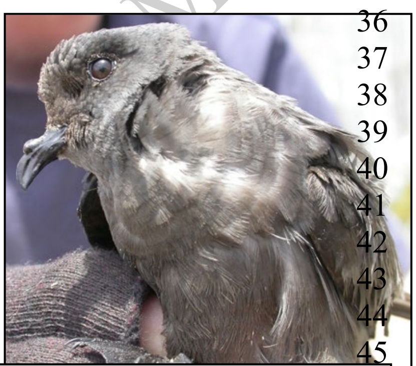

Figure 1.1. Ashy storm-petrel

as well as native amphibians, invertebrates, and plants. The ashy storm-petrel is a rare species with a range limited almost entirely to California, with about half of the world's breeding population occurring at the South Farallones. The South Farallones colony declined roughly 40% between 1972-73 and 1992 (Sydeman et al. 1998). The Leach's storm-petrel is a more widespread and numerous species but it has also declined in California (Carter et al. 1992). Data indicate the South Farallones colony has actually declined dramatically and may be close to extirpation (PRBO unpubl. data; G.J. McChesney pers. comm.).

1.3. Need for Action

1.3.1. Summary of House Mouse Impacts on the South Farallon Islands

The Farallon National Wildlife Refuge, which originally encompassed the North and Middle Farallon Islands but did not include the South Farallones, was established by President Theodore Roosevelt under Executive Order 1043 in 1909, as a preserve and breeding ground for marine birds. In 1969 the Refuge was expanded to include the South Farallones, and is still managed with the same basic purpose today. Non-native mice are negatively impacting the populations of small burrow- and crevice-nesting seabirds, particularly storm-petrels, and the Service has identified mouse eradication as an important aspect of fulfilling its main purpose.

Researchers have discovered that mice are indirectly responsible for extensive ashy storm-petrel predation by burrowing owls (*Athene cunicularia*) that winter on the islands (Mills 2006; PRBO unpubl. data). The physical and behavioral similarities between ashy storm-petrels and Leach's storm-petrels have led researchers to suspect that Leach's storm-petrels are suffering similar predation. Burrowing owls are not considered island residents, but each year burrowing owls dispersing from their resident habitat in California's interior lowlands overshoot the coast, and land on the South Farallones to rest before returning to the mainland (DeSante and Ainley 1980). The "accidental" arrival of migrating or dispersing landbirds onto the Farallones is actually quite common; over 400 different landbird species have been recorded on the islands since 1968 (Richardson et al. 2003). Most landbirds that arrive on the Farallones return to the mainland within a few days (DeSante and Ainley 1980). However, some burrowing owls arriving to the South Farallones stay on the islands and subsist largely on mice during the fall, when the mouse population is at an annual peak. By winter, the mouse population plummets (a cyclical counterpart to its fall peak) rendering mice essentially unavailable to burrowing owls as a food source. As a result, the wintering burrowing owls must switch to alternative prey sources. Adult storm-petrels, which arrive on the islands starting in mid-winter to visit breeding sites and engage in courtship activity, are susceptible to depredation by burrowing owls searching for alternative prey. Predation by owls is known to account for substantial annual mortality of the ashy storm-petrel population, which has recently undergone a precipitous decline at the South Farallones (Sydeman et al. 1998), and owl predation is

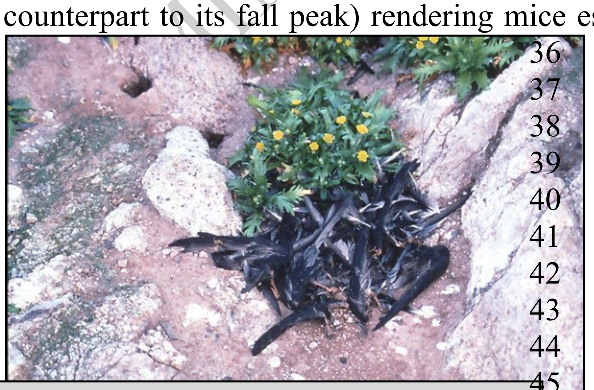

Figure 1.2. Ashy storm-petrel remains beneath burrowing owl roost.

thought to threaten Leach's storm-petrels as well. Ultimately, the owls' switch in prey is often insufficient to sustain them through the winter. The majority of owls that are monitored on the island through the winter do not survive, which researchers believe is related at least in part to food scarcity as well as fatal attacks by the territorial western gulls (*Larus occidentalis*) that dominate the islands by spring.

In addition to their indirect contribution to owl predation on storm-petrels, mice also may directly impact storm-petrels through egg predation and disturbance to burrows. The inconspicuous nest sites of these small seabirds makes observation difficult and evidence of mouse predation and disturbance on the South Farallones scarce. However, on other islands similar to the Farallones throughout the world, mice have been demonstrated to prey on seabird eggs and chicks (Cuthbert and Hilton 2004; Wanless et al. 2007). A more detailed discussion of the impacts of mice to storm-petrels may be found in Section 4.4.3.3.1.

Evidence from other islands also indicates that mice may have major impacts on invertebrates, plants, and the Farallones' endemic arboreal salamander subspecies (*Aneides lugubris farallonensis*). The term "endemic" refers to an organism that exists nowhere else on Earth. Mouse diet analysis on the South Farallones has shown that mice frequently consume native invertebrates and plants, including the ecologically important maritime goldfields (*Lasthenia maritima*) (Jones and Golightly 2006). Because invertebrates and plants play critical structural roles in most ecosystems, if mice on the Farallones have a major direct impact on any of these organisms, then this impact has the potential to indirectly affect other aspects of the ecosystem as well, possibly severely. More detailed discussions of the potential impacts of mice to invertebrates, plants, and salamanders may be found in Sections 4.4.3.2.2-3 and 4.4.3.4.

1.3.2. Past Actions on the South Farallones

To reduce the rate of burrowing owl predation on storm-petrels, the Service has explored the option of owl capture and translocation to sites on the mainland. However, attempts to capture burrowing owls on the Farallones have proven only partially successful and very time-consuming, especially when mice are abundant on the island and owls are consequently unresponsive to baited traps (J. Barclay pers. comm.). Additionally, a burrowing owl translocation program would have to continue in perpetuity in order to contribute meaningfully to storm-petrel habitat improvement. Finally, burrowing owl translocation would not address the other likely impacts of mice on the island ecosystem. While burrowing owl translocation may temporarily reduce predation on storm-petrels in the short term, it cannot alone fulfill the ecosystem-wide restoration objective identified as the purpose of action.

Western gulls, which nest on the South Farallones in large numbers, are also responsible for substantial storm-petrel mortality due both to predation on storm-petrels and attacks on storm-petrels that encroach on their nesting territories. In the early 1970s on Southeast Farallon Island, western gull breeding distribution was limited mainly to the islands's broad marine terrace, outside the principal talus slope breeding habitat of the storm-petrels (Ainley and Lewis 1974). Since that time, the South Farallones western gull colony has shifted and spread to nearly the entire island group, including important storm-petrel breeding areas. The Service has, with limited success, explored options for reducing the number of western gulls nesting in habitat critical to storm-petrels and other small seabirds. These options have included installing wire grids over breeding plots in an attempt to exclude predatory gulls. Additionally, the Service has considered the possibility of targeted lethal control of gulls that have been observed "specializing" in preying on small seabirds including storm-petrels. While options for reducing the gull population on the Farallones may be appropriate as short-term actions that might mitigate for high predation rates by gulls on storm-petrels, and might also complement mouse eradication, gull control without mouse eradication would not fully fulfill the ecosystem-wide restoration objective identified as the purpose of action.

The Service conducts its ongoing management activities with special consideration for protecting and enhancing seabird nesting habitat on the South Farallones, particularly for crevice- and burrow-nesting species such as ashy and Leach's storm-petrels. For example, on Southeast Farallon Island a "habitat sculpture" for crevice-nesting seabirds was recently built, and crevices suitable for storm-petrel or auklet nesting were deliberately placed within recently rebuilt rock walls. The Service may conduct restoration projects in the future that are designed specifically to enhance nesting habitat, such as the construction of artificial nests or nesting structures. Further enhancement of storm-petrel nesting habitat, without mouse eradication, would contribute partly towards the seabird restoration component of the South Farallon Islands' restoration needs, but benefits would be limited if the current levels of large scale adult storm-petrel mortality continue. In addition, these taxon-specific habitat enhancements would not fulfill the ecosystem-wide restoration objective identified as the purpose of action.

1.3.3. Benefits of House Mouse Eradication

The best scientific evidence available to the Service indicates that if mice are eradicated from the South Farallones, migrant burrowing owls that arrive on the island in the fall would not remain over winter, and would be unlikely to survive if they attempt to stay. Studies conducted on seasonal fluctuations in owl diet have lent support to the hypothesis that owls depend on mice for survival on the Farallones during the fall (Mills 2006). Furthermore, there have been no confirmed accounts, current or historical, of burrowing owls successfully breeding on the islands (DeSante and Ainley 1980), indicating the unsuitability of the Farallones environment for resident burrowing owls.

While ashy storm-petrels are present in at least low numbers year-round, neither ashy nor Leach's storm-petrels are common on the South Farallones until their pre-breeding burrow visits begin around February (Ainley and Lewis 1974; Ainley et al. 1990). On the other hand, two decades of data show that burrowing owls are much more likely to arrive on the South Farallones in the fall and early winter than in any other season (Richardson et al. 2003). Therefore, it is highly probable that if mice are removed from the South Farallones, then owls that arrive on the islands would behave similar to the thousands of other birds that are accidental to the islands each fall and stay no more than a few days. Thus, storm-petrels would no longer be at risk of predation by owls when they arrive later in the winter.

Mouse eradication may also lead to noticeable increases in invertebrate populations (Newman 1994; Ruscoe 2001). This was the case on Mana Island, for example, where populations of the Cook Strait giant weta *Deinacrida rugosa*, an insect native to New Zealand that is similar to a giant grasshopper, increased noticeably after mouse eradication (Newman 1994).

Mouse eradication would also remove pressure on the island's native salamander – from competition for insects as prey items, as well as possibly from predation on salamanders by mice – and may have a positive impact on their population. After successful mouse eradication on Mana Island in New Zealand the populations of McGregor's skinks (*Cyclodina macgregori*) and common geckos (*Hoplodactylus maculatus*), which were both under similar competitive and predation pressures from mice as the Farallones' salamanders are today, increased substantially (Newman 1994).

More discussion of the benefits of mouse eradication may be found in Section 4.4.6.

1.3.4. Background: The Problem of Introduced Species on Islands

1.3.4.1. Introduced species and the importance of island ecosystems

It is widely accepted that the natural world is currently facing a particularly high rate of species extinction (Raup 1988), that most recent extinctions can be directly attributed to human activity (Diamond 1989), and that for ethical, cultural, aesthetic, and economic reasons, this current rate of extinction is cause for considerable concern (Ehrlich 1988; Ledec and Goodland 1988). One of the major worldwide causes of anthropogenic extinctions is the introduction of non-native species. Introduced species are responsible for 39 percent of all recorded animal extinctions since 1600 for which a cause could be attributed (World Conservation Monitoring Centre 1992).

Island ecosystems are key areas for biodiversity conservation. While islands make up only about three percent of the earth's surface, they are home to 15-20 percent of all plant, reptile, and bird species (Whittaker 1998). However, small population sizes and limited habitat availability make species endemic to islands especially vulnerable to extinction, and their adaptation to isolated environments makes them especially vulnerable to aggressive introduced species (Diamond 1985; Diamond 1989; Olson 1989). Of the 484 recorded animal species extinctions since 1600, 75 percent were species endemic to islands (World Conservation Monitoring Centre 1992). Introduced species were at least partially responsible for at least 67 percent of these island extinctions (based on the 147 island species for which the cause of extinction is known, calculated from World Conservation Monitoring Centre 1992).

Islands are high-value targets for conserving biodiversity because:

1. A large percentage of their biota are endemic species and subspecies with small populations, which makes them particularly extinction-prone (Darwin 1859; Elton 2000).
2. They are critical habitat for seabirds and pinnipeds, which feed over thousands of square kilometers of ocean but are dependent on small isolated islands for safe breeding and nesting. Protection of these animals at their island breeding sites is easier and more cost-effective than protecting them from threats at sea (such as plastics pollution and

accidental or deliberate entanglement in fishing tackle), which could affect them anywhere along their travels (Wilcox and Donlan 2007; Buckelew 2007).

3. Many islands are sparsely inhabited or uninhabited by humans, keeping the socioeconomic costs of protection low.

1.3.4.2. Non-native house mice

The house mouse, which originated in Southeast Asia, is now among the most widespread of all mammals, a result of its close association with humans and the relative ease with which it can be transported and introduced to new locations. House mice are present on at least 64 island groups in all of the world's major oceans (Atkinson 1989). They are among the vertebrates considered to be "significant invasive species" on islands of the South Pacific and Hawaii, officially reported from 41 islands but having probably reached all inhabited islands in the Pacific and numerous uninhabited islands (Atkinson and Atkinson 2000). The resourcefulness of house mice is evident from their global distribution and their broad habitat range including buildings, agricultural land, coastal regions, grasslands, salt marshes, deserts, forests and subantarctic areas (Atkinson and Atkinson 2000; Efford et al. 1988; Triggs 1991).

1.3.4.3. Impacts of non-native house mice on island ecosystems

House mice on islands are omnivorous, eating a variety of seeds, fungi, insects, other small animals, reptiles and eggs of small birds. They are known to have dramatic negative impacts on endemic arthropods (Cole et al. 2000; Rowe-Rowe et al. 1989). This direct impact on arthropods in turn has the potential to extend throughout the ecosystem, as arthropods are often crucial in the pollination and seed dispersal strategies of plants, the decomposition of dead plant and animal matter, and as a food resource for other native species. On Marion Island in the southern Indian Ocean, for example, house mice are substantially affecting the populations of a number of endemic invertebrates, especially the flightless moth *Pringleophaga marioni*, the single most important decomposer species on the island. Furthermore, house mice may be affecting the amount of food available for the native insectivorous bird *Chionis minor*, the lesser sheathbill. Lesser sheathbill flocks on Marion Island are much smaller than those on nearby, mouse-free Prince Edward Island, suggesting that food competition from house mice is negatively affecting Marion's lesser sheathbill population as well (Crafford 1990; Rowe-Rowe et al. 1989).

Figure 1.3. A house mouse feeding on a seabird carcass on Gough Island.

House mice can also have a substantial negative impact to island native reptiles and amphibians. On Mana Island in New Zealand, for example, mice were a major contributing factor in the population collapse of the island's rare McGregor's skink (Newman 1994).

One of the more surprising effects of mice on islands is their negative impact to seabird and native landbird populations through direct predation on eggs and chicks. On Gough Island in the southern Atlantic Ocean, introduced house mice prey on chicks of the rare Tristan albatross (*Diomedea dabbenena*), leading to an unusually low breeding success rate of 27 percent in this declining seabird species (Cuthbert and Hilton 2004). Furthermore, mice on Gough Island appear to limit the breeding range of the endemic Gough bunting (*Rowettia goughensis*) to the small amount of mouse-free habitat remaining on the island (Cuthbert and Hilton 2004). Similarly, on Marion Island, where the recent eradication of feral cats left mice as the only non-native mammal on the island, researchers recorded several wandering albatross (*Diomedea exulans*) killed by mice (Wanless et al. 2007).

1.3.4.4. Hyperpredation on islands

The ecological concept of one prey species contributing indirectly to the decline of another prey species that shares its range, through increased predation by a local predator that is sustained by feeding on both prey species, is referred to as “hyperpredation” (Holt 1977; Smith and Quin 1996). The decline of ashy storm-petrels and likely Leach’s storm-petrels on the South Farallones, partially driven by the interaction between burrowing owls and non-native mice (as described in Section 1.3.1 above), is a good example of the impact that introduced species can have on an ecosystem through the mechanism of hyperpredation. A number of similar examples, involving one or more non-native species that contribute to declines in native island species, have recently been described. Allan’s Cay in the Bahamas provides an example that is similar to the current situation on the Farallones. Non-native mice on the island are attracting much larger numbers of barn owls (*Tyto alba*) than other ecologically similar sites in the region. Because owls also prey on the Audubon’s shearwater (*Puffinus lherminieri*) that has breeding colonies on many of the cays in the region, the shearwater population on Allan’s Cay is experiencing a mortality rate that is twice as high as on colonies that are mouse-free. This high mortality will likely contribute to the colony’s extirpation in the future if conditions do not change (W. Mackin pers. comm.).

Another example comes from Santa Cruz Island in Channel Islands National Park, southern California, where biologists found that golden eagles (*Aquila chrysaetos*) that were sustained by non-native feral pigs (*Sus scrofa*) were occasionally switching their prey preference to the endemic island fox (*Urocyon littoralis*). Eagle predation has played a major role in the ongoing catastrophic decline of the fox (Roemer et al. 2001). Feral pigs were recently eradicated from Santa Cruz Island, in hopes of breaking this cycle of predation and arresting the many other negative impacts that feral pigs had to the island’s resources (Morrison et al. 2007). Biologists have seen a similar pattern on islands where feral cats can maintain high population densities between seabird breeding seasons because they are subsidized by introduced rodents (Atkinson 1985) or rabbits (Apps 1983; Courchamp et al. 1999, 2000). In all of these examples, the presence of a non-native prey animal led to substantial declines in native prey species through opportunistic predation by a local predator that was sustained at artificially high population levels.

1.4. Authority and Responsibility to Act

The eradication of non-native house mice from the South Farallon Islands is authorized and in many cases mandated by several federal laws requiring land managers to conserve and restore wildlife and habitats under their jurisdiction.

The U.S. Fish and Wildlife Service's mission is to work with others to "conserve, protect and enhance fish, wildlife, and plants and their habitats for the continuing benefit of the American people." The threat that introduced species pose to habitat and native wildlife makes addressing their impacts one of the Service's top management priorities. Lessening or eliminating the impacts of introduced species on the Farallones is essential to the Service's management strategy for the islands.

The Fish and Wildlife Act of 1956 (16 U.S.C. 742a-742j, not including 742 d-l, 70 Stat. 1119), as amended, gives general guidance that can be construed to include alien species control, that requires the Secretary of the Interior to take steps "required for the development, management, advancement, conservation, and protection of fish and wildlife resources."

The National Wildlife Refuge System Administration Act of 1966 (NWRSAA) (16 USC 668dd) established the National Wildlife Refuge System, to be managed by the Service. Among other mandates, the NWRSAA requires the Service to provide for the conservation of fish, wildlife, and plants, and their habitats within the System; and to ensure that the biological integrity, diversity, and environmental health of the System are maintained.

The Endangered Species Act of 1973 (ESA) (16 U.S.C. 1531-1544, 87 Stat. 884), as amended, directs the Service to conserve ecosystems upon which threatened and endangered species depend.

The National Wildlife Refuge System Improvement Act of 1997 (NWRSIA), which amends the NWRSAA, serves as an "Organic Act" for the Refuge System and provides comprehensive legislation on how the Refuge System should be managed and used by the public. The NWRSIA clearly establishes that wildlife conservation is the singular Refuge System mission, provides guidance to the Secretary of the Interior for management of the System, provides a mechanism for refuge planning, and gives refuge managers uniform direction and procedures for making decisions regarding wildlife conservation and uses of the System.

The USFWS policy for maintaining biological integrity and diversity and environmental health (601 FW 3, 2001), directs Refuges to "prevent the introduction of invasive species, detect and control populations of invasive species, and provide for restoration of native species and habitat conditions in invaded ecosystems." 601 FW 3 further directs refuge managers to "develop integrated pest management strategies that incorporate the most effective combination of mechanical, chemical, biological, and cultural controls while considering the effects on environmental health."

The USFWS's Regional Seabird Conservation Plan lists mouse eradication from the Farallones as a top seabird conservation priority in the region.

Comprehensive Conservation Plan (CCP) for Farallon National Wildlife Refuge. As mandated by the NWRSIA, the Service is preparing a CCP to guide future management actions on the Refuge to meet the missions and purposes of the Refuge and the Service. The CCP includes mouse eradication from the South Farallon Islands as an objective for the Refuge's management direction.

Presidential Executive Order 13112 on Invasive Species (February 3, 1999): Section 2(a)(2), on Federal agency duties, states: "Each Federal agency whose actions may affect the status of invasive species shall, to the extent practicable and permitted by law, subject to the availability of appropriations, and within Administration budgetary limits, use relevant programs and authorities to: (i) prevent the introduction of invasive species; (ii) detect and respond rapidly to and control populations of such species in a cost-effective and environmentally sound manner; (iii) monitor invasive species populations accurately and reliably; (iv) provide for restoration of native species and habitat conditions in ecosystems that have been invaded; (v) conduct research on invasive species and develop technologies to prevent introduction and provide for environmentally sound control of invasive species; and (vi) promote public education on invasive species and the means to address them."

Executive Order 13112 defines "invasive species" as "an alien species [a species that is not native with respect to a particular ecosystem] whose introduction does or is likely to cause economic or environmental harm or harm to human health."

1.5. Scope of the Proposed Action

The proposed action focuses on three areas:

1. Activities necessary to eradicate house mice from the South Farallones;
2. Activities necessary to prevent the reintroduction of house mice to the Farallon Islands, and to prevent the new introduction of any terrestrial vertebrates to the Farallones in the future; and
3. Activities necessary to minimize negative impacts to native species and maintain wilderness values on the Farallones during the course of mouse eradication and reintroduction-prevention activities.

1.6. Environmental Issues (Impact Topics) Identified

1.6.1. Summary of Scoping

Section 1501.7 of the CEQ regulations for implementing NEPA requires that agencies implement a process, referred to as "scoping", to determine the scope of issues to be addressed in an environmental impacts analysis and identify the major environmental issues related to a proposed action that need to be analyzed. The scoping process included research in published and unpublished literature, consultations with experts in the ecology of the Farallones and experts in non-native species eradication, consultation with the government agencies that have a stake in the resources of the Farallones and adjacent waters, and invitations for comments from the public. There is a detailed description of the scoping process that the Service conducted for this EA in Chapter 5. During the scoping process, the Service identified the major environmental issues, or “impact topics,” that are described in Sections 1.6.2-1.6.4 below. These issues guided the development of the alternatives, and the scope and content of the environmental impacts analysis for each alternative found in Chapter 4.

1.6.2. Impact Topic: Physical Resources

1.6.2.1. Sub-topic: Impacts to water resources

Because the proposed action includes the delivery of a toxin into the Farallones environment, the potential impacts of the toxin to local water quality was identified as an important environmental issue.

1.6.2.2. Sub-topic: Impacts to geology and soils

Because the proposed action includes delivery of a toxin into the Farallones environment, the potential for transfer and persistence of the toxin in soils was identified as an important environmental issue.

1.6.2.3. Sub-topic: Impacts to wilderness character

All of the South Farallones except Southeast Farallon Island are designated as wilderness under the Wilderness Act of 1964 (PL 88-577). Wilderness designation makes the wilderness character of the South Farallones an important environmental issue.

1.6.3. Impact Topic: Biological Resources

1.6.3.1. Sub-topic: Non-target impacts from toxin use

Mouse eradication would include the use of a toxin that is lethal to mice. Toxins should only be used in the environment if the behavior of that toxin can be predicted with some accuracy. The impact of the toxin to species other than mice and the persistence of the toxin in the environment are important environmental issues related to impacts of the action to biological resources, because animals other than mice, including birds, could ingest the toxin.

1.6.3.2. Sub-topic: Disturbance to sensitive species

Similar to most other oceanic islands, the Farallones are critical habitat for species, such as seabirds and pinnipeds, that are especially sensitive to disturbance. The risk of disturbance to sensitive species from the proposed action is an important environmental issue related to impacts of the action to biological resources, particularly because of the importance of the islands for breeding seabirds and pinnipeds.

1.6.4. Impact Topic: Social and Economic Environment

1.6.4.1. Sub-topic: Impacts to Refuge visitors and recreation

The Farallones are currently closed to the public to protect the Refuge's sensitive biological resources, but the animal species that depend on the Farallones are nevertheless important resources for wildlife enthusiasts visiting the nearshore waters and throughout these species' ranges. Additionally, recreational boaters utilize the marine region surrounding the islands. Finally, a small number of FWS and PRBO personnel and contractors utilize the island year-round.

1.6.4.2. Sub-topic: Impacts to fishing resources

The waters surrounding the Farallones are important recreational and commercial fishing grounds for species such as salmon, albacore tuna, Dungeness crab, halibut, and rockfish (Scholz and Steinback 2006). The State of California is currently considering a proposal to create a no-take Marine Reserve around some or all of the Farallon Islands, as mandated by the State's Marine Life Protection Act legislation.

1.6.4.3. Sub-topic: Impacts to historical and cultural resources

There is evidence of past human uses of the South Farallones dating to pre-historical times. The impact of the action to historical and cultural sites, structures, objects and artifacts on the South Farallones is an important environmental issue.

Chapter 2. Alternatives

2.1. Introduction to the Development of Alternatives

As part of the analytical process mandated by NEPA, section 102(2)(E) requires all Federal agencies to "study, develop, and describe appropriate alternatives to recommended courses of action in any proposal which involves unresolved conflicts concerning alternative uses of available resources." Based upon the existing site conditions, need for action, constraints and the public concerns identified during the public scoping process, three alternatives were identified – two action alternatives, including the preferred alternative, and the alternative of no action, which is included in NEPA analysis to provide a benchmark with which to compare the magnitude of environmental effects of the action alternatives. The no action alternative will describe the Service's current management regime on the South Farallones with regard to the mouse population and its impacts to the island ecosystem.

The action alternatives were developed to focus on the issues identified by resource specialists within the Service, experts in island rodent eradication, government regulatory agencies, and the general public. All individuals, agencies and organizations that provided substantive input regarding the proposed action are listed in Chapter 5.

A number of additional alternatives were initially considered but rejected. In order to be retained for consideration, an alternative had to 1) have a high likelihood of success, 2) have an acceptably low probability for adverse effects on non-target species and the environment, and 3) be permitted under existing regulations governing the Refuge. The action alternatives that were dismissed from detailed consideration are also described, with rationale for their dismissal (Section 2.7).

The preferred alternative that was identified would be the eradication of mice using aerial bait broadcast as the primary bait delivery technique. The preferred alternative is identified as Alternative B (Section 2.3 below). The other action alternative would be the eradication of mice using enclosed bait stations as the primary bait delivery technique. This alternative is identified as Alternative C (Section 2.4 below).

2.2. Alternative A: No Action

Analysis of the no action alternative is required under NEPA. Mice would not be eradicated under this alternative. Other ongoing invasive species management programs on the South Farallones would continue, based on previous agency decisions. Low-intensity mouse control – primarily snap-trapping – currently occurs within and around the residences and buildings on Southeast Farallon Island. These localized control efforts would continue under the no action alternative, but the mouse population on the rest of the South Farallones would not be subject to control efforts. The Service currently removes invasive plants through hand-pulling and herbicide applications. Additionally, native plants are being planted to improve native populations and encourage the suppression of non-natives. Finally, vegetation on the islands is being closely monitored to allow for quick response to new invaders or spreading populations of current pests. These efforts would continue under the no action alternative. However, the continued presence and impacts of mice might compromise the effectiveness of future ecosystem restoration efforts.

The Service would also continue management activities focused on protecting storm-petrels and their habitat on the islands, including nest habitat construction and predator management. Prior to Fall 2008, the Service occasionally relocated burrowing owls that were overwintering on the island to protect storm-petrels from predation. The Service did not relocate any owls in 2008 to allow researchers to collect additional data on owl movement patterns. Under the no action alternative, the Service would continue to relocate burrowing owls whenever possible. Because western gulls are likely the most common resident predator of storm-petrels on the Farallones, there have been efforts in the past to deter gulls from nesting in prime storm-petrel habitat, but these efforts have been unsuccessful to date. The Service is considering the possibility for targeted control of gulls that specialize in preying on storm-petrels, and would continue to consider this possibility under the no action alternative.

The current rodent introduction-prevention protocols for vessels that transport personnel and materials to Southeast Farallon Island would continue under the no action alternative. However, these protocols are not always enforced, leaving the islands at risk of invasion by other species of rodents such as rats, or additional introductions of mice.

Furthermore, any other related programs or projects, now or in the future, decided and implemented under different authority would also continue.

Taking no action to address the effects of non-native mice would be contrary to the purpose of the refuge and other USFWS policies for conservation and restoration of natural biodiversity and management of designated wilderness.

2.3. Alternative B: Mouse Eradication with Aerial Bait Broadcast as Primary Technique (Preferred Alternative)

2.3.1. Rationale for Aerial Bait Broadcast

Employing aerial bait broadcast as the primary bait application method would minimize disturbance to the South Farallones' sensitive terrestrial habitat by allowing the Service to deliver bait to all potential mouse habitat on the islands without setting foot on much of the islands. Aerial bait broadcast is also the only safe way to deliver bait to inaccessible terrain such as steep cliffs. Aerial bait broadcast by helicopter is the bait delivery technique currently used most frequently for island rodent eradications (Howald et al. 2007).

2.3.2. Summary of Bait Delivery Methods

Bait pellets containing rodenticide would be systematically applied by helicopter to all land areas above the mean high tide mark on the South Farallones. In areas that cannot be baited by helicopter, such as caves, project staff would distribute bait pellets manually. Project staff would also install bait stations in limited circumstances such as within and near residences and outbuildings.

2.3.3. Timing

Aerial broadcast operations would occur in the late fall or early winter, most likely in the months of November and/or December. The actual time period for bait application under the preferred alternative would be defined by the islands' biological patterns. The period available for bait broadcast would begin after the summer breeding season for seabirds and pinnipeds on the Farallones has ended, and end before female northern elephant seals (*Mirounga angustirostris*) have started giving birth in the early winter. Bait broadcast would be completed within this time period, allowing for anticipated weather contingencies. Bait broadcast would only be initiated if local weather predictions indicate that precipitation would be unlikely for at least four days.

2.3.4. Equipment and Materials

Aerial broadcast operations would be conducted using a single primary-rotor/single tail-rotor helicopter. Helicopter models considered for use in the operations would include the Bell 206B Jet Ranger, Bell 206L4 Long Ranger, or other small- to medium-sized aircraft.

Bait would be applied from a specialized bait bucket, known as a hopper, slung beneath the helicopter. The hopper would be composed of a bait storage compartment, a remotely-triggered adjustable gate to regulate bait flow out of the storage compartment, and a motor-driven broadcast device that can be turned on (to broadcast bait over a wide swath) and off (to trickle bait at a low rate on a precise point below) remotely and independently of the outflow gate. The broadcast device would include a deflector that can be easily installed when directional (rather than 360°) broadcast is necessary, such as on the coastline.

Figure 2.1. Bait hopper.

The bait would be a compressed grain pellet, less than 0.1 oz (3 g) in weight, containing 25 parts per million (ppm) brodifacoum, which is a second-generation anticoagulant (see Section 2.5.2 for more information on brodifacoum). The bait used would be registered with the EPA in compliance with the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA). The bait product would be designed to be highly attractive to mice. All other ingredients in bait pellets would be non-germinating grains (either sterile or crushed). Any bait not initially consumed would likely remain attractive to mice. However, the bait would disintegrate completely within one or two major rainfall events.

2.3.5. Bait Application Operations

Bait broadcast by helicopter would consist of low-altitude overflights of the entire land area of the South Farallones and all immediately adjacent islets. The helicopter would fly at a speed ranging from 25-50 knots (29-58 mph or 46-93 km/hr) at an average altitude of approximately 164 ft. (50 m) above the ground, with the bait hopper long-lined 49-66 ft (15-20 m) below. The bait would be applied according to a flight plan that would take into account:

- The need to apply bait relatively evenly and to prevent any gaps in coverage or excessive overlap;
- Island topography;
- The distribution of roosting seabirds on the island, especially western gull and common murre (*Uria aalgae*);
- The need to avoid bait broadcast into the marine environment;
- The need to minimize disturbance to native wildlife, especially any pinnipeds hauled out on land and resting in nearshore waters; and
- The need to minimize the substantial costs associated with helicopter flight time.

The baiting regime would follow common practice based on successful island rodent eradications elsewhere in the U.S. and globally (Howald et al. 2007), in which overlapping flight swaths are flown across the interior island area and overlapping swaths with a deflector attached to the hopper (to prevent bait spread into the marine environment) flown around the coastal perimeter. The width of a flight swath would be determined beforehand in calibration trials. It would likely range from 164-246 ft (50-75 m). Each flight swath would overlap the previous by approximately 25-50 percent to ensure no gaps in bait coverage. During one application all points on the South Farallones would likely be subject to two helicopter passes. Within each bait application, there would be no more than three consecutive operating days.

In order to ensure eradication, it may be necessary to conduct more than one application, each between five and 10 days apart, to minimize the likelihood of either competitively inferior adult mice or juveniles surviving the initial broadcast because they were not given an opportunity to feed on bait. Nevertheless, if project leaders determine that palatable bait would be likely to remain available for mouse consumption for longer than 10 days after an initial application, a second or third application may not be necessary.

Figure 2.2. Bait pellet after exposure to moisture.

Bait would be applied strictly according to the limitations set by the EPA's pesticide regulations (FIFRA). The precise bait application rate, which would not exceed the rate set by the EPA, would be determined based on bait uptake experiments on the South Farallones prior to the eradication. These experiments would use a non-toxic placebo bait replica to measure an approximate rate of bait uptake (including both consumption and breakdown) on the South Farallones. Soon after application, bait pellets would be consumed or cached by mice and may be consumed by other animals as well. Bait pellets exposed to heavy moisture would degrade faster than pellets that fall in more protected locations. The application rate would be calculated so that an adequate amount of bait is available for consumption by mice for a period of at least four days. Before bait application, the pilot, helicopter, and hopper combination to be used in the application would conduct calibration operations to ensure consistency and accuracy of application using a placebo bait broadcast. The calibration would occur over a test site off-island in atmospheric conditions similar to those on the South Farallones.

To ensure complete and uniform application:

Figure 2.3. Helicopter broadcasting bait.

- The actual application path would be monitored onboard the helicopter using an onboard global positioning system (GPS), a navigation bar, and a computer to precisely guide the application in order to avoid gaps and unanticipated overlaps in application coverage.
- The application rate would be calculated using the known rate of bait flow from the hopper, the helicopter's reported velocity, and overlaps in the bait swath reported by the helicopter's onboard GPS tracking system.

Adjustments in bait flow rates, helicopter speed, and flight lines would be made as necessary to meet the optimal application rate, stay within the limits legally required by the EPA.

As a result of the need for caution near the marine environment, the coastlines of the main islands and offshore islets, which are potential mouse habitat, may not receive the optimal bait coverage with helicopter broadcast alone. In cases where it is evident or suspected that any land area did not receive full coverage, there would be supplemental systematic broadcast either by foot, boat, helicopter, or any combination of the above. Helicopters may hover for brief periods over land during bait application to bait offshore islets. All personnel who may participate in supplemental hand broadcasts would be trained and tested in systematic bait application at a target application rate (Buckelew et al. 2005).

Bait stations would be installed in and immediately surrounding all of the buildings and enclosed structures on the island. The bait used in bait stations would be identical to the bait pellets used for broadcast. The bait stations would have the design specifications listed in Section 2.4.4 below. A limited number of bait stations could also be installed elsewhere on the island as necessary.

All personnel that handle bait or monitor bait application in the field would meet or exceed all requirements for personal protective equipment (PPE) required by the EPA. All bait application activities (aerial broadcast, hand broadcast, and bait station filling) would be conducted by or under the supervision of pesticide applicators licensed by the State of California.

2.3.6. Project Support Operations

In addition to applying bait, helicopters would be used to transport equipment to the island for the purpose of this action. These additional helicopter operations would be localized to discrete flight paths that would be determined so as to minimize disturbance to native wildlife. Helicopters may hover for brief periods over land to drop off personnel and equipment.

Helicopters may be staged from the island or from a boat offshore of the island. Helicopters would only land at designated staging areas, where staff would re-fill the bait hopper, re-fuel, and conduct other necessary maintenance. These staging areas would be adequately stocked with fuel and other supplies and equipment to support the helicopters for the entire bait application process.

2.3.7. Additional Mitigation Actions

Pinnipeds are still present, possibly in locally large numbers, in the late fall and early winter, when aerial bait broadcast would occur. In order to reduce the risk of unpredictable and potentially harmful disturbance to pinnipeds from helicopter operations, the helicopter pilot would conduct a controlled surveillance flight around the coastline before bait operations begin in which pinniped haulout locations are noted. During this surveillance flight, an experienced pilot would approach major haulout sites with the intention of exposing hauled out animals to a gradual auditory and visual disturbance similar to the bait application. This controlled "dry run" would likely enable the animals to become aware of the helicopter and then move off of major haulouts into the water, which would allow the helicopter to treat coastal areas immediately afterward while most pinnipeds are still in the water rather than hauled out again. This approach would reduce the risk of a stampede among hauled out animals, thus reducing their risk of injury.

If preliminary trials (described in Section 2.5.4) indicate that non-target exposure to bait is substantially higher than expected, the Service may also consider additional mitigation actions. If these mitigation actions would require major changes in the operations described in Chapter 2, the Service would prepare supplemental NEPA analysis to reflect these changes. Mitigation actions could include:

- Systematic removal of mouse carcasses, and carcasses of any other animals suspected of succumbing to the toxin, to reduce the likelihood of secondary exposure in scavengers;
- Attempting to capture and hold some landbirds, such as wintering songbirds and/or birds of prey including burrowing owls, until the Service determines the birds would no longer be at risk of exposure to toxin;
- Attempting to capture and relocating burrowing owls to the mainland, as the Service has done in the past, to reduce the risk of toxin exposure; and/or

- Installing bait stations rather than broadcasting bait in areas that are determined to have particularly high concentrations of birds that would be likely to feed on bait pellets after an aerial broadcast.

Some or all of these mitigation actions may not be employed if Alternative B (the preferred alternative) is implemented, depending on the results of further operational planning and other factors.

2.4. Alternative C: Mouse Eradication with Bait Station Delivery as Primary Technique

2.4.1. Rationale for Bait Stations

Using bait stations as the primary bait application method would reduce the risk that birds or other non-target species would be exposed to the rodenticide, and reduce the total amount of rodenticide introduced to the environment. Using bait stations would also reduce the extent of helicopter operations over the South Farallones. Bait station delivery was historically the first method of island rodent eradication, and it remains common today (Howald et al. 2007; Bell 2002; Burbridge and Morris 2002; Hayes et al. 2004; Clout and Russell 2006).

It would not be technically feasible to have a high likelihood of eradicating mice using bait stations exclusively. Therefore, under this alternative, inaccessible areas such as cliffs and unstable slopes would be treated by hand and aerial bait broadcast. The rationale for using bait stations primarily – reducing overall non-target risk and the total amount of rodenticide used – would only be valid if bait stations are installed over the majority of the islands' land area, which would represent a major increase in human activity over large areas of habitat that is currently left undisturbed during the seabird breeding season, from spring through fall.

2.4.2. Summary of Bait Delivery Methods

Enclosed bait stations would be installed in a grid pattern across the majority of the land area on the South Farallones. In areas that cannot be included in the bait station grid, such as cliffs, unstable slopes, and critically sensitive habitat, bait pellets containing rodenticide would be spread by hand or by helicopter. In all areas where bait stations can be safely installed and major impacts to terrestrial habitat (such as seabird disturbance) can be avoided or minimized, bait stations would always be the chosen technique under this alternative. Bait stations would also be installed within and near residences and outbuildings.

2.4.3. Timing

Initial bait station installation would begin in the fall after the peak seabird fledging season. Bait stations would be armed immediately. Areas that are not included in bait station coverage would be baited by hand and helicopter, in the late fall or early winter according to the timing specifications described in Alternative B (the preferred alternative), Section 2.3.3. This sequence of operations would be particularly important in Alternative C: Because bait would only be available in broadcast-treated areas for a limited period of time, it would be important that mice have already been eliminated from adjacent bait station-treated areas before broadcast treatment to eliminate the possibility that mice could migrate into broadcast areas after all the bait had already disappeared.

2.4.4. Equipment and Materials

Bait stations are box-like enclosures with small entryways designed to be attractive to rodents but difficult to navigate for other species such as birds. Bait stations reduce the risk of rodenticide exposure in non-target species by making bait more difficult to access and reducing the total amount of bait introduced into the ecosystem. The bait station design for the Farallones would need to include the following characteristics:

- An entryway small enough to make entry by landbirds or cavity-nesting seabirds difficult, but large enough to allow for easy passage by mice
- An interior bait placement scheme that makes it very difficult for gulls or other curious larger birds to access the bait inside, but provides minimal difficulty for mice. This can be accomplished by placing the bait behind a baffle near the entryway that would block a gull's bill or foot.
- A "lockable" access panel that resists tampering by gulls but is easy to open by project personnel for station re-filling and maintenance.

A number of commercially-available bait stations fit these criteria and would be assessed for the best choice prior to implementation. Alternatively, bait stations could be fabricated specifically for this project.

Figure 2.4. Example of a bait station. Note: The design of bait stations used for this project may differ considerably from this picture.

Since bait stations would need to be accessed frequently during bait dispersal, sufficient access would have to be ensured for each bait station. In some cases, access would not pose substantial difficulties, but depending on the local placement of each station, a number of landscape modifications and/or installations may be necessary. Examples of these modifications could include:

- Paths and clearings cut in vegetation;
- Installation of boardwalks to avoid trampling seabird burrows or other sensitive resources;
- Anchor points, ladders, and fixed lines to allow for safe access to bait stations placed on steep and/or unstable terrain.
- Some bait stations may also require modification (i.e. additional covering) to prevent rain or moisture from entering the box and damaging the bait.

Some access pathways may need to cross especially sensitive habitat such as areas with seabird nest burrows and rocky talus slopes that harbor seabird nest crevice habitat. Whenever possible, access paths would be routed around sensitive biological habitat, or temporary platforms, walkways, or other temporary infrastructure would be installed to avoid trampling.

Each bait station would be secured to the ground with anchors placed into the soil or drilled into the rock as appropriate. The infrastructure required for the bait station grid would be durable enough to withstand the corrosive marine environment of the Farallones for up to two years, but it would be removable and not a permanent fixture on the islands.

Any areas in which bait station installation and maintenance would be extremely difficult (e.g. cliff areas) would be treated with a hand or aerial bait broadcast to ensure that all rodents on the island have access to the bait. The helicopter and hopper that would be used are the same as described in Alternative B, Section 2.3.4 above.

The bait that would be used in bait stations is the same as described in Alternative B, Section 2.3.4 above.

2.4.5. Bait Delivery Operations

Bait stations would be placed on a grid that covers the entire island, except for inaccessibly steep cliffs. To maximize the probability of delivering bait to each and every mouse, station spacing should be 33 ft (10 m) or 66 ft (20 m) apart. The total land area of the South Farallones is 120 acres (49 ha), but at least 25 percent of that land area is not accessible by foot. Assuming, then, that a bait station grid would cover 90 acres (36 ha), a 33 ft (10 m) spacing would require a ballpark estimate of 3,600 individual stations, and a 66 ft (20 m) spacing would require an estimated 900 stations.

The design and location of the bait station grids would be adaptive. The grid pattern would need to be carefully designed and installed taking the complex topography of the island into account – cliffs and highly unstable slopes would be identified during on-site surveys, mapped, and excluded from bait station grids. For all areas in which bait stations could be safely installed, the Service would choose bait stations over broadcasting bait, with two exceptions:

1. When the Service determines that bait stations in specific sites would likely cause major negative impacts to sensitive species such as seabirds and pinnipeds, bait may be broadcast instead, either by hand or by helicopter. When designing the bait station grid, however, the Service would need to prioritize the relative ecological importance of avoiding disturbance to seabirds nesting in different sections of the island, with the recognition that in order to cover greater than 50% of the island, a large number of seabirds would likely need to be disturbed.
2. In Designated Wilderness, the Service would choose hand or aerial broadcast before bait station installation in wilderness areas where bait station installation would require greater-than-normal habitat modification such as extra anchors or breaking rocks.

Each bait station would be armed with bait pellets as soon as possible once the program is initiated. Each station would be visited daily or on alternate days, checked, and bait replenished as necessary until activity ceases (activity includes bait chewed or taken by mice). Project crew would collect data (number of pellets taken, chewed, added, or replaced) from each station and enter it into a database for analysis. Bait application rates would be adjusted, if necessary, in response to these data to ensure that bait is always available to mice throughout the bait station grid. Bait stations would be loaded with bait immediately after installation and checked and re-armed frequently. When activity (bait removal or consumption) ceases, bait stations would be checked and re-armed bi-weekly then monthly for another full mouse breeding cycle, documenting bait take and mouse sign in stations.

Any areas of the South Farallones that cannot be treated within the bait station grid would be treated by bait broadcast. Whenever feasible, hand broadcast would be conducted by foot or by boat, but some inaccessible or critically sensitive areas would require the use of a helicopter. Helicopter broadcast methods and considerations in Alternative C would be to the same as those described in Alternative B (the preferred alternative), Section 2.3. The borders of broadcast and bait station treatment areas would need to overlap to ensure adequate bait delivery in the transition zone between treatment areas. As described above in Section 2.4.3, the sequence of implementation would be important. In addition to the seasonal timing requirements of aerial broadcast described in Section 2.3.3, bait broadcast operations would be further constrained: Broadcasting would not start until the Service no longer detects mice in the bait station grids, likely at least four weeks after stations are first armed and possibly as long as three months after arming.

Bait stations would also be installed in and immediately surrounding all of the buildings and enclosed structures on the island.

All personnel that handle bait or monitor bait application in the field would meet or exceed all requirements for personal protective equipment (PPE) required by the EPA. All bait application activities (aerial broadcast, hand broadcast, and bait station filling) would be conducted by or under the supervision of pesticide applicators licensed by the State of California.

2.4.6. Project Support Operations

Helicopters would also be used to transport equipment and supplies, including the bait and bait stations to be installed, to the island for the purpose of this action. These additional helicopter operations would be localized to discrete flight paths that would be determined so as to minimize disturbance to native wildlife. Helicopters may hover for brief periods over land to drop off personnel and equipment.

Helicopters may be staged from the island or from a boat offshore of the island. Helicopters would only land at designated staging areas, where staff would re-fill the bait hopper, re-fuel, and conduct other necessary maintenance. These staging areas would be adequately stocked with fuel and other supplies and equipment to support the helicopters for the entire bait application process.

The personnel required for bait station maintenance would join the PRBO researchers that live on-island year-round, using the residential facilities and infrastructure already in place as well as limited additional storage and staging space on already-modified land.

2.4.7. Additional Mitigation Requirements

The Service would first aim to avoid negative impacts to pinnipeds by timing activities to occur outside of sensitive breeding and molting seasons. However, under Alternative C the maintenance of bait stations would need to continue over at least one year, which would overlap with the breeding seasons of all pinnipeds on the islands. In order to minimize disturbance to pinnipeds, the bait station grids would be designed to be out of sight of large concentrations of pinnipeds. In particular, the bait station grid would avoid known breeding sites for the Threatened Steller sea lion (*Eumetopias jubatus*) to reduce disturbance.

Although supplemental bait broadcast under Alternative C would occur outside of any pinniped breeding activities, there are still many pinnipeds present during the late fall to early winter time period identified. The Service would follow the mitigation requirements described in Section 2.3.7 to reduce the risk of harmful disturbance to these pinnipeds.

If preliminary trials (described in Section 2.5.4) indicate that non-target exposure to bait is substantially higher than expected, the Service may consider additional mitigation actions. If these mitigation actions would require major changes in the operations described in this Chapter, the Service would prepare supplemental NEPA analysis to reflect these changes. Mitigation actions could include:

- Systematic removal of mouse carcasses, and carcasses of any other animals suspected of succumbing to the toxin, to reduce the likelihood of secondary exposure in scavengers;
- Attempting to capture and hold landbirds that would be likely to feed on bait pellets during aerial broadcast operations until the Service determines the birds would no longer be at risk of exposure to toxin; and/or
- Attempting to capture and relocating burrowing owls to the mainland, as the Service has done in the past, to reduce the risk of toxin exposure.

Some or all of these mitigation actions may not be employed if Alternative C is implemented, depending on the results of further operational planning and other factors.

2.5. Features Common to Alternatives B and C (Action Alternatives)

2.5.1. Use of Techniques with High Likelihood of Successful Eradication

The overarching technical goal in a successful rodent eradication is to ensure the delivery of a lethal dose of toxicant to every rodent on the island. The objective of eradication is unique within the field of pest management because 100% of the target population must be made vulnerable. Eradication is a more complex objective than the much more common goal of “control,” in which managers aim primarily to reduce a target population to acceptably low numbers. The Service considered mouse “control” rather than eradication but dismissed it from detailed consideration (see Section 2.7.7).

The high cost and high complexity of non-native mouse eradication from the South Farallones make success especially critical. The established record of successes (as well as failures) in the nearly 30 previous island mouse eradication attempts across the globe indicates that, if implemented carefully and correctly, both action alternatives would have a high likelihood of successfully eradicating mice (Howald et al. 2007; Witmer and Jojola 2006).

2.5.2. Use of the Rodenticide Brodifacoum

Brodifacoum is a coumarin-based anticoagulant. It is a vertebrate toxicant that acts by interfering with the blood’s ability to form clots, causing sites of even minor tissue damage to bleed continuously. Brodifacoum is the most commonly-used rodenticide in the United States (Erickson and Urban 2004). However, its use was recently restricted to professional pest control operations (72 FR 10 pp. 1992-3, 2007). Brodifacoum is also the most extensively utilized and best-understood rodenticide for rodent eradication from islands – out of the 332 known island rodent eradication efforts worldwide reported as successful, 71 percent of them used brodifacoum (Howald et al. 2007).

In order for the toxin to have physical effects, brodifacoum levels in the liver must reach a toxic threshold; this level can vary widely between species and even between individuals. The relative threshold level for mice to experience toxic effects from brodifacoum exposure is very low, but for other vertebrate species the threshold level is much higher. In other words, some vertebrates can consume large amounts of brodifacoum before experiencing physical symptoms of toxicity.

2.5.3. Bait Design Requirements

The same bait would be used in both action alternatives, and it would be subject to a number of limitations. The grain base of the bait pellets would be attractive as a food item only to granivorous and opportunistic omnivorous animals. Insectivores such as some landbirds, most shorebirds, and arboreal salamanders, would not intentionally consume pellets as food. Neither would the large majority of seabird species that use the Farallones, nor would marine mammals. Pellets may be attractive to highly curious birds such as gulls, but this would occur regardless of the inert "matrix" of the bait. Additionally, pellets would be dyed green, which has been shown to make pellets less attractive to some birds, including western gulls (Pank 1976; Tershy et al. 1992; Tershy and Breese 1994; H. Gellerman unpubl. data).

2.5.4. Preliminary Bait Trials

Prior to project implementation, the Service would conduct trials on the South Farallones as part of detailed operational planning, including:

1. Determination of the precise bait application rate for aerial broadcast required to maximize the probability of project success while minimizing the probability of non-target bait exposure (as described in Section 2.3.5); and
2. Site-specific examination of the potential for non-target exposure to bait, especially in gulls but also in other taxa. If these bait trials indicate that non-target exposure could be substantially higher than estimated in this EA, the Service would either a) design mitigation actions to reduce non-target exposure; or b) determine that the predicted level of non-target exposure is within acceptable limits. The Service would conduct supplemental NEPA analysis to address these new findings if appropriate.

2.5.5. Treatment of Buildings

The buildings on the Southeast Farallon Island, especially residences, provide high-quality habitat for mice. Ensuring that mice are removed completely from all buildings would be critical to the success of the proposed action. The Service and PRBO have already begun taking measures to eliminate sources of food for mice in and around residences by sealing off the island's compost system and modifying the treatment of food waste. Prior to the initiation of whole-island eradication, the Service and PRBO would take further steps to "mouse-proof" residences and other island buildings by sealing possible entryways for mice, setting traps in and around buildings, and eliminating mouse access to any food or food scraps. Throughout the course of the operation, personnel on-island would be required to adhere to strict protocols to reduce the availability of food for mice within residences. During the operation, a high concentration of bait stations would be installed and maintained inside and outside all structures on the island.

During detailed operational planning, structures would be examined carefully in order to determine if mice can likely be eradicated from buildings using bait alone. If a pest control specialist determines that bait alone may not be sufficient to ensure complete removal of mice from structures, it may be necessary to use a fumigant in one or more buildings. If the Service determines that a fumigant would be necessary to ensure success, supplemental NEPA analysis would be conducted based on the building-treatment protocol required.

2.5.6. Timing Considerations

The seasonal timing for the action alternatives would be a critical factor for both the likelihood of successful mouse eradication and the risk of negative impacts to the biological resources of the South Farallones. The likelihood of success is influenced by three seasonally-dependent factors: 1) the local population biology of mice; 2) the availability of alternative food sources for mice; and 3) local weather conditions and seasonal patterns that would affect the feasibility of conducting operations. The risk of negative impacts to biological resources depends on the seasonal local population biology, breeding and migratory patterns of animals other than mice that may be vulnerable to rodenticide exposure or to disturbance caused by the application process.

2.5.6.1. Biology of mice

Mouse eradication from an island is more likely to be successful if intensive baiting takes place when the mouse population is declining in response to annual resource declines. At this time, mice are typically more food stressed and therefore more likely to eat the bait presented. The probability of success is also increased if bait application takes place when mice are not breeding. During breeding seasons, there is a possibility that weanling mice could still be too young to leave the nest at the time of bait application. These weanling mice could be mature enough to emerge from the nest only after all the bait nearby has been consumed, and could therefore re-populate the island.

While mice in reproductive condition have been trapped on the South Farallones year-round, indicating that breeding may never completely cease, mouse trapping rates decline dramatically between December and April, indicating that the number of mice on the island also declines (Irwin 2006). From the perspective of mouse population ecology, therefore, the ideal time period for mouse eradication would be between the months of December and April.

2.5.6.2. Seasonal sensitivity of native wildlife

Effects of the operational activities associated with mouse eradication (e.g., helicopter operations, bait station installation and maintenance) on the native wildlife of the South Farallones, in particular birds and marine mammals, would be reduced by avoiding seasons in which large wildlife populations are present, such as breeding and migration. Bait station maintenance would be required year-round, which would lead to wildlife disturbance in many cases, but the initial installation of bait stations would be timed to avoid peak wildlife activity. Bait broadcast operations would occur during a season with minimal wildlife activity.

Specific timing considerations for birds include the following:

- Seabirds generally breed on the South Farallones between mid-March and October. The relative abundance of many of the seabird species on the South Farallones declines after the breeding season, which reduces the number of seabirds that could be exposed to rodenticide could be exposed to rodenticide – particularly for gulls – or disturbed by aerial application procedures.

- Migrant seabirds, landbirds, and shorebirds stop frequently on the South Farallones during spring and fall. Between November and February, however, only a small number of overwintering and visiting birds are present on the island – a daily average of around 30 landbirds and around 60 shorebirds between mid-November and mid-December (PRBO unpubl. data).

Specific timing considerations for marine mammals include the following:

- The main pinniped breeding season on the South Farallones occurs between March and September. This encompasses the breeding seasons for California sea lions (*Zalophus californianus*), harbor seals (*Phoca vitulina richardsii*), northern fur seals (*Callorhinus ursinus*), and Steller sea lions.
- Northern elephant seal pups are born on the South Farallones between late December and March. Pups are weaned at about four weeks old, and pups remain onshore in groups for up to 12 weeks, before departing for the sea. All pups should have dispersed from the island by the end of June (LeBoeuf and Laws 1994).
- Both harbor seals and northern elephant seals undergo an annual molt using the South Farallon Islands as a haulout site. Molt occurs at the end of the breeding season for harbor seals, from July to mid-September (Daniel et al. 2003). Northern elephant seals molt according to a rough schedule stratified by gender and age class. Juveniles and females molt starting in March, followed by sub-adult and then adult males, which molt through July (LeBoeuf and Laws 1994). During molt, pinnipeds undergo a short period of rapid hair loss during which time they may be reluctant to enter the water.

Disturbances to pinnipeds during critical activities such as breeding and molting can be particularly harmful. Conducting major operations such as aerial bait broadcast or bait station installation outside of these sensitive periods would substantially reduce the potential for harm to pinnipeds on the South Farallones.

From the perspective of minimizing risks to native wildlife, therefore, the acceptable time period for major eradication operations would be between October, when the seabird breeding season has largely concluded, and the end of December, before the first northern elephant seal pups are born. The ideal time, particularly for aerial broadcast, would be from mid-November to mid-December.

2.5.6.3. Weather considerations

While the climate of the Farallones does not fluctuate dramatically by season, the months of November through March are noticeably more unsettled and stormy (Null 1995; PRBO unpubl. data). Weather conditions must be fairly calm to effectively broadcast bait by helicopter, with average wind speeds lower than 30 knots (35 mph). It is important to the success of the eradication that areas that are treated with a bait broadcast be treated within a time frame as short as possible, rather than in partial-island stages separated by multiple days or weeks. This consideration prevents the potential reinvasion of mice back into areas previously treated with bait. Furthermore, the bait used would not withstand substantial rainfall, so it would be important that the bait application is implemented on a day with no precipitation in the near-term forecast. The likelihood of getting a long enough period of calm weather to complete a full bait application is more uncertain during the late fall and winter than during other seasons. However, the biological considerations of both native species and mice indicate that the late fall is the only reasonable time to conduct a bait application. While the late fall is not ideal from the perspective of helicopter operations and bait integrity, it is nevertheless likely that there would be ample opportunity to conduct two complete aerial broadcasts during the time period of November through December.

2.5.7. Preventing Bait Spread into the Marine Environment

Every reasonable effort would be made to minimize the risk of bait being broadcast into the marine ecosystem. The broadcast deflector would be attached to the hopper for all treatment passes of coastal bluffs and cliffs. The deflector would broadcast bait within approximately 120° of the onshore side of the helicopter, to minimize the risk of bait entering the ocean on the opposite, or seaward, side. Additionally, the hopper may be used with the broadcast motor off to trickle bait in precise points directly underneath, along the coastal perimeter of the island.

2.5.8. Reducing Wildlife Disturbance

Before eradication operations begin, personnel would be briefed on strategies and techniques for avoiding wildlife disturbance whenever possible and these techniques would be implemented during actual eradication operations. Requirements would include:

- Crouching or crawling when necessary to remain out of view of nearby animals, especially during the breeding season
- Moving slowly and deliberately to avoid frightening animals
- Traveling carefully by foot and avoiding sensitive areas when possible to reduce potential disturbance to seabird nest sites
- All staff would be given a map detailing areas with sensitive wildlife.

2.5.9. Protecting Cultural Resources

Project personnel would exercise caution in general in order not to disturb the cultural or historical resources that have been identified on the South Farallones. Additionally, planning for the final layout of the bait station grid would be conducted in consultation with the State Historical Preservation Officer so as to avoid inadvertently damaging buried resources during bait station installation. Personnel would be briefed on the known locations and identification of archaeological and historical resources that may be present on the islands. All known sites of significance would be clearly marked with weather-resistant marking materials that are recognizable to all field personnel. Field personnel would be prohibited from disturbing any sites of historical or cultural importance.

2.5.10. Minimizing Impacts to Wilderness

To address the special management regulations for the wilderness area on the South Farallones, the Service would:

1. Avoid touching down in a helicopter anywhere other than Southeast Farallon Island except in an emergency.
2. Minimize travel to West End to activities necessary for the eradication such as bait station installation and maintenance, non-target mitigation actions such as monitoring pinniped responses to helicopter operations, and efficacy monitoring such as setting traps.
3. Choose aerial broadcast before bait station installation in wilderness areas where bait station installation would require greater-than-normal habitat modification such as extra anchors or breaking rocks.

2.5.11. Monitoring Eradication Efficacy and Ecosystem Response

During and after bait application activities, the mouse population on the South Farallones would be monitored to assess effectiveness of eradication efforts. Examples of monitoring activities would include:

- During the eradication operations, radio transmitters attached to individual mice, which would allow project personnel to track mouse activity and confirm 100 percent mortality within a sample of mice on the island; and
- During and after eradication, rodent detection devices such as traps, chew indicators, and special tracking surfaces to capture mouse tracks and bite marks.

In addition, the Service and its contractors would monitor the response of pinnipeds to all activities, including helicopter operations, bait station installation and maintenance, and other project tasks to ensure compliance with the Marine Mammal Protection Act (MMPA) and the ESA. This observational monitoring is discussed in detail in Appendix J.

Biological monitoring on the South Farallon Islands, conducted primarily by PRBO Conservation Science in cooperation with the Service, has been an integral part of the management of the islands for over 40 years. The Refuge's current monitoring activities fall outside the scope of this specific action, and would continue independent of the results of mouse eradication, so their environmental impacts are not analyzed here. The ongoing monitoring programs would provide valuable information on the ecosystem's response after mouse eradication, using baseline data from before the mouse eradication for comparison in order to detect any positive or negative changes.

The additional monitoring activities that would be necessary to determine the success of the eradication would largely be incorporated into ongoing monitoring activities for other aspects of the ecosystem, without adding more than a negligible amount of additional environmental disturbance. The current ongoing monitoring activities fall outside the scope of analysis of this document, and thus post-eradication monitoring activities will not be analyzed in detail here.

2.5.12. Public Information

All of the Farallon Islands are off-limits to the general public, but the waters surrounding the islands are productive fishing grounds and provide recreational opportunities for the nearby San Francisco Bay Area. Informational posters describing the eradication actions taking place on the South Farallones would be distributed to tour boats that visit the islands as appropriate to ensure public safety and as an opportunity for interpretation, and posted at nearby ports from which ships might embark for the vicinity of the islands. Researchers with an interest in the South Farallones would also be directly informed about eradication activities and timing.

For the purpose of educating approved island users such as research biologists and technicians, contractors, and volunteers, signs would be posted in the island's researcher housing and at all reasonable access points to the island stating that brodifacoum is present on the island, describing its appearance, and its intended purpose. These signs would remain visible until bait pellets are no longer found, estimated at no more than three months after bait application has been completed but subject to actual uptake rates and weather conditions.

2.5.13. Rodent Introduction Prevention and Response to Rodent Detection

The benefits of a successful eradication could be lost with the introduction of even one pregnant female rodent. Rodents can be accidentally transported to islands and escape from:

- Cargo such as food boxes, personal gear, and construction or other bulk materials
- Watercraft moored directly to the island or anchored nearby
- Debris washed ashore from the mainland
- Sinking or disabled vessels
- Aircraft

2.5.13.1. Prevention

The Service currently obligates personnel, partners, and contractors traveling to the island to abide by a rodent and invasive plant exclusionary plan, but the requirements of this plan are not always enforced. These requirements include the following measures:

- Insuring through physical inspection that all materials and equipment transported to the island are free of seeds, plant materials, or rodents
- Managing any mainland staging/storage areas so as not to attract rodents
- Using only new materials for construction projects
- Transporting materials in rodent proof containers
- The implementation of these measures would be thoroughly reviewed and enforced beginning before mouse eradication is complete. Full compliance among all island visitors would be necessary.

In addition, a combination of rodent traps and poison bait stations would be maintained at the East and North Landing areas, the helicopter landing pad, and at any additional landing areas that may be utilized in the future.

2.5.13.2. Response

After the Service has determined that the eradication operation has concluded, personnel remaining on the island would continue to monitor the island for new rodent introductions or the possibility that some mice remained after eradication operations. In the event that rodents are detected after eradication operations have ended, a rodent response plan would be implemented immediately. The response plan would include, at minimum, the installation of bait stations in an area immediately surrounding the site of a rodent sighting. If necessary, bait would also be hand- or aerially broadcast within the seasonal constraints described in Section 2.3.3.

2.6. Comparative Summary of Actions by Alternative

Table 2.1. Comparison of important attributes of actions under each action alternative

Action attribute	Alternative B (preferred alternative)	Alternative C
Primary bait delivery method	Aerial broadcast	Bait stations
Secondary bait delivery methods	Hand broadcast; bait stations	Hand broadcast; aerial broadcast
% of land area w/ broadcast bait	~95%	25-45%
Start season	Late fall	Early fall
Duration	~1 month	Up to 2 years

2.7. Alternatives Dismissed from Detailed Analysis

2.7.1. Use of a First-Generation Anticoagulant (Diphacinone)

The rodenticide brodifacoum, which is classified as a "second-generation" anticoagulant, has been used in 71 percent of documented successful rodent eradication operations (Howald et al. 2007). However, due to the potency of brodifacoum, there is interest in the conservation community for the examination of less-toxic alternative compounds for rodent eradication purposes. Diphacinone, a "first-generation" anticoagulant, is the most commonly considered alternative compound because it has been used for localized rodent control for conservation purposes (e.g. Nelson et al. 2002; VanderWerf 2001). However, diphacinone has been used only rarely on islands to eradicate rats (e.g. Wingate 1985; Donlan et al. 2003; Witmer et al. 2007). Land managers in Hawai`i recently completed two aerial broadcasts of diphacinone to eradicate rats from small offshore islands; it is still too early to confirm the success of these operations. All other diphacinone-based island rodent eradications have been conducted with bait stations. Diphacinone has never been successfully used to eradicate mice (see review in Howald et al. 2007).

The toxicity of diphacinone to mice is unclear; rats are considered to be fairly sensitive to diphacinone but experiments have shown a wide range of sensitivity for house mice, from relatively low to very high (Erickson and Urban 2004). In addition, due to the weaker physiological binding properties of diphacinone, rodents have to feed on diphacinone bait in a very large quantity and/or multiple times over a period of several days in order to achieve mortality. By comparison, both rats and mice are very susceptible to brodifacoum, which can result in high mortality rates after only a single dose. While there are differences in toxicity among taxa, relative potency is better illustrated by comparing the amount of rodenticide bait that must be eaten in order to reach a roughly 50 percent probability of mortality, known as an LD50 dose. According to scientific evidence, house mice would need to eat at least 60 percent of their body weight for up to five days in order to achieve an LD50 dose of 50 ppm diphacinone. In comparison, house mice would need to eat only between one percent and 2.6 percent of their bodyweight in a single dose to achieve the same level of mortality with 20 ppm brodifacoum (Fisher 2005).

In experimental trials with wild-caught house mice, diphacinone pellets did not kill any of the mice after three days of exposure in a captive laboratory situation (Witmer 2007). After seven days of exposure, diphacinone pellets still only killed 40 percent of the treatment mice. By comparison, brodifacoum pellets resulted in 80 percent and 100 percent efficacy (two different brodifacoum baits were tested) after three days of exposure.

Because of 1) the low toxic threshold of diphacinone to mice, 2) the large amount of bait that mice would need to eat to achieve that threshold, and 3) the typically sporadic feeding habits of mice (Rowe 1973), which would reduce the probability that mice would feed consistently on the bait, the risk of failure of an eradication operation using diphacinone is very high. For this reason, use of diphacinone as an alternative bait has been dismissed in this evaluation.

2.7.2. Use of Other Toxins

The use of other rodenticides registered with the EPA was dismissed from further consideration, for one or more of the following reasons: 1) lack of proven effectiveness in island mouse eradications; 2) potential for development of bait shyness in the mouse population; and 3) the lack of an effective antidote in case of human exposure. Each of these issues and the associated rodenticides are discussed below.

The vast majority of documented island-wide rodent eradication programs (226) have used brodifacoum or similar “second-generation” anticoagulants, while only 29 have used “first-generation” anticoagulants such as diphacinone (Howald et al. 2007). Nine additional eradications have used non-anticoagulant toxins including zinc phosphide, strychnine, and cholecalciferol. Acute rodenticides, such as zinc phosphide and strychnine, have the ability to kill mice quickly after a single feeding. However, because poisoning symptoms appear rapidly, the acute rodenticides can induce future bait avoidance if animals consume a sub-lethal dose. Studies with zinc phosphide have demonstrated that rodents associate toxic symptoms with bait they had consumed earlier if the onset of symptoms occurs as long as six to seven hours after consumption (see Lund 1988). Thus, any individual that consumes a sub-lethal dose is likely to avoid the bait in the future (Record and Marsh 1988). Also, acute rodenticides are often extremely toxic to humans and there are not always effective antidotes. The combination of these factors disqualifies the acute rodenticides from detailed consideration.

Cholecalciferol, which is classified as a "subacute" rodenticide, has the ability to kill mice more quickly than the anticoagulant rodenticides, but most often more slowly than the acute rodenticides. Cholecalciferol has a lower level of toxicity to birds. It has been used successfully to eradicate rodents (rats) from very small islands (Donlan et al. 2003). While these characteristics show potential as a candidate toxin for eradications, the effectiveness of cholecalciferol in eradicating mice has not been tested. Furthermore, in experimental trials with wild-caught house mice, oral cholecalciferol killed only 20 percent of treatment mice after three days of exposure in a captive laboratory situation (Witmer 2007). After seven days of exposure, cholecalciferol was still only 20 percent lethal. Cholecalciferol's dubious efficacy for mice disqualifies it from detailed consideration.

2.7.3. Use of Disease

While there is ongoing research focused on the development of taxon-specific diseases that can control populations of non-native species (such as by the Australian agency CSIRO, www.cse.csiro.au/research/rodents/publications.htm), there are no pathogens with proven efficacy at eradicating rodents (Howald et al. 2007). Even a highly lethal mouse-specific pathogen would be ineffective at eradicating mice from the South Farallones, because if the mouse population rapidly declined, the introduced disease would likely disappear before being able to affect the few remaining individuals. Furthermore, the introduction of novel diseases into the environment carries tremendous potential risks to non-target species.

2.7.4. Trapping

This alternative would call for the use of live traps and/or lethal ("snap") traps to eradicate mice. This action is highly unlikely to succeed on the South Farallones. The use of live traps and/or lethal traps to remove mice from an area is a strong selection agent in favor of mice that are "trap-shy". Thus, after extensive trapping the only mice that would remain would be those that are behaviorally less likely to enter a trap, and these mice will be very difficult to remove without the introduction of alternate methods such as toxins. Furthermore, the widespread use of traps is not feasible because of the extensive effort and considerable personnel risk required to set and monitor traps. Therefore, this alternative would not be feasible to implement.

2.7.5. Biological Control

The introduction of predators on mice, such as snakes and cats, was dismissed because biological control most often only reduces, rather than fully eliminates the target species and thus fails to achieve the desired ecological benefit gained through complete mouse removal. There is no known effective biological control agent for mice on islands, and some forms of biological control would result in unreasonable damage to the environment. The introduction of cats to islands in order to control introduced rodents has been attempted numerous times since European explorers began crossing the Atlantic and Pacific Oceans. The introduction of a rodent predator, such as cats, generally results in a greater combined impact on birds than if one or the other were present alone. When seabirds are present, cats have been shown to prey heavily on seabirds (Atkinson 1985), consuming fewer rodents during these times. When seabirds migrate off of the islands following the breeding season, cats switch prey to rodents, which allows the island cat population to remain stable at a higher level than if no rodents were present on the island (Atkinson 1985; Courchamp et al. 1999, 2000). Thus, birds are impacted not only by rodents but the larger number of cats that are sustained by rodent presence on the island. Introduction of another species onto an island can have severe and permanent consequences to the ecosystem (see Quammen 1996). Therefore, this alternative was eliminated from further consideration.

2.7.6. Fertility Control

Fertility control has been used with limited success as a method of pest management in a few species. Experimental sterilization methods have included chemicals and proteins delivered by vaccine, and genetically-modified viral pathogens. However, the effectiveness of these experimental techniques in the wild, as well as their impacts to non-target animals, are unknown. Aerial application of rodenticide is a more practical, effective, and safer method to eradicate mice than repeated baiting of oral contraceptives on a remote island across seasons or capturing, vaccinating, and releasing every member of one gender of the South Farallones' mouse population. This lack of data and tools disqualifies the use of fertility control from detailed consideration (see Tobin and Fall 2005).

2.7.7. Mouse Removal with the Goal of "Control"

The net conservation gain achieved by mouse control (i.e. reducing and maintaining mouse populations at extremely low levels), rather than complete eradication, is comparatively small, yet the risks to non-target wildlife are nearly the same through the impacts of mice as well as through the impacts of the control operations. Mice can reproduce rapidly and re-colonize areas from which they were previously eliminated. The constant maintenance of an ecologically beneficial mouse control program (i.e. control of mouse populations to levels low enough island-wide to eliminate them as a reliable food source for migrating burrowing owls) is far less cost-effective and does not result in the permanent conservation benefits of entire-island eradication, and was therefore eliminated from consideration.

Chapter 3: Affected Environment

3.1. Introduction

The Farallon National Wildlife Refuge was established in 1909, and expanded to its current size in 1969. It includes all of the islands in the Farallon group. Within the Refuge, all of the emergent land except the island of Southeast Farallon is also Designated Wilderness under the Wilderness Act of 1964. The Service has cooperative agreements with PRBO Conservation Science and the U.S. Coast Guard to facilitate protection and management of the Refuge.

The waters around the Farallones below the mean high tide line are part of the Gulf of the Farallones National Marine Sanctuary. This Sanctuary is one of three contiguous Marine Sanctuaries, with Cordell Bank National Marine Sanctuary to the north and Monterey Bay National Marine Sanctuary to the south, which together convey special protected status to the biological resources of almost 7,000 square miles of ocean from Cambria to Bodega Bay and out to sea well past the continental shelf.

The Farallones' isolated nature, varied and extensive habitats, and adjacent productive marine environment makes them an ideal breeding and resting location for wildlife, especially seabirds and marine mammals. The Refuge comprises the largest continental U.S. seabird breeding colony south of Alaska, and supports the world's largest breeding colonies of ashy storm-petrel, Brandt's cormorant (*Phalacrocorax penicillatus*), and western gull.

The Farallones have also had extensive human activity beginning in the early 1800s when marine mammals were harvested for fur and food, as an egg gathering venture in the mid to late 1800s, a military outpost during two world wars, and until the early 1970s as a manned U.S. Coast Guard light station. Wildlife populations were heavily exploited from the late 18th to late 19th centuries for meat, hides, and eggs. Over-fishing of Pacific sardines (*Sardinops sagax*) in the mid-20th century may have reduced seabird and marine mammal food supplies. Some species were extirpated or declined drastically. The active U.S. Coast Guard station further impacted island wildlife and habitat until the full automation of the light station in 1972. Under USFWS stewardship, some extirpated species have re-colonized the islands, and wildlife populations as a whole are slowly recovering. Still, certain Refuge species are still at reduced population levels or even declining, and wildlife remains vulnerable to the impacts of introduced animals and plants, oil spills, other pollution, fisheries interactions, and global climate change.

3.2. General Description of the South Farallon Islands

3.2.1. Geographical Setting

The South Farallon Islands are situated just inshore of the continental shelf edge, 28 miles west of the Golden Gate and the city of San Francisco, California, at 37°42'N latitude and 123°00'W longitude. The South Farallones are made up of two main islands that are separated by a narrow channel: Southeast Farallon Island and West End (or "Maintop Island"). Several offshore islets immediately surround the main islands, including Saddle (or "Seal") Rock, Sugarloaf, Arch Rock, Aulon Islet, Sea Lion Rock and Chocolate Chip.

The Farallon Island group and the Farallon National Wildlife Refuge also includes a number of islets that extend to the northwest, including the North Farallon Islands, Middle Farallon, and Noonday Rock, which becomes completely submerged at times. These islets to the northwest are isolated, relatively small, barren, extremely difficult to access, and are not known to harbor house mice or any other non-native mammals. Thus, they would not be included in the mouse eradication actions described and analyzed in this document.

3.2.2. Size and Topography

The South Farallones have a planar land area of approximately 120 acres (49 ha). The highest peak, at the top of Lighthouse Hill, is 370 ft (113 m) above sea level. The topography is generally rocky and uneven, with comparatively flat terraces at the lower elevations of Southeast Farallon. The coastline is generally steep, rocky, wave-washed, and difficult to access. The south side of Southeast Farallon has an extensive marine terrace that terminates in an extensive intertidal zone. West End is dominated by the steep-sided, dome-shaped peak called Maintop, and several other smaller peaks and ridges. An extensive north-south valley, called Sand Flat, is situated on the western side. See Appendix A for a topographic map of the South Farallon Islands.

3.2.3. Climate

The climate of the Farallones is characterized by moderate temperatures, wet winters and dry summers. Average temperature is 55.2 ºF (12.9 ºC) with little seasonal variation. September is the hottest month (average temperature 59 ºF (15.0 ºC)), and January the coldest (average temperature 52.3 ºF (11.3 ºC)). The region's hottest days are typically during the fall when high pressure builds into the Pacific Northwest and Great Basin, and dry offshore winds replace the Pacific seabreeze. The three hottest days on record in the city of San Francisco occurred in September and October (Null 1995). The lowest and highest temperatures recorded for Southeast Farallon Island from 1971 through 2007 were 34 ºF (1.1 ºC) in December 1990, and 90 ºF (27.2 ºC) in September 2000.

Summertime is characterized by cool marine air and persistent coastal stratus and fog. Rainfall from May through October is relatively rare. Considerable moisture, although rarely measurable as precipitation, is due to drizzle when the marine layer deepens sufficiently. Spring and fall are transition periods. Spring and early summer are characterized by strong northwesterly winds. The occurrence of rainfall during the early spring and fall is infrequent. While most storms during these periods produce light precipitation, there are occasional heavy rainfall events. In winter, the islands experience periods of storminess and moderate to strong winds, as well as periods of stagnation with very light winds. Annual rainfall averages 20 in (with a standard deviation of 7.25 in). Winter rains (November through April) account for about 89 percent of the average annual rainfall.

Climate data summarized here are from PRBO unpublished data 1971-2007 except where noted otherwise.

3.3. Physical Resources

3.3.1. Water Resources

Since 1998 a rainwater collection, filtration, and distribution system has supplied all of the field station's water needs. Water samples are tested three to four times a year by Alameda County Water District for coliform and nitrates. Results have been below levels of concern.

Marine water quality within the surrounding Gulf of the Farallones NMS is somewhat unaffected by threats to water quality due to the distance from sources of pollutants and land-based runoff, as well as the continuous circulation of the offshore waters at many scales. However, discharges from sunken vessels and illegal discharges from oil tankers and cargo vessels have been a periodic source of negative impacts to marine organisms within the sanctuary. The threat of an offshore spill is a constant presence in areas near well-used shipping lanes. In the event of an oil spill, the impact to the open coast would mainly be determined by the wind and sea conditions, which could easily overcome protection efforts. Also, persistent organic pollutants such as DDT and PCBs were widely used nationwide before the mid-1970s, and residuals of these chemicals still remain in sediments and organisms within the Sanctuary. Elevated levels of pollutants have been reported for fish, seabirds, and marine mammals found within the Sanctuary (NOAA 2008).

The waters surrounding the South Farallones have also been designated an Area of Special Biological Significance (ASBS). California regulations prohibit any waste discharge into ASBSs. A recently-installed septic system on Southeast Farallon treats all wastewater generated by the field station, and disperses it into a leach field located a sufficient distance away from the ocean to avoid pollution of the surrounding waters and to ensure compliance with California marine water quality regulations.

Between 1946 and 1970, nearly 50,000 drums of hazardous and radioactive wastes were dumped over a 350 square nautical mile area that overlaps the boundaries of the Gulf of the Farallones NMS. However, precise locations of these drums are unknown, with only 15 percent of the potentially contaminated area mapped. The extent of contamination to the waters surrounding the islands is unknown (Karl et al. 2001).

3.3.2. Geology and Soils

The Farallones are composed primarily of granitic rock, evidence of the ancient marine terraces of which they are a part. During the last ice age, the coastline of California extended beyond the Farallones, and the islands were part of a coastal range of hills that is now almost entirely submerged. The Refuge is primarily made up of rocky surfaces with little soil coverage. However, much of the marine terrace and certain other portions of Southeast Island are covered with dark brown soil up to eight inches thick (Vennum et al. 1994). Soil examination indicates that the composition is largely made up of decomposing guano and granitic sand and lesser amounts of feather, bone fragments, vegetation, possible fish teeth and human-made detritus (Vennum et al. 1994).

3.3.3. Wilderness Character

West End Island is designated Wilderness as regulated by the Wilderness Act (PL 88-577). See Appendix B for a map illustrating the Farallon Wilderness. Under the Wilderness Act, an area's wilderness character is defined by the following qualities:

1. Untrammeled by human impacts;
2. Undeveloped, without permanent structures or habitations;
3. Influenced primarily by natural forces; and
4. "Has outstanding opportunities for solitude or a primitive and unconfined type of recreation."

The overall goal of wilderness management under the Wilderness Act is to keep lands as wild and natural as possible, including restoring the wilderness character where it has been severely damaged by human use or influence. Because one of the major components of wilderness character is that it be untrammeled by human activities, one of the most important stipulations of the Wilderness Act is that all necessary wilderness management work should be conducted with the "minimum tool" required for the job. The "minimum tool" has the least discernible impact on the land and is the least manipulative or restrictive means of achieving a management objective. Under this principle, the use of vehicles, motorized tools, and other mechanized devices is generally discouraged, but in some instances the use of mechanized tools or equipment is necessary for the managing agency to effectively administer designated wilderness areas. The Wilderness Act and other related agency-specific guidance provide a general framework for determining the minimum tool necessary to complete a restoration action in a wilderness area. See Appendix K for a detailed "Minimum Requirements Analysis" for non-native house mouse eradication on the South Farallones.

3.4. Biological Resources

3.4.1. Introduction

All of the alternatives described and analyzed in this document, including the alternative of No Action, have the potential to affect the biological resources of the South Farallones. The no action alternative would allow the direct and indirect impacts that non-native house mice currently have to the native species of the South Farallones to continue. The proposed mouse eradication would have three basic types of impacts to biological resources: impacts from the use of rodenticide, impacts from disturbance caused by the personnel activities and machinery operation necessary for bait application, and subsequent ecosystem response to the removal of mice from the ecosystem. This section will describe the status, trend, and biology of animals and plants on the Farallones as they relate to the potential for each of the alternatives to have an effect on these resources.

3.4.2. Birds on the South Farallones

Appendix C contains a full list of birds that breed on the South Farallones. Appendix D contains lists of birds that are likely to visit or reside at the South Farallones at some point during the year, categorized according to their risk profiles (detailed in Chapter 4). Appendix F illustrates common seabird roosting and nesting areas.

3.4.2.1. Breeding birds

The South Farallones are the largest seabird breeding colony in the lower 48 U.S. states. Thirteen bird species are known to breed on the islands, including 12 seabirds and one shorebird (black oystercatcher *Haematopus bachmani*). During the peak of the summer breeding season there may be more than 250,000 breeding birds present. Most habitat types on the Farallones are occupied by breeding seabirds between mid-March and mid-August, but some species continue breeding activities until December. Cormorants, common murre, and oystercatcher inhabit rocky slopes and cliffs. The marine terrace and slopes of Southeast Farallon are dense with nesting gulls, with lower densities in other areas. Even below the surface, rock crevices and burrows house nesting storm-petrels, auklets, guillemots, and puffins.

The Farallones are the breeding site for about half of the world's population of the ashy storm-petrel, which breed only along the coast of California and northern Baja California, Mexico. The Farallones also host the world's largest colonies of Brandt's cormorant and western gull, as well as one of the southernmost major colonies for rhinoceros auklet (*Cerorhinca monocerata*) and tufted puffin (*Fratercula cirrhata*) on the west coast of North America. Common murre, which nest in extremely dense colonies, are the most abundant breeding species and the Farallones likely has the largest common murre colony outside of Alaska (G. McChesney pers. comm.).

The onset of breeding activity varies considerably between seabird species. The earliest egg-laying occurs in March, with Cassin's auklet (*Ptychoramphus aleuticus*). While most eggs have been laid by early July, some ashy storm-petrel may not lay until as late as August. While the length and dynamics of each species' breeding season differ, there is a clear seasonal pattern among nearly all seabirds in which chicks have fledged by September or earlier. The only major exception to this is the ashy storm-petrel, with most fledging in September and October although some chicks may not fledge until December (Ainley 1990; Ainley and Boekelheide 1990; PRBO unpubl. data).

Some of the seabird species that nest on the Farallones are extremely sensitive to disturbance – they will frighten and take flight readily, and in the process either knock their eggs from their precarious perch or leave them exposed to be eaten by avian predators. Crevice- and burrow-nesting species are sensitive to habitat disturbance and handling. Adult storm-petrels frequently abandon nests if they are handled (Ainley and Boekelheide 1990). Disturbance becomes a comparatively smaller concern during the non-breeding season.

All of the seabirds on the South Farallones can generally be characterized as slow-reproducing. All but one species (Cassin's auklet) lay only one clutch of eggs annually, and some species lay only a single egg in each clutch. Because they cannot reproduce quickly to counteract negative impacts to their populations, seabirds are especially vulnerable to factors that reduce the survival of breeding adult birds. Small decreases in adult survival can result in population declines and hamper population recovery. As a result, factors that increase mortality in adults can seriously jeopardize seabird populations, especially if population levels are already low (USFWS 2005b).

A plethora of factors affect each of the seabird species that are present on and around the South Farallones, both at the islands and elsewhere in their ranges. The Service's 2005 Seabird Conservation Plan for the Pacific Region describes current threats, management goals and detailed information for seabirds. The most serious human-caused threats to seabirds in the region involve: 1) invasive species; 2) interactions with fisheries (both direct and indirect); 3) oil and other pollution; 4) habitat loss and degradation; 5) disturbance; and 6) global climate change. In addition, all of the species that forage in the waters surrounding the South Farallones are affected by changes in the productivity of the marine ecosystem, occurring over different spatial and temporal scales. Researchers are often able to find a correlation between years of particularly high or low marine productivity and breeding productivity in the Farallones' seabird species (e.g. Ainley and Boekelheide 1990).

3.4.2.2. Visiting birds

The productive waters surrounding the Farallones provide foraging grounds for a number of additional species such as grebes, shearwaters, scoters, phalaropes, and several species of gulls, most of which remain in the water or in flight but a few of which also use the islands for roosting. Additionally, the islands' intertidal habitat supports a number of shorebird species such as plovers and turnstones. Finally, many other species of freshwater and estuarine waterbirds have been sighted on the Farallones during migration, and some have occasionally overwintered. The community makeup of these additional waterbirds varies substantially, both seasonally and inter-annually.

There are no permanently resident landbirds on the Farallones, but the islands are well known for the number and diversity of landbirds that arrive on the islands during spring and fall migrations (DeSante 1983; Pyle and Henderson 1991). More than 400 species of landbirds have been recorded for the Farallon Islands (Richardson et al. 2003; USFWS unpubl. data). DeSante and Ainley (1980) conclude that the vast majority of these arrivals are birds that are in the process of returning to the mainland after veering off their migratory course along California's coast. During the spring and fall large numbers of migrants may be present on the island, often concentrated in and around the small trees that were planted near the residences on Southeast Farallon. While nearly all landbirds spend little time on the islands before departing, perhaps 100 or fewer remain through the winter. There are no landbird species that consistently breed on the Farallones, although there are occasional historical nesting records for a few species (mainly rock wren *Salpinctes obsoletus*; DeSante and Ainley 1980).

3.4.2.3. Seasonal patterns in the avian communities of the South Farallon Islands

The following section is adapted from DeSante and Ainley's *Avifauna of the South Farallon Islands* (1980).

The greatest density and diversity of visiting bird species occurs during fall. Shorebirds, rocky intertidal species predominating, begin arriving in July and gradually increase to maximum visitation rates in September, when the usually rare estuarine and freshwater species also occur.

Pelagic seabirds occurring offshore of the islands likewise reach maximum diversity during September although maximum numbers of sooty shearwater (*Puffinus griseus*) often occur during summer, and phalaropes are often most abundant in August. With the exception of pelicans and gulls, none of these visitant seabirds land on the islands but rather stay on or above the surrounding waters. The seabirds that breed on the South Farallones are mostly absent from the island during fall.

Landbird migrants, primarily species breeding in western North America and wintering in the tropics, begin arriving in early August and reach maximum visitation rates in September or early October, when the major arrival of landbirds wintering in coastal California occurs. The maximum diversity usually occurs from mid-September to early October. Landbird visitants decline during late October and dwindle to very low numbers by late November.

Neritic seabirds begin arriving in very late September or October and reach maximum diversity during November. With the exception of pelicans and gulls, none of these visitant seabirds land on the islands but rather stay on or above the surrounding waters. Fall resident California brown pelicans (*Pelecanus occidentalis californicus*) are present in maximum numbers in October, often roosting on the islands.

Besides the year-round resident breeding seabirds, neritic seabirds, particularly eared grebes (*Podiceps nigricollis*), surf scoters (*Melanitta perspicillata*), and large *Larus* gulls, frequent the waters around the island during winter. Rocky intertidal shorebirds also winter in low numbers, although other shorebirds, estuarine and freshwater species, and pelagic seabirds are generally very rare. Few landbirds winter on the island. These include white-crowned sparrow (*Zonotrichia leucophrys*), golden-crowned sparrow (*Zonotrichia atricapilla*), fox sparrow (*Passerella iliaca*), yellow-rumped warbler (*Dendroica coronata*), western meadowlark (*Sturnella neglecta*), and black phoebe (*Sayornis nigricans*). Most overwintering landbirds arrive during the fall migration period, primarily October and November, and depart in March and April. Researchers on Southeast Farallon record a daily average of around 30 landbirds and around 60 shorebirds between mid-November and mid-December (PRBO unpubl. data).

Early spring migrants may first appear in late February but usually arrive in March. Spring migration is generally quite sporadic and unpredictable, especially during March and April. At this time, however, the immense numbers of breeding seabirds begin their nesting activities. Nearly all waterbirds, including most pelagic and neritic seabirds and virtually all estuarine and freshwater species and shorebirds, are rare during the spring migration. Large numbers of small gulls and phalaropes, however, sometimes pass by the island.

One and occasionally two major waves of visitant landbirds usually occur in early and/or late May. Different populations are probably involved in each of these flights but most are of species that breed in western North America and winter in the tropics. Very few western landbirds visit after late May or very early June. Spring vagrant landbirds may first appear in mid-May but reach maximum diversity during the first half of June.

3.4.2.4. Special legal protection for birds on the South Farallones

The birds that reside at or visit the South Farallones are protected from harm by the Migratory Bird Treaty Act (MBTA).

Additionally, the California brown pelican, which does not breed on the Farallones but roosts on the islands in large numbers, is listed as Endangered under the ESA. See Appendix E for a map of popular brown pelican roost sites on the South Farallones. Brown pelican populations were severely reduced throughout the U.S. during the 1960s as a result of exposure to organochlorine pesticides such as DDT. Many pelican breeding colonies experienced total reproductive failure for multiple consecutive years. After DDT's use as an agricultural pesticide was banned in the U.S. in 1972, pelican populations began to recover (USFWS 2007). Although DDT and related compounds are still present in low levels in the marine ecosystem, especially in southern California where the Montrose Chemical Company discharged large amounts of DDT into the ocean during the late 1960s and early 1970s, these chemicals currently have a negligible impact to the California brown pelican (USFWS 2007). Because of substantial increases in the California pelican population, the Service recently initiated the process to remove brown pelicans, including the California subspecies, from the Endangered Species list. However, the ESA regulations will continue to apply to California brown pelicans on the South Farallones until the de-listing process is complete, which may not be until after the proposed mouse eradication is implemented.

Also, in response to a 2007 petition for listing, the Service is currently conducting a status review to determine whether the ashy storm-petrel warrants listing under the ESA. The results of this status review are not yet available. If the ashy storm-petrel's listing status changes as a result of this status review before the implementation of the project, the Service would initiate consultation according to ESA regulations if appropriate.

3.4.3. Terrestrial Wildlife of the South Farallon Islands

3.4.3.1. Seabirds and the South Farallon Islands ecosystem

Breeding seabirds are a major component in the terrestrial ecosystem of the South Farallones. Seabirds trample, burrow, and substantially alter the chemical content of the soil (through guano deposition) across most of the islands, which makes the growing environment for plants highly specialized and generally less productive than similar habitat on the mainland. While the effects of seabirds on the island soil prevent some species from thriving, they simultaneously provide ideal habitat for many other species. The island's ubiquitous maritime goldfields, a small herbaceous composite, exists only on seabird breeding colonies and roosts (Vasey 1985). In turn, western gull, Brandt's cormorant and double-crested cormorant at the South Farallones rely heavily on maritime goldfields for nesting material (Coulter 1971; Ainley and Boekelheide 1990). With increasing seabird populations, the overall use of maritime goldfields by seabirds has also likely increased (PRBO unpubl. data). Similarly, seabird burrows provide habitat for subterranean animals such as the Farallon arboreal salamander and numerous invertebrate species. Finally, the inevitable abundance of seabird carcasses that occurs on seabird colonies provides a reliable food resource for a host of decomposer invertebrates.

3.4.3.2. Salamanders

Figure 3.1. Arboreal salamander.

The arboreal salamander subspecies *A. l. farallonensis* is endemic to the South Farallones. In the most habitat-rich areas of the islands, salamander densities can reach nearly 300 animals per acre (700/ha) (Boekelheide 1975). Farallon arboreal salamanders are nocturnal insect predators. Like many salamanders, they are lungless, respiring through their skin. While they are most active when the surrounding environment is moist, they are not dependent on water for any part of their lifecycle and are more tolerant of dry conditions than other salamander species (Cohen 1952). They breed and lay eggs during the summer (Boekelheide 1975), with young appearing in the fall (Lee 2008). Salamanders are a major predator on the endemic camel cricket (*Farallonophilus cavernicola*) (Steiner 1989).

PRBO Conservation Science recently began collecting baseline data to monitor the seasonal abundance and distribution of salanders on the South Farallones and thereby measure the impacts of mouse eradication over time (Lee 2008).

3.4.3.3. Bats

There are no breeding or resident bats on the South Farallones. However, similar to birds, a number of bat species are known to visit and roost on the islands during spring and fall migrations. Most are hoary bats (*Lasiurus cinereus*) but others have included western red bat (*Lasiurus blossevillii*), Mexican free-tailed bat (*Tadarida brasiliensis*), little brown bat (*Myotis lucifugus*), and Eurasian pipistrellus (*Pipistrellus* sp.) (PRBO unpubl. data; Cryan and Brown 2007).

3.4.3.4. Invertebrates

Many of the insects on the South Farallones are most commonly associated with seabird carcasses (Schmieder 1992). This is not surprising given the inevitably high number of carcasses usually found on any seabird colony, including the Farallones. Globally, insects play a major role in processing detritus, and the role of invertebrates in the decomposition of carcasses on the Farallones is particularly critical given the paucity of larger detritivores on the islands compared with ecosystems on the mainland.

Few insect studies have been conducted on the Farallones. The most well-described invertebrate endemic is the camel cricket (Steiner 1989), but a unique island form of the flightless intertidal beetle *Endeodes collaris* has been described as well (Giuliani 1982).

3.4.3.5. Non-native animals

When the Service incorporated the South Farallon Islands into the Refuge in 1969, there were non-native rabbits, feral cats, and house mice present on the islands. Although island managers do not know when mice were first introduced to the South Farallones, anecdotal evidence suggests that they arrived early in the sequence of human activities, which began in the early 1800s. Russian sealers, egg collectors, lighthouse keepers, the U.S. Navy and the U.S. Coast Guard all inhabited the island before the Service assumed management and any of these previous occupants could have introduced mice, presumably by accident. Shortly after the Service assumed management they implemented a management program to remove rabbits and cats, which ended successfully in 1975 leaving house mice as the only non-native vertebrate on the Farallones.

House mice are small rodents, around 0.5-0.7 oz (15-20 g) in mass. They are prolific breeders, with females commonly producing six to eight litters a year, each with four to seven young which mature within three weeks and are reproductively active soon after (Witmer and Jojola 2006). Individual house mice most frequently travel no further than 49-66 ft (15-20 m) from a burrow, although occasional forays of longer distances do occur (Triggs 1991; Ruscoe 2001). House mice are omnivorous; mice on the Farallones eat both vegetation and invertebrates year-round and have been found with eggshell fragments and seabird feathers in their stomachs during the seabird breeding season (it is possible that these seabird remains came from scavenged eggs or carcasses) (Jones and Golightly 2006).

The population of non-native house mice on the South Farallones is highly cyclical, growing steadily and rapidly throughout the summer to a peak in October and then crashing just as rapidly as food resources decline through the winter to a low in April (Irwin 2006; Jones and Golightly 2006). Mice are the primary prey item for burrowing owls during the fall and early winter months. As discussed in Section 1.3.1, the presence of mice as a seasonal food resource for burrowing owls has enabled these owls to subsequently prey heavily on small seabirds such as ashy and Leach's storm-petrels each spring when mouse numbers are low. The islands' ashy storm-petrel breeding population was reported to have declined more than 40% between 1972-73 and 1992 (Sydeman et al. 1998). This decline likely resulted, in part, from the presence of mice on the South Farallones.

While mice are the only non-native vertebrate residents on the South Farallones, non-native landbirds such as European starling (*Sturnus vulgaris*), house sparrow (*Passer domesticus*), and rock pigeon (*Columba livia*, commonly known simply as "pigeon") may be present during some seasons. Starling and house sparrow have also bred on the South Farallones in the past, but not in the past decade. Non-native birds are unlikely to have any impact on the small avian landbird community of the islands.

3.4.4. Intertidal and Nearshore Ecosystems

This section was compiled with information from J. Roletto (NOAA – Gulf of the Farallones NMS), pers. comm.

Gulf of the Farallones National Marine Sanctuary is contiguous with the Farallon National Wildlife Refuge at the mean-high tide line. The Sanctuary has conducted long-term monitoring of the rocky intertidal habitats of the Farallon Islands since 1992. Data include percent cover, density counts, and species inventories. Surveys are conducted annually during late summer (August), fall (November) and winter (February) months.

The intertidal habitat between the low and high tides is characterized by extreme conditions caused by wind, waves, and the fluctuation of tides. Organisms living in the intertidal face many challenges that are unique to living at the edge of the ocean, including threat of desiccation, physical wave action, and limited space. The intertidal areas of the islands are also highly biologically productive and diverse, supporting diverse assemblages of algae, plants and animals. Researchers have found over 200 taxa; five are rare and seven were extended ranges. See Appendix H for the rocky intertidal species list. The mean annual percent cover for algae and sessile macroinvertebrates at the South Farallones ranges from 148-255 percent.

Perennial macrophytes exhibit conspicuous zonation in the rocky intertidal community. Microscopic algae are common in the splash zone in winter months when large waves produce consistent spray on the upper portions of the rocky shore. Descending into the intertidal are several zones dominated by (1) ceramial algae in the high intertidal; (2) a dense turf of erect coralline and gigartinal algae in the mid-intertidal; and (3) beds of rhodymenials and laminarials in the low intertidal zone. The presence of the seagrass *Phyllospadix* is a good indicator of the mean low water level. In general, the rocky intertidal areas on the South Farallones are predominated with red-turf and coralline algae. The most common genera at the Farallon Islands include *Corallina*, crustose corallines, *Cryptopleura*, *Egregia*, *Endocladia*, *Gastroclonium*, *Gelidium*, *Mastocarpus*, *Mazzaella*, *Neorhodomela*, *Petrocelis*, *Prionitis*, and *Ulva*.

Intertidal invertebrates also exhibit conspicuous zonation. The periwinkle *Littorina keenae*, and the barnacle *Balanus glandula* can be used as an indicator of the splash zone. The barnacle *B. glandula* and red algae *Endocladia muricata* and *Mastocarpus papillatus* are used as indicators of the high intertidal zone, but these species are also found in other areas of the rocky shore. At wave-exposed sites, the mussel *Mytilus californianus* can dominate the available attachment substratum in the mid-intertidal zone. Intertidal predators generally include whelks, sea stars, sea urchins, octopus, fishes, and shore crabs. Overall on the South Farallones, the most common invertebrates include *Anthopleura* and *Mytilus*.

Kelp forests, which include the giant kelp species bull kelp *Nereocystis luetkeana*, are important habitat and food for many invertebrate and finfish species. Kelp forests are common along the nearby mainland coast but do not dominate the sub-tidal areas of the South Farallones.

Black oystercatcher and black turnstone (*Arenaria melanocephala*) are the most common birds along the rocky shoreline. The oystercatchers are resident. The turnstones are most abundant during fall and winter, and during this period, are accompanied by small numbers of ruddy turnstone (*Arenaria interpres*), surfbird (*Aphriza virgata*), and wandering tattler (*Tringa incana*). A variety of species commonly considered landbirds also feed along rocky shores during fall and winter, including black phoebe, Brewer's blackbird (*Euphagus cyanocephalus*) and European starling.

The heads of coves on Southeast Farallon and West End Islands include small sandy beaches. These areas are prime haulout locations for northern elephant seals and California and Steller sea lions. Over the past two decades the elephant seals have caused erosion of the sand from these coves, thus reducing their use as haulouts. The diversity of intertidal algae and invertebrates are greatest at some of these sandy coves, bordered by rocky walls and substrate. Examples can be found at the sandy coves near Dead Sea Lion Flat and Low Arch on Southeast Farallon Island.

Oil spills pose a major threat to the health and balance of life on the South Farallones' rocky shores. Past spills, including the November 2007 *Cosco Busan* oil spill in San Francisco Bay, have deposited oil on nearby rocky shores on the mainland. Oil can smother mussel beds and kill acorn barnacles, and limpets and cause disruption in reproductive processes in invertebrates and algae. Monitoring programs are vital in addressing the potential impacts, restoration and recovery rates from spills.

Non-native species have also made their way to the South Farallones' intertidal zones. These introductions are a major concern, due to the sanctuary's close proximity to the highly invaded San Francisco Bay. To date, almost 150 species of introduced marine algae, plants and animals have been identified in the Gulf of the Farallones National Marine Sanctuary. Invasive invertebrates, such as the green crab *Carcinus maenas*, make up more than 85 percent of all introductions in Gulf waters. They threaten the abundance and/or diversity of native species, disrupt ecosystem balance and threaten local marine-based economies.

Marine Sanctuary staff may establish a baseline collection of intertidal survey data – particularly surveys of intertidal fish taxa, which are comparatively poorly known – prior to project implementation and would monitor response, either positive or negative, in the intertidal community after mouse eradication.

3.4.5. Marine Wildlife

Maps illustrating the distribution of marine mammals haulouts and rookeries can be found in Appendix G.

3.4.5.1. California sea lion

California sea lions are the most abundant pinniped to haul out on the South Farallones. There are probably roughly between 1,000 and 3,000 animals present on the island and in surrounding waters year-round, with peak numbers during the spring (Ainley and Allen 1992; PRBO unpubl. data). California sea lions breed during the summer months of May through September, but the South Farallones are not a major breeding site. Most California sea lions at the Farallones breed either on the California Channel Islands or on islands off the coast of Mexico (Sydeman and Allen 1997). California sea lion abundance has increased substantially at the South Farallones during the last quarter century.

3.4.5.2. Northern elephant seal

Northern elephant seals are present in the waters surrounding the South Farallones year-round, but they are more abundant, particularly hauled out on the islands, during breeding and molting seasons (LeBoeuf and Laws 1994; Sydeman and Allen 1997). In mid-December, adult males begin arriving on the South Farallones, closely followed by pregnant females on the verge of giving birth. Females give birth, nurse their pups, and copulate (conceiving pups that will not be born until the following winter) until March, when they leave the islands to forage in deep offshore waters. The spring peak generally occurs in April and May, when females and immatures (animals one through four years old) arrive again at the colony to molt. The year's new pups remain on the colony through both of these peaks, generally leaving by the end of April. In May, the majority of animals leave the colony to forage during summer and fall, although small numbers of subadult and adult males are present to molt during the summer and a smaller peak of immatures arrives to molt in the fall (LeBoeuf and Laws 1994).

The current elephant seal colony at the Farallones was established in 1972, as the population of elephant seals throughout the region was recovering from its near extinction, due primarily to overharvesting, in the 19th century. The colony grew rapidly during the 1970s, and in 1983 a record 475 pups were born on the South Farallones (Stewart et al. 1994). Since then, the size of the South Farallones colony has declined, but the population currently appears stable. In 2007, a total of 179 cows were counted on the South Farallones, and 132 pups were weaned (Lee 2007).

3.4.5.3. Pacific harbor seal

Pacific harbor seals are present on or around the South Farallones year-round; the average number of animals observed hauled out or in nearby waters is generally highest in the summer and currently fluctuates between roughly 30 to slightly more than 100 (PRBO unpubl. data). Harbor seal abundance at the Farallones appears to fluctuate largely based on food availability in waters closer to shore; harbor seals are generally most abundant directly off the mainland coast, but they venture out to the Farallones when food near the coast is scarce (Sydeman and Allen 1997). Harbor seals breed between March and June, but few harbor seal pups have been born on the South Farallones. Harbor seal abundance has increased at the South Farallones during the last quarter century. This increase in abundance is thought to be largely the result of immigration from coastal waters where food availability has declined (Sydeman and Allen 1997).

3.4.5.4. Northern fur seal

Northern fur seals are also present year-round in the waters surrounding the South Farallones. They are most commonly seen during the fall season, although the monthly average number of northern fur seals sighted is generally less than 20 (Pyle et al. 2001; PRBO unpubl. data). Although the Farallones are believed to have been a major northern fur seal breeding area before the arrival of hunters in the early 19th century, the species was essentially extirpated from the region by the second half of that century. Not until 1996 did northern fur seals begin breeding again on the Farallones (Pyle et al. 2001), and each year since then they have bred in generally small numbers on West End Island during the summer. These numbers have increased dramatically in recent years, with nearly 200 animals observed in 2006 (PRBO unpubl. data).

3.4.5.5. Steller sea lion

Steller sea lions are primarily a species of the far north Pacific, and their colony on the South Farallones is near the southern end of their breeding range (Steller sea lions also currently breed at Año Nuevo and previously bred at the Channel Islands as well). Steller sea lions are present on and around the South Farallones year-round, but their numbers are considerably greater during the summer breeding season and again in late fall (Hastings and Sydeman 2002). Monthly averages of Steller sea lion counts range very roughly between 20 and 100 animals (PRBO unpubl. data). Steller sea lion breeding on the South Farallones primarily occurs on West End Island, although breeding sites have shifted over the years. The South Farallones breeding colony has become less productive over the past quarter century; generally only between five and 10 pups are born here annually compared with 20 to 30 pups annually during the 1970s (Sydeman and Allen 1997). In general, the Steller sea lion population utilizing the South Farallones for breeding and resting has undergone a major decline in the past quarter century. The reasons for this decline are unclear; it is possible that some adult animals have merely shifted their geographic range northwards (Hastings and Sydeman 2002). Regardless, the status of Steller sea lions on the South Farallones is precarious, in contrast to the other pinnipeds that utilize the islands. See Appendix E for a map of Steller sea lion distribution on the South Farallones.

The eastern Distinct Population Segment (DPS) of Steller sea lions, which includes individuals occurring in California (including the South Farallones), Oregon, Washington, Canada and southeast Alaska, is listed as Threatened under the ESA. The South Farallon rookery and waters around the islands are listed as designated Critical Habitat under the ESA (50 CFR 226.202). In addition to the islands, critical habitat includes the waters and air space within a radius of 3,000 feet of the rookery. The Steller sea lion was listed as Federally Threatened under the ESA in 1990 due to an 80 percent decline in the U.S. population between the 1950s and 1990. In 1997, after new genetic information revealed the existence of significant stratification between regional populations, management of Steller sea lions under the ESA was split among two distinct population segments (DPS), the western DPS and the eastern DPS. The western DPS, which is primarily composed of Steller sea lions in the Aleutian Islands, was up-listed to Endangered at that time. The eastern DPS, which includes Steller sea lions on the South Farallones, remained listed as Threatened.

Over the past 20 years, the eastern DPS overall has been increasing, but most of this increase has occurred in southeast Alaska and British Columbia, with population counts in California remaining stagnant or decreasing (NMFS 2008). The reasons for ongoing declines in California are unclear; the growing population of California sea lions in this region may be out-competing Steller sea lions, possibly in combination with changing oceanic conditions that are negatively affecting food availability for Steller sea lions but not for California sea lions (NMFS 2008).

3.4.5.6. Other marine mammals in the Gulf of the Farallones

In addition to the marine mammals discussed above, Guadalupe fur seals (*Arctocephalus townsendi*) and southern sea otters (*Enhydra lutris nereis*) have on rare occasions been spotted on the islands or in the waters surrounding the Farallones (Brown and Elias 2008). The rarity with which these species occur precludes them from detailed analysis in this document.

There are also a number of cetacean species that inhabit the Gulf of the Farallones, but they are very unlikely to be affected by any of the actions described and analyzed in this document, because all project activities would occur on or directly above the islands themselves and not in the surrounding marine environment.

3.4.5.7. Special legal protection for marine mammals at the South Farallones

All of the marine mammals discussed here are protected from harm under the MMPA. The Steller sea lion is also protected under the ESA.

3.4.6. Terrestrial Vegetation

The vegetation diversity on the Farallon Islands is low compared to the nearby mainland due to the harsh marine environment. Sparse soil coverage, guano, and trampling by seabirds and pinnipeds further limits the extent of vegetation on the Farallones. The islands' flora includes at least 44 species, 26 of which are non-native (Coulter and Irwin 2005). Maritime goldfields cover much of Southeast Farallon Island. Maritime goldfields are specialized for life on offshore seabird colonies, occurring on islands, sea stacks and coastal cliffs along the Pacific coast of North America from San Luis Obispo County, California to Vancouver Island, British Columbia. They are tolerant of the caustic soil conditions that are characteristic of guano-covered seabird habitat (Crawford et al. 1985; Vasey 1985).

In the most recent study conducted in 2005, 26 different non-native plants were recorded (Coulter and Irwin 2005), several of which are harmful pests. These include two non-native grass species which currently dominate Southeast Farallon's southeast end (*Bromus diandrus* and *Hordeum murinum leporinum*), New Zealand spinach (*Tetragonia tetragonioides*), mallow (*Malva parviflora*), and plantain (*Plantago coronopus*). Most non-native plants are found on the marine terrace in the south and southeast portions of Southeast Farallon and up the slopes of Lighthouse Hill and Little Lighthouse Hill. The spread of some of these non-native plants to the northern side of the island could pose a further threat to native species. New Zealand spinach has been identified as a particularly serious threat to the Farallones ecosystem because its impenetrable mats of growth degrade seabird burrowing and nesting habitats (USFWS 2005b).

Several trees (Monterey cypress *Cupressus macrocarpa* and Monterey pine *Pinus radiata*) were planted on Southeast Farallon Island before the island was added to the Refuge. There are two Monterey cypress individuals (planted in 1982; Pyle and Henderson 1991) near the housing. There are also three "cultivated patches" of bush mallow (*Lavatera arborea*), a non-native species, all within 200 m of the housing units (Pyle and Henderson 1991). The islands' few landbirds largely congregate in the immediate vicinity of these larger plants.

Much of the vegetation on the Farallones senesces or dies by the summer and rebounds in the early winter and spring when seasonal rainfall begins.

3.5. Social and Economic Environment

3.5.1. Ownership/Management/Major Stakeholders

The South Farallones are managed as the Farallon National Wildlife Refuge, part of a national system of Federal lands managed by the Service for the primary benefit of wildlife and their habitats. However, the U.S. Coast Guard's authority to use Southeast Farallon Island for a navigational light station pre-dates and supersedes the Service's jurisdiction. Coast Guard personnel visit the island about twice a year to maintain the automated, solar-powered light at the top of Lighthouse Hill, and rarely become involved in management of the island. The surrounding waters are managed primarily by NOAA as the Gulf of the Farallones National Marine Sanctuary. The waters surrounding the islands out to a distance of one mile are designated as the Farallon Islands State Marine Conservation Area by the California Department of Fish and Game. This Department is currently considering a proposal to create a no-take Marine Reserve around some or all of the Farallon Islands, as mandated by the State's Marine Life Protection Act legislation.

Due to the sensitive nature of the wildlife and the difficulty of landing on the islands, access to the South Farallones is strictly monitored and currently limited to FNWR and PRBO Conservation Science staff, their approved contractors and collaborators, special-use-permit holders, and the US Coast Guard. Between March 15 and August 15, boat traffic is also prohibited within 300 ft. of the shoreline. Except as prohibited above, vessels use the East Landing, and less often the North Landing, as calm-weather anchorages.

The South Farallones are within San Francisco County limits, but the islands do not provide any employment opportunities for the general public. The waters surrounding the islands are harvested by commercial fishing operations. Wildlife-viewing and sport-fishing charter boats, none of them operated by the Service, also generate income for the region.

3.5.2. Recreational and Aesthetic Uses

There are currently no recreation opportunities available to the public on land due to the presence of sensitive wildlife and habitat. However, the immediate surrounding waters provide an estimated 3,500 “wildlife viewing visitor days” annually (USFWS 2005a). Several wildlife-viewing boats conduct natural history tours throughout the year (weather permitting) out to the waters surrounding the islands. These tours focus on seabirds, marine mammals, and sharks. The wildlife-viewing opportunities associated with the Farallones extend to the nearby mainland coast as well, as some of the seabird species that breed on the Farallones forage near the mainland, to the advantage of land-bound bird enthusiasts.

For several major species – notably nearshore rockfishes, surfperches, greenlings, lingcod, flatfishes, salmonids, and sculpins – north-central California accounts for a majority of the statewide recreational catch. Generally speaking, recreational fisheries provide considerable value to coastal economies. Based on the average annual number of fishing trips of residents and nonresidents in 1998-99, aggregate annual expenditures related to marine recreational fishing, including costs for gear, licenses, and other supplies, amounted to $570 million (in 2003 dollars), $200 million of which derived from fishing activity in north-central California (Scholz and Steinback 2006).

In addition to guided tours and recreational fishing, there are other private pleasure boats that use the waters surrounding the South Farallones. However, due to the often-unsettled nature of the weather and seas, general recreational boating is much less common outside of the Golden Gate than it is within the protected waters of the San Francisco Bay.

3.5.3. Commercial Fisheries

The waters immediately surrounding the South Farallon Islands are productive grounds for commercial fishing. Scholz and Steinback (2006) conducted an in-depth examination of the use of the adjoining National Marine Sanctuaries that span the coast of central California as fishing resources. Currently, the most important fisheries in the study area — the Cordell Bank and Gulf of the Farallones and adjacent port communities from Bodega Bay to Pillar Point (Half Moon Bay) — are Dungeness crab, groundfish (including several nearshore species), herring, salmon, squid, tuna and urchins. Between 1981 and 2003, these seven fisheries yielded an average of nearly 35 million pounds of landings worth over $31 million per year (in constant 2003 dollars).

In general, the fisheries in the study area are more valuable than in the state as a whole. Over the past 23 years, the proportion of revenues derived from commercial fisheries’ landings in study-area ports has increased, from 5 percent of the state total in 1981 to several times that number in recent years.

Overall, commercial fisheries are conducted with fewer vessels than a generation ago. Since the most recent peak of commercial fisheries in 1981, the number of fishing vessels in California has declined steadily. The number of vessels making landings in study-area ports has similarly declined, from 2,200 in 1981 to 603 in 2004. Fewer than half of these vessels are responsible for

90 percent of landed catch. The fisheries are not just losing vessels. In general, fishermen report that there are fewer young people entering the fisheries.

If the California Department of Fish and Game approves a current proposal to establish a State Marine Reserve at the Farallones, commercial or recreational fishing would no longer be permitted within the Reserve. The boundaries of the proposed Reserve have not yet been established.

3.5.4. Historical & Cultural Resources

The South Farallones have had extensive human activity beginning as a marine mammal hunting ground, a coveted egg gathering site, a manned Coast Guard light station, and a military outpost. These past activities have left behind many remnant elements that may possess some level of cultural significance. Thus, the entire Southeast Farallon Island was listed on the National Register of Historic Places in 1977. This designation did not specifically identify significant structures or other elements. Instead, structures and elements are evaluated for their historic significance when the structure is being considered for rehabilitation or renovation. Not every element on the islands has been evaluated. Specific structures that have been determined to be culturally significant include the two residences, a carpenter's shop, the lighthouse trail, and the rail cart system. The oldest structural remains on the South Farallones are thought to be the Russian House foundation, which was used by seal hunters. The area surrounding the Russian House foundation also has the highest concentration of historical-origin marine mammal bones on the island.

There are numerous artifacts from the islands' 19th century history as an important source of eggs for the rapidly growing San Francisco region. The infamous Farallon Egg Wars were fought here in 1863 (White 1995; Wake and Graesch 1999). Another area with significant egging history is the stone enclosures and wall south of North Landing. These structures were used by eggers for cleansing and storage of eggs (Wake and Graesch 1999). Russian era shelters and eggers barracks also contain a high frequency of surface artifacts and mid-19th century bottle glass. Sewer Gulch and Garbage Gulch served as dump sites in the later part of the 19th century. Many archaeological deposits are still present in these areas that help to provide insight into early human occupation on the island.

Figure 3.2. Southeast Farallon residences as seen from Lighthouse Hill.

The two existing residences were built in 1860 to accommodate lighthouse crews, which were limited to men and then eventually families. The architect is unknown, but the houses are good examples of 19th century institutional architecture. These residences were extensively altered around 1959, but renovations in 1999 returned them closer to their original appearance. The two residences are considered culturally significant and are included in the National Register of Historic Places. Moreover, the function of these houses as residences still continues for PRBO biologists, Refuge staff, and other visiting researchers and contractors today. Rock features in front of one of the houses could potentially represent a prepared butchering area for preparation of marine mammals and other prey (Wake and Graesch 1999).

During habitation by the lighthouse crew, the rail cart system on Southeast Island was an important vehicle for transporting goods from ships to the main structures. The rail cart system is estimated to have been built in about 1878 to connect the North Landing with the residences and coal storage. The line was later extended to the East Landing. The system carried coal and other freight from the landing to the quarters by mule power and was never motorized. The last mule was used in 1913 and since then, carts have been powered by residents. This system is considered culturally significant because it represents a certain function during a historic period (1878-1939). Due to harsh environmental conditions and replacement by other means, the rail cart system has been maintained only modestly.

The building now called the Carpenter Shop was constructed by the U.S. Navy in 1905 as barracks and occupied until about 1945. The structure was evaluated in 2005 and is considered a significant cultural element because it is the only standing building that represents the Navy period.

While the water catchment area is not considered culturally significant, the area surrounding it may contain high potential sub-surface artifacts and features that should be carefully traversed to prevent potential damage (Valentine 2000).

The wooden water tanks and foghorn remnants have not been evaluated to determine their historical significance. However, the foghorn should be noted as the island's first attempt at providing a navigation warning.

A limited amount of aboriginal artifacts are present on the Southeast Farallon Island. Some artifacts are ascribed to Aleut or Northwest Coast origin, while others are associated with California Native Americans. Those items that were manufactured by Native Americans were thought to be associated with the Russian fur traders and their various Native American employees. Other cultural pieces including bones from elk, deer, and pig indicates that occupants relied on meat from the mainland.

Chapter 4: Environmental Consequences

4.1. Purpose and Structure of this Chapter

Chapter 4 analyzes the environmental consequences of the alternatives as presented in Chapter 2. For comparative purposes, Chapter 4 also includes a similar analysis of the consequences of taking no action to address the problem of non-native house mice on the South Farallones. The purpose of the impacts analysis in this chapter is to determine whether or not any of the environmental consequences identified may be significant.

The concept of significance, according to CEQ regulations (40 CFR 1508.27), is composed of both the *context* in which an action will occur and the *intensity* of that action on the aspect of the environment being analyzed. “Context” is the setting within which an impact is analyzed, such as a particular locality, the affected region, or society as a whole. “Intensity” is a measure of the severity of an impact. Determining the intensity of an impact requires consideration of the appropriate context of that impact as well as a number of other considerations, including the following:

1. Impacts may be both *beneficial* and *adverse*. A significant effect may exist even if on balance the effect will be beneficial.
2. The degree to which an action affects *public health or safety*.
3. *Unique characteristics of the geographic area* (e.g. historical or cultural significance, specially protected lands, ecologically critical areas).
4. The degree to which the impacts of an action are likely to be *highly controversial*. The courts have since elaborated on this consideration, stating that controversy would be in the form of “substantial dispute” as to “the size, nature or effect of the major Federal action rather than to the existence of opposition to a use [e.g. eradication of mice], the effect of which is relatively undisputed” (*Hanly v. Kleindienst,* 471 F.2d 823, 830 [2d Cir. 1972]).
5. The degree to which the possible impacts of an action are *highly uncertain, or involve unique or unknown risks*.
6. The degree to which an action may i) *establish a precedent* for future actions with significant effects; and/or ii) *represents a decision in principle* about a future consideration.
7. Whether an action is related to other actions with individually insignificant but *cumulatively significant impacts*. Significance exists if it is reasonable to anticipate a cumulatively significant impact on the environment.
8. The degree to which an action may adversely affect properties listed in or eligible for listing in the National Register of Historic Places, or may cause *loss or destruction of significant scientific, cultural, or historical resources*.
9. The degree to which an action may *adversely affect an endangered or threatened species or critical habitat as listed under the ESA*.
10. Whether the action *threatens a violation of Federal, State, or local law* or requirements imposed for the protection of the environment.

4.2. Environmental Issues (Impact Topics) Addressed

4.2.1. Scoping for Environmental Issues (Impact Topics)

The Service compiled a list of major environmental issues, or impact topics, that warranted specific consideration in this analysis. The compilation of this list of issues was informed by a scoping process that included informal discussions with representatives from numerous government agencies, private groups and individuals with relevant expertise or a stake in the Farallon Islands, and solicitation of public comments (see Section 1.6.1 and Section 5.3-6).

In the analysis below, the potential significance of effects of each action alternative and the no action alternative will be discussed on a case-by-case basis for each environmental issue considered.

4.2.2. Impact Topics

The impact topics analyzed in this document include:

- Impacts to physical resources
    - Water resources
    - Geology and soil
    - Wilderness character
- Impacts to biological resources
    - Impacts to species vulnerable to toxin use
        - Terrestrial and intertidal foragers
        - Marine foragers
    - Impacts to species vulnerable to disturbance
    - Indirect effects to biological resources
- Impacts to the social and economic environment
    - Impacts to refuge visitors and recreation
    - Impacts to fishing resources
    - Impacts to historical and cultural resources
- Cumulative impacts
- Irreversible or irretrievable commitment of resources
- Relationship of short-term uses to long-term productivity

Brief descriptions of many of these topics can be found in Section 1.6.

4.2.3. Aspects of the Environment Excluded from Detailed Analysis (with Rationale)

4.2.3.1. Air quality

Impacts of the action alternatives on air quality at the South Farallones will not be analyzed in detail because there are no activities proposed that would represent a measurable change from the background levels of air pollution caused by nearby water- and aircraft. The brief, localized helicopter operations that would occur as part of each action alternative would have no more than a negligible contribution to local or regional changes in air quality.

4.2.3.2. Marine fish

Potential impacts of mouse eradication activities to fish in the waters surrounding the South Farallones will not be analyzed in detail in this EA, because the likelihood of the either of the action alternatives having measurable impacts on fish populations is negligible:

- The number of bait pellets that would enter the marine environment as a result of aerial bait broadcast, across the full island (as in Alternative B) or in limited areas (as in Alternative C), would be low as a result of the mitigation measures described in the Alternatives chapter (Chapter 2) for avoiding bait application into the ocean;
- The bait pellets would disintegrate rapidly upon contact with the water;
- In tests conducted by researchers in southern California, as well as in Alaska, Hawai`i, and the equatorial Pacific, marine fish species have demonstrated almost no interest in placebo bait pellets that entered the water nearby (Buckelew et al. 2008; Howald et al. 2005; A. Wegmann, pers. comm.).

4.2.3.3. Exclusively marine mammals (e.g. cetaceans)

Potential impacts of mouse eradication activities to cetaceans (whales, dolphins, and their close relatives) in the waters surrounding the South Farallones will not be analyzed in this EA. The likelihood of cetacean exposure to brodifacoum would be negligible. Except for small boat traffic, which would be limited in duration and concentrated immediately offshore of the island, all of the activities described in the action alternatives would be aerial or terrestrial, and the likelihood of these activities having measurable impacts on cetaceans would be negligible as well.

4.2.3.4. Environmental justice

The impacts of the action alternatives on environmental justice – the agency mandate set in Executive Order 12898 to identify and address the potential for disproportionate placement of adverse environmental, economic, social, or health impacts on minority and low-income populations – will not be analyzed in detail because there are no minority or low-income populations that would be affected by either of the action alternatives.

4.3. Consequences: Physical Resources

4.3.1. Water Resources

4.3.1.1. Analysis framework for water resources

The potential for significant environmental impacts of the action alternatives on water quality, irrespective of other water quality regulations, will be analyzed for the potential for biologically adverse quantities of brodifacoum to be introduced into the marine water column surrounding the South Farallones including persistent tidepools. Water quality in the State of California is regulated by the State Water Resources Control Board, which requires all state waters to meet minimum criteria for a number of designated uses. While the federal Clean Water Act (CWA) prohibits the discharge of "pollutants" into waters of the United States, the EPA recently clarified its interpretation of the term "pollutant" to exclude pesticides that may unavoidably enter the water while being applied to control pests that occur "over, including near" water bodies (71 CFR 227 pp. 68483-68492). As mice on the South Farallones frequently utilize habitat at the shoreline, the application of a rodenticide to eliminate mice according to the techniques described in the action alternatives and as permitted under the EPA's pesticide regulations may include areas immediately adjacent to water bodies without additional compliance requirements under CWA.

4.3.1.2. Alternative A: No action

Mice on the South Farallones do not currently affect the quality or quantity of island drinking water or marine water resources, nor would the Service expect any future impacts.

4.3.1.3. Alternative B (preferred alternative): Mouse eradication with aerial bait broadcast as primary technique

Some bait pellets would be likely to drift into nearshore marine waters during bait application operations. However, the bait application techniques described would include mitigation measures to limit bait entry into water bodies to a level well under the target bait application rate.

Even if bait does enter water bodies on or around the South Farallones at the full application rate, it would be very unlikely to contribute to detectable levels of brodifacoum in the water column. The low water solubility and strong chemical affinity of brodifacoum to the grain matrix of the bait pellets largely prevents the rodenticide from entering aquatic environments via run-off. Hypothetically, even if brodifacoum was highly water soluble, and bait was broadcast at the rate of 16 lb/ac (18 kg/ha) into water only 3.3 ft (1 m) deep, the resultant brodifacoum concentration in the water – about 0.04 parts per billion – would still be nearly 1000 times less than the measured LC50 value for trout (0.04 parts per million) (Syngenta 2003).

Environmental testing during rodent eradications and eradication trials in the California Current marine system and elsewhere have failed to detect brodifacoum in any water samples taken after bait application (Howald et al. 2005; Buckelew et al. 2008; Island Conservation, unpubl. data). Furthermore, post-application sampling in the Anacapa Island rat eradication did not detect any brodifacoum residue in any of the intertidal invertebrates tested (Howald et al. 2005).

Water supplies for personnel on the South Farallones would be protected during bait application activities to prevent the entry of pellets into water catchment areas.

In summary, there would be a negligible risk that the marine water column or drinking water supplies would register biologically harmful, or even detectable, levels of brodifacoum as a result of bait application to the island.

4.3.1.4. Alternative C: Mouse eradication with bait station delivery as primary technique

Bait from bait stations would not be likely to enter water bodies on or around the South Farallones. During aerial bait application of inaccessible areas, the risk profile under Alternative C would be similar to that of Alternative B described in Section 4.3.1.3.

4.3.2. Geology and Soils

4.3.2.1. Analysis framework for geology and soils

The major issues of concern for the geology and soil resources of the Farallones are 1) permanent damage to granitic rock formations, 2) increases in soil erosion, and 3) contamination of soils.

4.3.2.2. Alternative A: No action

Under the no action alternative, mice would remain on the island and would continue to burrow in areas with a substantial soil layer. However, there are numerous seabird species that burrow on the island as well, and mouse burrowing activity would not be likely to contribute to noticeably more erosion than seabird burrowing. Mice would not measurably impact rock formations or contamination in soils.

4.3.2.3. Alternative B (preferred alternative): Mouse eradication with aerial bait broadcast as primary technique

The activities in Alternative B would not have a noticeable impact on soil erosion, rock formations, or soil contamination. The installation and maintenance of bait stations in limited circumstances may have highly localized impacts to soil and rock but these impacts would not be significant. The extremely low concentration of brodifacoum in bait pellets would not lead to measurable soil contamination. In environmental monitoring after rat eradication on Anacapa Island using brodifacoum pellets, all soil samples collected tested negative for brodifacoum residue.

4.3.2.4. Alternative C: Mouse eradication with bait station delivery as primary technique

The bait station grid required under Alternative C would have minor, localized impacts on soil erosion and rock formations, but these impacts would not be significant. Limited aerial broadcast of brodifacoum pellets would not lead to measurable soil contamination.

4.3.3. Wilderness Character

4.3.3.1. Analysis framework for wilderness character

Areas of the South Farallones are designated Wilderness as regulated by the Wilderness Act (PL 88-577). Preservation of wilderness character is not a category of analysis required under NEPA regulations, but the special designation of segments of the South Farallones as Wilderness will be considered through an analysis of the impacts of each action alternative. Under the Wilderness Act, an area's wilderness character is defined by the following qualities:

1. Untrammeled by human impacts;
2. Undeveloped, without permanent structures or habitations;
3. Influenced primarily by natural forces; and
4. Has outstanding opportunities for solitude or a primitive and unconfined type of recreation.

The impacts of each alternative that relate to the Wilderness Act will be discussed according to their benefit or harm to each of the above four qualities that characterize wilderness. Additionally, the Service is preparing a Minimum Requirements Analysis as required for projects which require the use of tools normally prohibited in Designated Wilderness.

4.3.3.2. Alternative A: No action

Since humans introduced mice to the South Farallones, they have influenced the islands' natural ecosystem. Their presence and impacts have thus degraded the wilderness character of the Designated Farallon Wilderness Area. Taking no action with regard to non-native mice on the South Farallones would allow this degradation to continue.

4.3.3.3. Alternative B (preferred alternative): Mouse eradication with aerial bait broadcast as primary technique

The aircraft and personnel activity required in the Farallon Wilderness Area under Alternative B would produce short term negative impacts on the wilderness character of West End. The eradication effort would require manipulation of the existing ecological processes in an effort to restore natural systems that have been disrupted through the introduction of a non-native species. However, the long term benefits of an enduring wilderness with restored ecological systems gained through a successful mouse eradication would be greater than the short term negative impacts the effort may have to the wilderness character of the Farallon Wilderness Area.

4.3.3.4. Alternative C: Mouse eradication with bait station delivery as primary technique

The installation and maintenance of a bait station grid in designated wilderness under Alternative C would produce short-term negative impacts on the wilderness character of West End. The operation of helicopters would contribute further to this short-term degradation. Alternative C would require a major increase in human activities within the Wilderness Area, unprecedented since the Service assumed responsibility for the South Farallones. In addition, the mouse eradication effort would require manipulation of the existing ecological processes in an effort to restore natural systems that have been disrupted through the introduction of a non-native species. These impacts would have the potential to decrease a Refuge visitor's opportunity to experience solitude and unconfined recreation. However, the long term benefits of an enduring wilderness with restored ecological systems gained through a successful mouse eradication would be greater than the short term negative impacts the effort may have to the wilderness character of the South Farallones wilderness areas.

4.4. Consequences: Biological Resources

4.4.1. Introduction

In order for the project to be considered a restoration success, the long-term benefits of mouse eradication must outweigh any potential ecosystem costs. The eradication of mice is expected to have benefits for a number of animals and plants that are currently being negatively affected by mouse presence. However, it is also critical to identify the potential biological impacts of the actual eradication operations, including mortality and injury to sensitive wildlife species as a result of ingestion of rodenticide and/or disturbance from project operations. Furthermore, it is important to identify any biological resources that are currently dependent on the non-native mice in some way and may be negatively affected once mice are removed. This document's analysis of impacts to biological resources will identify both the benefits (positive effects) of mouse eradication and the costs (negative effects).

While the impacts of each alternative to the biological resources of the South Farallon Islands will be examined with respect to individual animals, the primary focus will be to analyze whether impacts to a particular resource (species or taxonomic group) could be considered significant according to the general significance criteria described in Section 4.1. The concept of significance will be defined separately for each topic analyzed below. In some cases, after all relevant considerations are taken into account, impacts at the individual level (i.e. causing mortality or behavior changes to individual animals) must be considered significant. One example of this case is species that are listed under the ESA. However, in the case of many of the taxa analyzed here, impacts to individual organisms, however major, may not qualify as significant impacts in the context of population-level impacts to species utilizing the South Farallones. In other words, for species that have large populations, a wide range, and are capable of rapidly recovering from losses, impacts to individuals are usually unlikely to harm the population as a whole. The results of risk analyses for individual animals will contribute to the overall analysis of significance for each biological taxon considered, but they should not be considered interchangeable with the significance determination for each impact topic.

While the impacts of each alternative can be analyzed with considerable confidence over the short term, it is more difficult to accurately predict specific long-term responses to mouse eradication. While the overall determination of the overall ecosystem response to mouse eradication on the South Farallones includes too many variables to analyze with precision in this document, data from other island mouse eradications can be used to predict long-term ecosystem responses. Whenever possible, these data will be used to help determine long-term effects in the analysis sections below.

4.4.2. Assessing Significance of Impacts to Biological Resources

As described in Section 4.1, the concept of significance is shaped by both the context of an action and the intensity of the action's effects. In the case of the action alternatives analyzed here, the action itself has a very limited, site-specific context. However, many of the species that utilize the South Farallones have large ranges or interact, at a population level, with other individuals that may be spread out over an area much larger than the South Farallones. Therefore, the most generally appropriate context within which to consider impacts to biological resources is at the level of populations rather than individual organisms. The intensity of effects is dependent on numerous variables that are different for each taxon. This analysis will focus on additional legal protection (ESA listing and MMPA listing) as the primary defining criterion for determining the intensity of an impact to a species; in other words, impacts to species that have been assigned specific legal protection under ESA or MMPA will be considered for the purpose of this analysis as "more intense" than similar impacts would be to unlisted species.

For all biological resources analyzed, except those identified in the "special considerations" below, the potential for significance will be determined using the following guidelines:

- Is there a high likelihood that the population of an organism will experience noticeable changes that will not be counteracted by immigration?
- Is there a high likelihood that impacts on organisms at the South Farallones will be measurable elsewhere in the region?

4.4.2.1. Special significance considerations for ESA-listed species

There are two species that are likely to occur on the South Farallones that are on the Federal Endangered Species list, the eastern DPS of the Steller sea lion (Threatened), and the California brown pelican (Endangered). Listing under ESA provides a context for impacts analysis which lowers the threshold of significance. This analysis will identify any ESA-listed species and any ESA-designated critical habitat that may be affected by the preferred alternative. The significance of these impacts will be determined separately, but the ESA-listed status of the species affected will be given special weight.

For Steller sea lions, the significance threshold for effects will be set at an action that causes the significant potential for mortality in an individual animal.

For California brown pelicans, the significance threshold for effects will be set at an action that is likely to cause the mortality of one or more pelicans.

Endangered Species Act regulations also oblige Federal agencies to ensure that the actions they take are not likely to "jeopardize the continued existence of a listed species or result in the destruction or adverse modification of designated critical habitat" (ESA Section 7(a)2). If a Federal action may adversely affect an ESA-listed species or its designated critical habitat, the action agency must initiate a formal process of consultation with either USFWS (for pelicans) or NMFS (for Steller sea lions) to determine whether or not the action will put the potentially affected species in jeopardy of continued survival. Additionally, if individual animals that are listed under ESA may be affected by the agency's action, the Service must apply for an Incidental Take Permit.

4.4.2.2. Special significance considerations for marine mammals generally

Listing under MMPA provides a context for impacts analysis which lowers the threshold of significance. The MMPA regulations generally prohibit the killing, injury or disturbance of marine mammals, but permits can be granted allowing exceptions to this prohibition for actions that may impact a marine mammal if the impact is incidental to rather than the intention of the action. This analysis will identify the potential for impacts to marine mammals that may require additional permits under MMPA.

The significance of these impacts will be determined separately, but the MMPA-listed status of the species affected will be given special weight. For marine mammals, the significance threshold for effects will be set at an action that causes the significant potential for mortality in an individual animal. MMPA regulations prohibit "disturbance" of marine mammals, which is a lower threshold of impact than mortality. Disturbance according to the MMPA definition will not alone constitute a significant impact in this analysis, but other potential circumstances (including cumulative impacts analysis) may nevertheless contribute to an overall determination of significant impacts.

4.4.3. Impacts of Alternative A (No Action) on Biological Resources

4.4.3.1. Introduction

If no action is taken regarding non-native house mice on the South Farallones, the impacts that mice are having to the islands' biological resources would continue. This section will summarize the impacts that are known and suspected to numerous aspects of the South Farallones environment. Additionally, this section will describe the possibility of new environmental impacts from mice emerging in the future, as has occurred on other islands where house mice were introduced.

4.4.3.2. Mouse impacts to terrestrial and intertidal foragers

4.4.3.2.1. Indirect impacts to burrowing owls

The presence of mice on the Farallones makes the islands a population sink for burrowing owls. The burrowing owls that have been documented overwintering on the South Farallones and preying on storm-petrels have largely been juveniles. Although burrowing owls of all ages arrive on the islands when they become lost at sea during their fall migration, most leave shortly after and usually only a small number of burrowing owls ultimately remain into the winter. Island biologists tracking these owls find most of them dead by the spring. While some of these owls are killed by western gulls, which become extremely territorial during their spring breeding season, others are found dead of probable malnutrition (PRBO pers. comm.). The California Department of Fish & Game has designated the burrowing owl as a Species of Special Concern.

On its own, burrowing owl mortality on the Farallones is unlikely to have population-level impacts to burrowing owls, but it may contribute to cumulative negative impacts to the species along with other threats on the mainland.

4.4.3.2.2. Indirect impacts to salamanders

The endemic Farallon arboreal salamander has a diet similar to house mice on the South Farallones, so when the mice are abundant each summer and fall on the island they may limit the amount of food available to salamanders. Furthermore, the food preferences of introduced mice on other islands (Newman 1994) indicate that mice on the South Farallones could prey directly on salamanders but the effect of such predation is unknown.

4.4.3.2.3. Impacts to invertebrates

Invertebrates comprise a major portion of the diet of mice on the South Farallones (Jones and Golightly 2006). Comparisons to other islands with introduced house mouse populations (Cole et al. 2000; Crafford 1990; Rowe-Rowe et al. 1989) suggest that mice probably have a substantial impact to the South Farallones invertebrate community, especially during the annual mouse population boom of the late summer and fall. In New Zealand, researchers have estimated that one house mouse would need to consume 4.4 g (0.16 oz) of invertebrate prey each day, if no other foods were available, to meet its daily energy requirements (Miller 1999 as cited in Ruscoe 2001). Invertebrates perform numerous important ecosystem functions on the South Farallones including pollination and decomposition, and they are a food resource for numerous species including salamanders and migrating birds and bats. Consequently, mouse impacts to invertebrates have the potential to reverberate throughout the South Farallones ecosystem.

4.4.3.3. Mouse impacts to marine foragers

4.4.3.3.1. Impacts to breeding seabirds

Non-native house mice are negatively affecting the populations of burrow- and crevice-nesting seabirds on the South Farallones, particularly ashy and likely Leach's storm-petrels. Researchers have observed introduced house mice preying on seabird eggs and chicks on other islands (see Wanless et al. 2007; Cuthbert and Hilton 2004), and there are a few records of mouse predation on storm-petrel eggs and chicks on the South Farallones (Ainley et al. 1990). Mice likely also cause disturbance to storm-petrels as well as all the other crevice- and burrow-nesting seabirds breeding on the islands by repeatedly entering their burrows, leading to abandonment of active or potential breeding success sites.

More worryingly, mice are indirectly responsible for a substantial portion of ongoing declines in the breeding populations of ashy storm-petrels, and likely Leach's storm-petrels, due to predation by burrowing owls (PRBO unpubl. data). Burrowing owls are not considered island residents, but each year burrowing owls dispersing from their resident habitat in California's interior lowlands overshoot the coast, and land on the South Farallones to rest while returning to the mainland (DeSante and Ainley 1980). However, the South Farallones' mouse population, which is at an annual peak during the fall, makes the Farallones appear to be suitable hunting grounds for some of the burrowing owls that arrive in the fall. The owls that choose to overwinter on the islands can survive on mice for the fall season and into the early winter, but by mid-winter the mouse population has plummeted – the cyclical counterpart to its fall peak. As a result, the overwintering burrowing owls are forced to find an alternative food source, and they subsequently begin to prey on adult storm-petrels that arrive on the islands in mid-winter to breed. Predation by wintering owls accounts for substantial annual mortality in breeding ashy storm-petrels, estimated from counts of bird remains near owl roosts at an average minimum of 67 ashy storm-petrels each year (PRBO unpubl. data). There are other predatory landbirds that visit the South Farallones in migration and winter, including other owl species, but none have had as noticeable an impact on the local biota as the burrowing owl.

Most seabirds, and storm-petrels in particular,

- are long-lived – storm-petrels are known to live at least 35 years;
- mature slowly – storm-petrels generally do not begin breeding until they are 5 years old; and
- have a low rate of reproduction – storm-petrel pairs almost always produce only one egg per year (although they may lay a second egg if the first egg fails) and only 50-75% breed successfully each year (Ainley and Boekelheide 1990; Ainley 1995).

These characteristics make each breeding adult storm-petrel especially valuable to the reproductive success of the species.

Unfortunately, researchers on the Farallones found that during a recent 20-year period, the population of breeding adult ashy storm-petrels on the South Farallones decreased by about 42 percent (Sydeman et al. 1998). Sydeman et al. identified owl predation, along with western gull predation, egg and chick predation by mice, and long-term habitat changes as the major causes of decline in the South Farallones ashy storm-petrel colony. While Sydeman et al. (1998) speculated that burrowing owl predation was probably considerably less than gull predation, more recent evidence (Mills 2006; PRBO, unpubl. data) indicates that owl predation on storm-petrels is higher than previously realized. These predation patterns are likely similar in Leach's storm-petrels, which are similar in size and behavior to ashy storm-petrels. Leach's storm-petrels range throughout the North Pacific and North Atlantic Oceans, and their population on the Farallones is small in comparison to other Leach's storm-petrel colonies, but this colony appears to have declined substantially based on occasional surveys from the 1970s through recent years (G. McChesney pers. comm.). Owl predation on Leach's storm-petrels likely threatens the existence of the Farallones' Leach's storm-petrel population.

4.4.3.3.2. Impacts to California brown pelican (Endangered)

Mice are not known to affect the California brown pelican. Pelicans roosting on the South Farallones would not be affected if the No Action alternative is adopted and mice are allowed to remain.

4.4.3.3.3. Impacts to Steller sea lion (Threatened)

Mice are not known to affect Steller sea lions. Steller sea lions on and around the South Farallones would not be affected if the No Action alternative is adopted and mice are allowed to remain.

4.4.3.3.4. Impacts to pinnipeds (protected under MMPA)

Mice are not known to affect pinnipeds on the South Farallones. Pinnipeds would not be affected if the No Action alternative is adopted and mice are allowed to remain.

4.4.3.4. Mouse impacts to vegetation

The endemic plants of the Farallones have evolved with no pressure from rodents and mice are thus a potential threat to native plants. Seeds of the endemic maritime goldfields, in particular, are a common food item for mice on the South Farallones (Jones and Golightly 2006).

On the other hand, many of the non-native plants that have been introduced to the South Farallones originally evolved under grazing pressure from small mammals such as rodents on the mainland, so mice are less likely to negatively affect them in their adopted island habitat. Particularly during the fall, mice on the Farallones commonly consume the seeds of the non-native grass *Hordeum murinum leporinum*, which has spread to new areas on the islands in recent years (Coulter and Irwin 2005). The Service currently recognizes non-native plants as a major threat to the South Farallones ecosystem. The presence of mice increases the likelihood that introduced plants that have an adaptation to dispersal by rodents will successfully establish and spread on the islands.

4.4.4. Impacts to Biological Resources Vulnerable to Toxin Use

4.4.4.1. Analysis framework for impacts from toxin use

The risk of impacts from brodifacoum or any other rodenticide to individual animals is determined by two factors:

1. the toxicity of the compound to that individual; and
2. the likelihood of that individual's exposure to the compound (Erickson and Urban 2004).

From the perspective of risks from the rodenticide, the two action alternatives differ primarily in the second factor: individual animals' likelihood of exposure. Since the same rodenticide would be used in either action alternative, the toxicity values (the first factor) would be similar for each taxon in either alternative.

4.4.4.1.1. Toxicity

Toxicity to birds and mammals – The toxicity of a particular compound to an individual animal is often expressed in a value known as the "LD50" – the dosage (D) of a toxin that is lethal (L) to 50 percent of animals in a laboratory test. The EPA has compiled laboratory data on the brodifacoum LD50 value for a number of species. However, due to the difficulty and expense of obtaining extensive laboratory data, the LD50 values for many species – including most species on the Farallones – remain unknown. Besides lethal toxicity, there are other physiological effects from ingestion of anticoagulants. Erickson and Urban (2004) report that individual birds and mammals that are exposed to anticoagulants and survive may nevertheless experience internal hemorrhaging, external bleeding, and other physical symptoms of anticoagulant toxicity.

The EPA has determined that the toxicity of brodifacoum to all birds and mammals in general is high (Erickson and Urban 2004). However, animals that have a large body mass, such as pinnipeds, would generally need to ingest more of the compound in order to reach an LD50 threshold.

While the concentration of brodifacoum in bait pellets would be consistent, the number of bait pellets that individual animals would be likely to consume would vary considerably and unpredictably. Furthermore, predatory and scavenging animals can also be exposed to brodifacoum through the consumption of other animals that have previously been exposed (see Section 4.4.4.1.2). It is even more difficult to predict the amount of brodifacoum that would be present in these prey animals, and consequently difficult to predict how much a particular predator or scavenger would need to consume to reach a toxic threshold.

Overall, therefore, it is difficult to accurately predict risk to birds or mammals based on toxicity data. Instead, risks from the toxin will be estimated primarily using animals' risk of exposure (see Section 4.4.4.1.2 below). However, the large body mass of animals such as pinnipeds, which would likely reduce the risk of toxic effects, will also be taken into account. Also, Appendix I contains a very rough model for estimating toxicity in birds and mammals on the South Farallones, which may be used to complement the risk analysis in Chapter 4.

Toxicity to salamanders – Salamanders are insectivores and would only be at risk of brodifacoum exposure through the consumption of prey animals. Very little is known about the specific effects of brodifacoum on reptiles and amphibians. Because little is known quantitatively about the potential effects of brodifacoum on salamanders, potential impacts to salamanders on the South Farallones must be analyzed primarily based on observations from previous island rodent eradications. There is one known case of reptiles found dead after consuming brodifacoum bait, in Mauritius (Merton 1987). However, there have been no indications of adverse population-level effects to island reptiles or amphibians as a result of brodifacoum use for rodent eradication. On Anacapa Island, for example, monitoring of slender salamanders showed no changes in population after rats were eradicated using brodifacoum (Island Conservation unpubl. data). In fact, in many cases, the removal of non-native rodents from the ecosystem has led to large increases in native reptile/amphibian populations (e.g. Eason and Spurr 1995; North et al. 1994; Towns 1991; Towns 1994; Newman 1994; Towns and Dougherty 1994).

Toxicity to invertebrates – Arthropods are not thought to be susceptible to brodifacoum (Booth et al. 2001). Soft-bodied invertebrates such as molluscs may be affected, but the evidence for this is still inconclusive (Booth et al. 2001). The only soft-bodied invertebrates of concern on the South Farallones are intertidal organisms, and the extremely low brodifacoum concentration likely in the intertidal environment would put these organisms at only a low risk of exposure. Post-application sampling in the Anacapa Island rat eradication did not detect any brodifacoum residue in any of the intertidal invertebrates tested (Howald et al. 2005).

Invertebrates may also function as short-term intermediate carriers of brodifacoum that could be ingested by their predators. The exact mechanisms of brodifacoum retention are unclear but the general understanding is that most invertebrates only retain brodifacoum briefly in their digestive system and not in body tissues (Booth et al. 2001).

Toxicity to plants – Plants are not known to be susceptible to toxic effects from brodifacoum.

4.4.4.1.2. Exposure

Exposure to brodifacoum is essentially dependent on two factors:

1. Any food habits, behavior patterns, and other specific characteristics that increase or decrease an animal's exposure to the rodenticide; and
2. The availability of rodenticide in the local environment.

In the form used for rodent control or eradication, brodifacoum can only effectively be delivered through oral ingestion: animals can either ingest brodifacoum by consuming bait pellets (known as "primary exposure"), or by preying or scavenging on other animals that have previously consumed bait pellets (known as "secondary exposure"). Brodifacoum molecules adhere strongly to the bait pellet grains, and are unlikely to be leached away in moisture or precipitation. Once the pellets disintegrate to particles too small for most foraging animals to consume, brodifacoum is essentially unavailable within the environment. Eventually even the sub-measurable quantities of brodifacoum remaining from a fully disintegrated pellet break down to non-toxic component compounds including carbon dioxide and water with no toxic intermediate compounds.

Primary exposure – Herbivorous and omnivorous species are much more likely to consume bait (primary exposure) than carnivorous species (including insectivores) because the bait is composed primarily of grain. None of the carnivorous or insectivorous species on the South Farallones would consume bait pellets intentionally as food.

Secondary exposure – Mice, and any other animals that directly consume bait, can also transfer some of the brodifacoum in their systems to their predators or scavengers (secondary exposure). Different organisms show considerable variation in the amount of time that they retain brodifacoum in their bodies. For vertebrates that are exposed sub-lethally, brodifacoum can be retained in the liver for many months – in rats dosed sub-lethally, brodifacoum concentrations in the liver took 350 days to be reduced by 50 percent (Erickson and Urban 2004). Brodifacoum retention times for birds have not been determined. For invertebrates, the exact mechanisms of brodifacoum retention are unclear but the general understanding is that most invertebrates only retain brodifacoum briefly in their digestive system and not in body tissues (Booth et al. 2001).

The most substantial difference between the two action alternatives considered in this EA lies in the extent, duration, and major exposure pathways of brodifacoum availability for organisms on the South Farallones. A detailed characterization of brodifacoum exposure risk for both action alternatives follows.

Exposure risk under Alternative B (preferred alternative) – Under Alternative B (the preferred alternative), in which bait would primarily be broadcast directly into the environment over a period of at least 10 days, the toxicant would be directly available to any animal that would be apt to ingest the pellets (granivores, omnivores, or the highly curious). Bait would be applied according to EPA regulations, which set specific application rate values, ranges, and/or limits for the bait product used. For the purpose of risk modeling in this document, application rates will be used based on the maximum application rate allowed by the EPA for brodifacoum pellets for conservation purposes: 16 lb/acre (18 kg/ha). Given an estimated individual pellet weight of .08 oz (2.40 g), these application rates equate to a target application rate of 0.66 pellets/yd^2 (or one pellet every 1.51 yd^2) (0.75 pellets/m^2; one pellet every 1.33 m^2). This analytical model assumes the maximum application rate and a pellet size that may not be similar to the optimal size determined during detailed operational planning. The actual application rate may be much lower than this, and the pellet size may be much smaller or even slightly larger, depending on results of detailed operational trials in the future.

Assuming that multiple consecutive bait applications are necessary, as described in Section 2.3.5, the concentration of pellets in the terrestrial environment (including the coastline) would be up to one pellet every 1.51 yd^2 (0.66 pellets/yd^2) immediately after bait application, and would decline steadily for a period of seven to 10 days through consumption by mice, other species, and through pellet degradation (Buckelew et al. 2005). Concentrations would spike again with further bait applications, and then decline steadily again until only trace numbers of bait pellets remain 30 days after bait application is completed. Bait concentrations would decrease on the coastline at a faster rate than in the island interior, due to tidal shifts and sea spray. The precise bait application rate would be calculated, based on experimental bait uptake results, to provide only enough bait to last four days with minimal bait remaining. As long as some bait is available in the environment, some wildlife would be at risk of exposure, but that risk would be proportional to the amount of bait readily available. The vast majority of the brodifacoum would be made unavailable due to pellet disintegration within 30 days of the final bait application, although a trace amount of the toxicant could remain in pellets and fragments on the ground for up to a few months.

Under Alternative B (the preferred alternative), brodifacoum would also be available to animals that prey on bait consumers, particularly on mice ("secondary exposure"). Poisoned mice would be available to predators starting the day that bait application begins and possibly continuing for up to three weeks after the final bait application is complete, although there would probably be too few mice to detect within two weeks after the first bait application is complete. Most evidence indicates that the majority of rodents intoxicated with an anticoagulant retreat to their burrows before succumbing (87-100% in field studies; e.g. Taylor 1993; Howald 1997; Buckelew et al. 2008), so far less than 100% of the mouse population would be exposed to vertebrate scavengers. Any mouse carcasses or other poisoned animals that are exposed to scavengers would be largely decomposed and thus unavailable as food items within 30 days of the final bait application. Furthermore, project staff would attempt to remove carcasses opportunistically or systematically, which would further decrease the likelihood of secondary exposure. A very small number of invertebrates on the island may continue to register measurable levels of brodifacoum for as long as bait pellets are available in the environment, up to a few months after bait application.

Bait would not be broadcast directly into the marine environment, but a limited number of pellets would be likely to drift into the intertidal or nearshore zones. During a rat eradication on Anacapa Island in southern California, project personnel monitoring bait drift into the intertidal environment reported 72 bait pellets in the water over a 598 yd^2 (500 m^2) area, which equates to 0.12 pellets/yd^2 (0.14 pellets/m^2) (Howald et al. 2005). Bait pellets that enter the water would be available for consumption for only a short period of time after entry. In bait disintegration experiments and observations in New Zealand (Empson and Miskelly 1999) and California (Howald et al. 2005), observers found that pellets similar to those planned for use on the South Farallones sank almost immediately and disintegrated completely in as little as fifteen minutes. Brodifacoum's water solubility is very low (Primus et al. 2005; US EPA 1998), making the risk of brodifacoum contaminating the water column also very low. Hypothetically, even if brodifacoum was highly water soluble, and bait was broadcast at the maximum rate of 16 lb/ac (18 kg/ha) into water only 3.3 ft (1 m) deep, the resultant brodifacoum concentration in the water – about 0.04 parts per billion – would still be nearly 1000 times less than the measured LC50 value for trout (0.04 parts per million) (Syngenta 2003). Similar in concept to an LD50 value, this LC50 value represents the concentration of brodifacoum dissolved in water that will be lethal to 50 percent of the trout within 96 continuous hours of exposure in a laboratory test.

Environmental testing during rodent eradications and eradication trials in Alaska (Buckelew et al. 2008) and on Anacapa Island in Southern California (Howald et al. 2005) did not detect brodifacoum in any water samples taken after bait application. Even in a "worst-case scenario," brodifacoum availability in the intertidal and marine environments proved extremely low. In 2001, 17.7 tons of brodifacoum bait pellets – an estimated equivalent of 0.79 lb (360 g) of pure brodifacoum – was accidentally spilled in the tidal environment in New Zealand (Primus et al. 2005). Brodifacoum was measurable in the water at the spill location for only 36 hours and was undetectable afterwards (measuring less than .020 parts per billion). Additionally, brodifacoum was undetectable in sediment samples taken from the ocean floor nine days after the spill.

Some intertidal invertebrates would be likely to consume bait pellets or ingest bait fragments through filter feeding, and could therefor function as intermediate carriers of brodifacoum to predator animals. However, due to the rapid disintegration of bait pellets in water the likelihood of intertidal organisms ingesting them would be low.

Exposure risk under Alternative C – Under Alternative C, bait would be available to mice in enclosed bait stations over most of the islands. In steep areas that bait stations could not be effectively installed or maintained, bait would be aerially broadcast or broadcast by hand. As compared with Alternative B (the preferred alternative), under Alternative C there would be less bait available for direct consumption by species larger than mice, although bait stations would not completely prevent bait from being transported into the open by mice or other animals.

Because mice and other animals often carry food away before eating it, some bait and bait fragments would likely be available on the ground after being transported by mice or other animals. The amount of bait on the ground in areas treated with bait stations would always be much lower than areas treated with bait broadcast, but bait would be available for much longer than in Alternative B. Bait stations would need to be kept armed for more than one year, during which time bait would be available to any animals that could enter or vandalize the bait stations, and small amounts of bait could be transported outside of stations and left in the open.

The precise locations and extent of bait station coverage under Alternative C have not been determined, but over 25 percent of the island surface area is inaccessible by foot and this area would need to be treated with a bait broadcast. In areas that are treated by broadcast, bait would be available according to the same parameters as in Alternative B (described above in this section). Much of the area that would need to be treated by broadcast is along the shoreline, so the overall likelihood of bait entering the intertidal environment in Alternative C would actually be similar to Alternative B. Within terrestrial areas that are treated by bait broadcast, bait would be available for a similar duration of time as in Alternative B, with nearly all of the brodifacoum unavailable within 30 days of the final broadcast application.

As with Alternative B, brodifacoum would also be available to animals that prey on bait consumers under Alternative C. While less bait would be available in the environment for primary consumption under Alternative C, brodifacoum would be available in small quantities for a considerably longer duration of time than in Alternative B because bait stations would stay armed for more than one year.

Table 4.1. Likelihood of exposure to brodifacoum based on food habits and other characteristics

Food habits/habitat	**Exposure risk: Alternative B (preferred alternative)**			**Exposure risk: Alternative C**			**Taxon examples** (not **exhaustive)**
	Primary	*Secondary*	*Risk window*	*Primary*	*Secondary*	*Risk window*	
Terrestrial/intertidal foragers							
Diet: Seeds/plant matter	High	Negligible	High for <50 days; low for a few months	Low-High	Negligible	Low for more than 1 year; high for <50 days	Geese; sparrows
Diet: Animals							
Mice	Negligible	High	High for <50 days; low for a few months	Negligible	Low-High	High for 6 weeks; low for more than 1 year	Owls; hawks
Birds	Negligible	Low	A few months	Negligible	Low	More than 1 year	Peregrine falcon; merlin
Large inverts	Negligible	High	A few months	Negligible	Low-High	High for 3 months total; low for more than 1 year	Sandpipers; wrens; salamanders
Micro-inverts	Negligible	Low	A few months	Negligible	Low	More than 1 year	Warblers; vireos; hummingbirds
Diet: Omnivorous	High	High	A few months	Low (except mice)	Low	More than 1 year	Gulls; turnstones; sparrows; mice
Rocky intertidal foragers							
Diet: Large intertidal inverts	Negligible	Low	<50 days	Negligible	Low	<50 days	Most shorebirds
Marine foragers	Negligible	Negligible	N/A	Negligible	Negligible	N/A	Grebes; most seabirds; pinnipeds
*Intertidal organisms**	Low	Negligible	<50 days	Low	Negligible	<50 days	Mussels; crabs; intertidal fish
*Benthic and pelagic fish***	Negligible	Negligible	N/A	Negligible	Negligible	N/A	Anchovies; rockfish

* Invertebrate exposure data is only relevant for extrapolations of secondary exposure likelihood for predators on intertidal invertebrates
** Fish are not considered in detail. See Section 4.2.3.2 for rationale.

4.4.4.1.3. Assessing overall risk from brodifacoum use

The risk of brodifacoum poisoning is a function of both exposure and toxicity. In other words, the toxicity of brodifacoum is only relevant if the species of concern has an actual risk of exposure. Because there are so few data on sublethal effects of brodifacoum in wildlife, it is not possible to precisely predict the likelihood or characteristics of these effects. Furthermore, it is even more difficult to predict whether or not sublethal effects, if they do occur, would lead to measurable decreases in the fitness of individual animals. However, the only pathways for brodifacoum exposure are through direct bait consumption or through predation on bait consumers, and all of the species on the South Farallones that would be at risk of sublethal brodifacoum exposure through either of these pathways would also be at risk of lethal exposure. In order to compensate for the lack of data on the sublethal effects of brodifacoum, the risk level of lethal exposure to brodifacoum will be estimated liberally in this document.

Usually, the likelihood of discovering all of the individual nontarget deaths attributable to island rodent eradications is very small. In most instances, the Service would not expect to discover a precise number of dead or sublethally affected species attributable to brodifacoum. For example, it would be possible that individual birds would succumb to brodifacoum after leaving the islands. However, the Service can still estimate the likelihood and severity of toxin impacts to most of the animal populations on the Farallones based on evidence from other similar island restoration projects, an understanding of the likelihood of exposure to brodifacoum in different taxa, and the ability of populations of different species to recover from impacts to individuals.

4.4.4.2. Toxin impacts under Alternative B (preferred alternative): Mouse eradication with aerial bait broadcast as primary technique

4.4.4.2.1. Introduction

The only animals on the South Farallones that would be at more than negligible risk of exposure to brodifacoum would be animals that feed in the terrestrial or intertidal ecosystems. Potentially vulnerable taxa that forage in the terrestrial and intertidal ecosystems on the islands include gulls, shorebirds, birds of prey, other landbirds, and salamanders. The high abundance and broad diet of gulls on the islands makes them more vulnerable to effects from brodifacoum, so they are discussed separately.

4.4.4.2.2. Toxin impacts to terrestrial and intertidal foragers under Alternative B (preferred alternative)

Brodifacoum exposure risk – Generally, birds that primarily eat plant matter such as seeds and fruits would initially be at high risk for primary exposure to brodifacoum. Predators and scavengers, including both birds and salamanders, would in some cases initially be at high risk of secondary exposure to brodifacoum. Animals that feed on mice, mouse carcasses, or large ground-dwelling invertebrates such as beetles would initially be at high risk of secondary exposure to brodifacoum. Birds that have a broad, omnivorous diet would initially be at high risk for both primary and secondary exposure.

The risk of exposure (either primary or secondary) in initially high-risk animals (terrestrial herbivores, many predators and scavengers, and omnivores) would begin to decline rapidly within 30 days of the final bait application session as the mouse population declines, bait pellets are consumed or disintegrated, and bait becomes less available to invertebrate consumers. The risk of exposure in these initially high-risk animals would generally be low within 30 days of the final bait application, and negligible within a few months.

On the other hand, birds foraging in the intertidal zone would be at lower risk for primary exposure because pellets that enter the water would disintegrate and become unavailable within a few hours. Similarly, birds that forage primarily in the intertidal zone and specialize in intertidal invertebrates would only be at an initially low risk of secondary exposure. Also, birds and bats that feed primarily on flying insects and "micro-invertebrates" would be at an initially low risk of secondary exposure due to the low likelihood that these classes of invertebrates would be carrying brodifacoum in their systems. Finally, peregrine falcons (*Falco peregrinus*), which almost exclusively feed on birds, would initially be at low risk of secondary exposure.

The risk of exposure (secondary) in birds and bats that feed on flying insects and "micro-invertebrates", as well as peregrine falcons, would initially be low, and would steadily decline to negligible within a few months. The likelihood of exposure in intertidal specialists would decline even more rapidly, becoming negligible within 30 days of the final bait application.

Overall toxin risks to terrestrial/intertidal foragers – Because the toxicity of brodifacoum to both birds and bats is high, the risk of brodifacoum exposure would roughly correspond to the risk of mortality or sublethal effects in individual animals.

For terrestrial herbivores, many predators and scavengers, and omnivores, the risk of mortality or sublethal effects in individual birds would initially be high, during the period in which bait is actively being applied. Once bait application is complete, the risk of mortality or sublethal effects would decline rapidly, becoming low within 30 days of the final bait application and negligible within a few months. Bird species that would fit this high-risk profile may include:

- Canada goose (*Branta canadensis*) (2-3 individuals may be present)
- Northern harrier (*Circus cyaneus*) (1 individual may be present)
- Red-tailed hawk (*Buteo jamaicensis*) (1 individual may be present)
- Black-bellied plover (*Pluvialis squatarola*) (1-3 individuals may be present)
- Killdeer (*Charadrius vociferus*) (3-9 individuals may be present)
- Black oystercatcher (30-90 individuals may be present)
- Barn owl (1 individual may be present)
- Burrowing owl (3-9 individuals may be present)
- Long-eared owl (*Asio otus*) (1 individual may be present)
- Short-eared owl (*Asio flammeus*) (1 individual may be present)
- Northern saw-whet owl (*Aegolius acadicus*) (1 individual may be present)
- Hermit thrush (*Catharus guttatus*) (3-9 individuals may be present)
- American robin (*Turdus migratorius*) (10-29 individuals may be present)
- Varied thrush (*Ixoreus naevius*) (1-2 individuals may be present)
- Starling (at least 90 birds may be present)

- Fox sparrow (1-4 individuals may be present)
- White-crowned sparrow (1-6 individuals may be present)
- Golden-crowned sparrow (2-10 individuals may be present)
- Dark-eyed junco (*Junco hyemalis*) (1-2 individuals may be present)
- Western meadowlark (3-25 birds may be present)
- Pine siskin (*Carduelis pinus*) (1-2 individuals may be present)

The high theoretical risk to these bird species does not imply that all of the individuals present during the project would be affected. Individual differences in foraging behavior and brodifacoum toxicity would substantially affect the risk to individuals. Nevertheless, individual mortalities among some of these species would be likely.

With the exception of black oystercatchers, none of these birds breed on the Farallon Islands, and they represent a negligible fraction of the mainland populations with which they are associated. Therefore, the impact of a small number of individual mortalities on the effective breeding populations of most of these species would be negligible. The impact of a small number of individual mortalities on the South Farallones black oystercatcher population would be negligible to low, well below the threshold of significance described in Section 4.4.2.

For birds that feed on flying insects and "micro-invertebrates", intertidal specialists, and birds of prey that specialize on other birds, the risk of mortality or sublethal effects in individual animals would be low (during and immediately after active bait application) to negligible (within 30 days of the final bait application session). Species that would fit this low-risk profile may include:

- Sharp-shinned hawk (*Accipiter striatus*) (1-2 individuals may be present)
- Peregrine falcon (2-5 individuals may be present)
- Wandering tattler (4-9 individuals may be present)
- Willet (*Tringa semipalmata*) (3-5 individuals may be present)
- Whimbrel (*Numenius phaeopus*) (7-11 individuals may be present)
- Ruddy turnstone (3-9 individuals may be present)
- Black turnstone (40-90 individuals may be present)
- Black phoebe (2-6 individuals may be present)
- Yellow-rumped warbler (1-12 individuals may be present)

Bats also fit this low-to-negligible risk profile, but it is unlikely that any bats would be present during bait application activities in Alternative B.

The low theoretical risk to these species does not imply that effects to individual animals would not occur. Individual differences in foraging behavior and brodifacoum toxicity would substantially affect the risk to individuals. Nevertheless, individual mortalities among some of these species would be possible. The impact of a small number of individual mortalities on local populations of most of these species would be negligible.

The toxicity of brodifacoum to salamanders is unknown. Consequently, the risk of individual mortalities in salamanders is unknown. However, based on evidence from rodent eradications elsewhere in the world (see Section 4.4.4.1.1), brodifacoum use would not be likely to lead to negative population-level effects in salamanders.

Brodifacoum exposure risk to gulls – Gulls in the genus *Larus* are omnivorous generalists in diet, foraging at sea as well as scavenging on land. These feeding habits set them apart from most of the other seabirds that occur on the South Farallones and also increase their risk of exposure to brodifacoum. Due to their dietary habits, large *Larus* gulls would be at high risk of exposure to brodifacoum starting immediately after bait application begins. Individual gulls would mostly be at risk of secondary exposure through predation and scavenging of mice and invertebrates that have consumed bait rather than primary exposure through direct ingestion of bait pellets. Project staff would opportunistically or systematically remove mouse carcasses after bait application, which would reduce this risk somewhat.

Western gulls, the most abundant breeding species, are present on the South Farallones essentially year-round but during the early-winter target time period for bait application the western gull population is much lower than during breeding season. While western gull attendance patterns outside of the breeding season are extremely variable from year to year, in general the late fall and early winter are characterized by the gradual arrival of western gulls returning after a brief absence in the early fall to stake out territories for the spring breeding season (Penniman et al. 1990). The Western gull population on the South Farallones during this time window can be quantified very roughly as 50% of the breeding population (Penniman et al. 1990; PRBO unpubl. data). Extrapolated from the average breeding population from 1997-2006 (18,091 birds; Warzybok and Bradley 2007), there would be roughly 9,000 western gulls present during and immediately after the bait application time window. Most of these gulls would be occupying breeding territories during this time, and therefore present somewhat regularly.

Other large gull species are also present during the bait application time window, although much less abundant than western gulls. These generally include:

- California gull (*Larus californicus*) (which breed on the islands alongside western gulls) (between 70 and 430 individuals may be present)
- Herring gull (*Larus argentatus*) (4-21 individuals may be present)
- Glaucous-winged gull (*Larus glaucescens*) (11-43 individuals may be present)

Occasional individuals or groups of a few other species are possible, including:

- Heermann's gull (*Larus heermanni*) (3-9 individuals may be present)
- Mew gull (*Larus canus*) (3-9 individuals may be present)
- Thayer's gull (*Larus thayeri*) (3-9 individuals may be present)

During the late fall and early winter, gulls on the South Farallones generally leave the island during mid-day, presumably to forage elsewhere. These gull species are generalist predators that primarily feed on marine invertebrates and fishes. However, they may also eat the eggs, chicks, and adults of other bird species or even other gulls, and they are opportunistic scavengers on both natural and man-made refuse. Within this wide dietary range, certain individuals are thought to specialize, particularly in the case of secondary food resources. Although it is possible that individual gulls could consume bait pellets directly, the more likely exposure scenario would be secondary exposure through consumption of brodifacoum-intoxicated mice. Based on a conservative average of gull body weight (1.8 lb; 800 g), the assumption that gulls have an LD50 value for brodifacoum similar to a mallard (0.4 mg/kg), and figures extrapolated from "body burden" data for rodents feeding on brodifacoum bait (appr. 4.9 mg/kg) (Howald et al. 1999), a western gull could ingest a potentially lethal amount of brodifacoum through the consumption of one to three intoxicated mice.

Gulls' exposure risk level, while initially high, would begin to decline rapidly within 30 days of the final bait application session, as the mouse population declines and bait pellets are consumed or disintegrated. Exposure risk would be low within 30 days of the final bait application, and negligible within a few months.

Overall risks to gulls from brodifacoum use – The toxicity of brodifacoum to gulls is high. Furthermore, the likelihood of gulls experiencing both primary and secondary exposure to brodifacoum would be high during and after bait application. Overall, the risk of mortality or sub-lethal effects in gulls on and around the South Farallones as a result of brodifacoum use would be high from the first bait application to approximately three weeks after the final bait application. The risk would decline to low within 30 days of the final application, and would be negligible within a few months.

Implementation of mouse eradication activities as described in Alternative B would likely lead to individual mortalities in gulls on the South Farallones. Overall, however, the evidence indicates that significant (population-level) effects on any of the gull species present would be unlikely. The western gull colony on Anacapa Island in southern California (approximately 2,500 birds; Sowls et al. 1990) was not affected by a rat eradication project with brodifacoum exposure parameters very similar to Alternative B. A total of only two deceased western gulls, suspected to have succumbed to the effects of brodifacoum, were found during extensive searches of the islands after bait application. While it is likely that more than two gulls on Anacapa were exposed to brodifacoum, there is no evidence that brodifacoum use affected the western gull population on Anacapa in any measurable way. Individual gull mortalities have also been recorded as a result of brodifacoum-based rodent eradications elsewhere (Eason et al. 2002) but there is similarly no evidence available for population-level effects on any *Larus* species as a result of brodifacoum use, despite this genus's varied diet.

Extrapolated directly from the proportion of gulls within the Anacapa colony found dead after brodifacoum application for rodent eradication (0.08 percent of the total western gull breeding population), the Service would expect to find 15 western gulls dead as a result of brodifacoum ingestion on the South Farallones. Due to gulls' highly mobile nature, this number would likely be an underestimate of the total number of lethally-exposed gulls. However, since many of the western gulls on the South Farallones during the application time period would already be defending breeding territories (Penniman et al. 1990), they would not be likely to disperse far from the islands and would likely spend (very roughly) 50 percent of their time on breeding territories. Therefore, doubling the total number of anticipated western gull mortalities – 30 – would account for individuals that succumb to brodifacoum away from the islands.

The Service may also discover one or two individual mortalities in other gull species. All of these mortalities would likely be individuals that consumed intoxicated mice. These low levels of mortality would be unlikely to result in population-level effects to any of these species.

4.4.4.2.3. Toxin impacts to marine foragers under Alternative B (preferred alternative)

Brodifacoum exposure risk – Most of the marine birds, and all of the pinnipeds, present in nearshore waters feed exclusively on marine organisms and do not feed while on land, so the only possible routes for bait ingestion would be accidental. The likelihood of primary exposure to brodifacoum would therefore be negligible, and the likelihood of secondary exposure through fish or other prey species would be negligible as well (as discussed above in Section 4.2.3.2).

There are two exceptions:

1. There are a number of *Larus* gull species that forage at sea, but due to their habits of feeding on land as well they are analyzed separately in Section 4.4.4.2.2, above.
2. Some pinniped pups that may be present on land may experimentally ingest individual pellets during reflexive suckling, but the low pellet density on land (less than one pellet per yd^2) would make ingestion of multiple pellets extremely unlikely.

Species that regularly occur on the South Farallones during Alternative B that forage for food exclusively in marine environments include:

- Surf scoter
- Pacific loon (*Gavia pacifica*)
- Common loon (*Gavia immer*)
- Eared grebe
- Western/Clark's grebe (*Aechmophorus occidentalis/A. clarkii*)
- Northern fulmar (*Fulmarus glacialis*)
- Sooty shearwater
- Ashy storm-petrel
- Brown pelican*
- Brandt's cormorant
- Pelagic cormorant (*Phalacrocorax pelagicus*)
- Red phalarope (*Phalaropus fulicarius*)
- Black-legged kittiwake (*Rissa tridactyla*)
- Common murre
- Ancient murrelet (*Synthliboramphus hypoleucus*)
- Cassin's auklet
- Rhinoceros auklet
- California sea lion
- Steller sea lion*
- Harbor seal
- Northern fur seal
- Northern elephant seal

*Brown pelicans and Steller sea lions, each listed under ESA, would be at negligible risk of exposure to brodifacoum. Due to their special status, they are discussed separately below.

Overall toxin risks to marine foragers – The toxicity of brodifacoum to marine birds and pinnipeds is likely high. However, the likelihood of most marine birds, and all pinnipeds, experiencing either primary or secondary exposure to brodifacoum would be essentially negligible. Therefore, the overall risk of mortality or any sub-lethal effects in most of the marine birds present in nearshore waters around the South Farallones as a result of brodifacoum use would be negligible. Furthermore, due to their large body sizes even at the smallest end of the large range described earlier in this section, pinnipeds would need to consume an extremely large dose of brodifacoum in order to be at risk of adverse effects from the toxin.

California brown pelican (Endangered) – California brown pelicans forage and rest in the waters surrounding the South Farallones, and use the islands' terrestrial habitat for roosting. California brown pelicans would be likely to be present during bait application operations. California brown pelicans are exclusively piscivorous and do not feed while on land, so the only possible routes for bait ingestion would be accidental. The likelihood of primary exposure would therefore be negligible, and the likelihood of secondary exposure through fish or other prey species would be negligible as well (as discussed above in Section 4.2.3.2).

The toxicity of brodifacoum to California brown pelicans is likely high. However, the likelihood of pelicans experiencing either primary or secondary exposure to brodifacoum would be negligible. Therefore, the overall risk of pelican mortality or any sub-lethal effects as a result of brodifacoum use would be negligible.

Steller sea lion (Threatened) – Steller sea lions are marine mammals, but they also use terrestrial habitat year-round. Steller sea lions are likely to be present in the waters surrounding the South Farallones, and may be hauled out on beaches or rocky shoreline at any given time during bait application operations. Steller sea lions are carnivorous (almost exclusively piscivorous) and do not feed while on land, so the only possible routes for bait ingestion would be accidental. Pups may experimentally ingest individual pellets on land during reflexive suckling, but the low pellet density (less than one pellet per yd2) would make ingestion of multiple pellets unlikely. The likelihood of primary exposure would therefore be negligible, and the likelihood of secondary exposure through fish or other prey species would be negligible as well (as discussed above in Section 4.2.3.2).

The toxicity of brodifacoum to Steller sea lions is likely high. However, the likelihood of Steller sea lions experiencing either primary or secondary exposure to brodifacoum would be negligible. Furthermore, due to their large body size, Steller sea lions would need to consume an extremely large dose of brodifacoum in order to be at risk of adverse effects from the toxin. Therefore, the overall risk of Steller sea lion mortality or any sub-lethal effects as a result of brodifacoum use would be negligible.

4.4.4.3. Toxin impacts under Alternative C: Mouse eradication with bait station delivery as primary technique

4.4.4.3.1. Introduction

One major difference between Alternative C and Alternative B (the preferred alternative) is that the project activities in Alternative C would take place over a much longer duration. Alternative B would only take place during late fall and early winter months, when the biological community at the South Farallones is much smaller than in other seasons. On the other hand, Alternative C would require activities over a period of up to two years, which could expose a much larger diversity of birds to brodifacoum, specifically migratory birds that visit the islands during the fall and spring seasons.

4.4.4.3.2. Toxin impacts to terrestrial and intertidal foragers under Alternative C

Brodifacoum exposure risk – In general, birds would not have access to bait loaded into bait stations, but they may encounter small amounts of bait that has been removed from bait stations by mice or other animals throughout the course of operations. In addition, birds that are foraging on land would likely encounter bait pellets during and after aerial bait broadcast on areas that are not included in the bait station grid.

Salamanders may be able to access to bait loaded into bait stations throughout the course of operations, as well as during and after aerial bait broadcast, but they are insectivorous and would be unlikely to consume bait.

Birds that primarily eat plant matter such as seeds and fruits would be at some risk for primary exposure to brodifacoum as long as bait is available in the environment, for more than one year. Their exposure risk would be low but not negligible as long as bait stations are present and armed with bait. Exposure risk in these birds would become high when bait is aerially broadcast on areas that are not included in the bait station grid. Within 30 days of the final aerial bait application, their risk level would drop again to low and remain low until bait stations are removed, up to two years after their initial installation.

However, birds foraging for plant matter in the intertidal zone would only be at low risk of exposure (primary) during broadcast application, because pellets that enter the water would disintegrate and become unavailable within a few hours. These birds would be at negligible risk of brodifacoum exposure outside of the aerial bait application period.

Many predators and scavengers, including both birds and salamanders, would be at some risk of exposure (secondary) to brodifacoum as long as bait is available in the environment, for more than one year. Animals that feed on mice or mouse carcasses would be at high risk of brodifacoum exposure for an initial period of about six weeks after bait stations are first installed due to the abundance of mice that have been exposed. After the mouse population drops, exposure risk in these animals would drop to low. Animals that feed on large ground-dwelling invertebrates (such as beetles) but do not feed on mice, including some bird species and salamanders, would only be at low risk of exposure (secondary) beginning with the installation of bait stations. Exposure risk in most predators and scavengers (including those that do not eat mice) would increase to high when bait is aerially broadcast on areas that are not included in the bait station grid. Within 30 days of the final aerial bait application, their risk level would again drop to low and remain low until bait stations are removed.

Birds and bats that feed primarily on flying insects and "micro-invertebrates" would be at only a low risk of exposure throughout the operation due to the low likelihood that these classes of invertebrates would be carrying brodifacoum in their systems. Additionally, peregrine falcons, which almost exclusively feed on birds, would only be at low risk of secondary exposure throughout the operation.

Birds that forage primarily in the intertidal zone and specialize in intertidal invertebrates would be at negligible risk of exposure outside of the aerial bait application period. They would only be at a low risk of secondary exposure during broadcast application. The likelihood of exposure in intertidal specialists would be negligible within 30 days of the final bait application.

Birds that have a broad, omnivorous diet would be at high risk for both primary and secondary exposure to brodifacoum as long as bait is available in the environment, for more than one year.

Overall toxin risks to terrestrial/intertidal foragers – Because the toxicity of brodifacoum to both birds and bats is high, the risk of brodifacoum exposure would roughly correspond to the risk of mortality or sublethal effects in individual animals.

For 1) terrestrial herbivores, 2) many predators and scavengers (except those discussed later), and 3) many omnivores, the risk of mortality or sublethal effects in individual birds would be low but not negligible for as long as bait stations are present and armed with bait, for more than one year. Their risk would become high for a short time period during the project, when bait is aerially broadcast on areas that are not included in the bait station grid. Risk would again be low within 30 days of the final aerial bait application. The risk of mortality or sublethal effects in these birds would remain low until bait stations are removed. Bird species that fit this risk profile and may be present during aerial bait broadcast – when they would be at high risk – may include:

- Canada goose (2-3 individuals may be present)
- Black-bellied plover (1-3 individuals may be present)
- Black oystercatcher (30-90 individuals may be present)
- Killdeer (3-9 individuals may be present)
- Fox sparrow (1-4 individuals may be present)
- White-crowned sparrow (1-6 individuals may be present)
- Golden-crowned sparrow (2-10 individuals may be present)
- Dark-eyed junco (1-2 individuals may be present)
- Pine siskin (1-2 individuals may be present)
- Starling (at least 90 birds may be present)
- Western meadowlark (3-25 birds may be present)

For animals that feed on mice or mouse carcasses, there would be a high risk of mortality or sublethal effects in individual animals for an initial period of about six weeks after bait stations are first installed due to the abundance of mice that have been exposed. However, far less than 100% of the mouse population would be available to predators and scavengers because most mice would retreat to burrows before expiring. After the mouse population has been reduced, exposure risk in these animals would drop to low. When bait is aerially broadcast on areas that are not included in the bait station grid, the risk of mortality or sublethal effects in individual animals would again become high temporarily but decrease to low within 30 days of the final aerial bait application and remain low until bait stations are removed. Mouse predators and scavengers that would fit this particular risk profile if they are present on the South Farallones at some point in time under Alternative C may include (average abundance could vary considerably between seasons):

- Great blue heron (*Ardea herodias*)
- Northern harrier

- Red-tailed hawk
- Rough-legged hawk (*Buteo lagopus*)
- American kestrel (*Falco sparverius*)
- Barn owl
- Burrowing owl
- Long-eared owl
- Short-eared owl
- Northern saw-whet owl

The temporarily high theoretical risk to individuals of the species listed in the paragraphs above does not imply that all of the individuals present during the project would be affected. Individual differences in foraging behavior and brodifacoum toxicity would substantially affect the risk to individuals. Nevertheless, individual mortalities among some of these species would be likely. More comprehensive lists of regularly-occurring bird species on the South Farallones that would fit this risk profile, including birds that would only be likely to arrive during low-risk time periods, are included in Appendix D.

With the exception of black oystercatchers, none of the birds listed above breed on the Farallon Islands, and represent a negligible fraction of the mainland populations to which they are associated. Therefore, the impact of a small number of individual mortalities on the effective breeding populations of most of these species would be negligible. The impact of a small number of individual mortalities on the South Farallones black oystercatcher population would be negligible to low, well below the threshold of significance described in Section 4.4.2.

For birds that forage exclusively in the intertidal zone, there would be a short time period of low risk of mortality or sublethal effects in individual birds during broadcast application. There would be a negligible risk of mortality or sublethal effects in these birds within 30 days of the final bait application. Before bait has been applied aerially, these birds would likewise have a negligible mortality risk. Bird species that may fit this particular risk profile in Alternative C are identical to those listed in Alternative B, including:

- Wandering tattler (4-9 individuals may be present)
- Willet (3-5 individuals may be present)
- Whimbrel (7-11 individuals may be present)
- Ruddy turnstone (3-9 individuals may be present)
- Black turnstone (40-90 individuals may be present)

For birds and bats that feed on flying insects and “micro-invertebrates”, as well as birds of prey that specialize on other birds, the risk of mortality or sublethal effects in individual animals would be low throughout the operation, for as long as bait stations are present. A list of regularly-occurring species that would fit this risk profile if they are present on the South Farallones at some point in time under Alternative C is included in Appendix D.

The low theoretical risk to these species does not imply that effects to individual animals would not occur. Individual differences in foraging behavior and brodifacoum toxicity would substantially affect the risk to individuals. Nevertheless, individual mortalities among some of these low-risk species would be possible. The impact of a small number of individual mortalities on local populations of most of these species would be negligible.

The toxicity of brodifacoum to salamanders is unknown. Consequently, the risk of individual mortalities in salamanders is unknown. However, based on evidence from rodent eradications elsewhere in the world (see Section 4.4.4.1.1), brodifacoum use would not be likely to lead to negative population-level effects in salamanders.

Brodifacoum exposure risk to gulls – Due to their dietary habits, large *Larus* gulls would be at risk of exposure to brodifacoum throughout the operation. Individual gulls would mostly be at risk of secondary exposure through predation and scavenging of mice and invertebrates that have consumed bait rather than primary exposure through direct ingestion of bait pellets. Bait stations would further reduce the probability that gulls would be able to access bait directly, but gulls are known for their relative ingenuity and persistence and it is possible that some gulls would be able to pry open the stations. Additionally, small amounts of bait that have been removed from bait stations by mice or other animals may be available to gulls.

Gulls' risk of brodifacoum exposure would be particularly high for a period of about six weeks after bait stations are first installed due to the abundance of mice that have been exposed. However, the western gull population on the South Farallones is greatly reduced during this period – during the fall after the peak seabird breeding season has subsided – so far fewer individual gulls would be at risk of exposure (Penniman et al. 1990). Gull species present during this initial period of high risk may include:

- Heermann's gull (more than 90 individuals may be present)
- Mew gull (10-30 individuals may be present)
- Ring-billed gull (3-9 individuals may be present)
- California gull (more than 90 individuals may be present)
- Herring gull (more than 90 individuals may be present)
- Thayer's gull (3-9 individuals may be present)
- Western gull (more than 90 individuals may be present)
- Glaucous-winged gull (more than 90 individuals may be present)

After the mouse population drops as a result of bait station deployment, exposure risk in gulls would drop to low. It would increase to high again when bait is aerially broadcast on areas that are not included in the bait station grid. In Alternative C, overall exposure risk in gulls would be lower during the period of aerial bait application than in Alternative B (see Section 4.4.4.2.2), because there would be far fewer – if any – mice available to consume. However, gulls may nevertheless still be at high risk of primary exposure during this period. Gull species that may be present during the aerial bait application time window would, identical to the list in Alternative B, include:

- California gull (which breed on the islands alongside western gulls) (between 70 and 430 individuals may be present)
- Herring gull (4-21 individuals may be present)
- Western gull (roughly 9,000 gulls may be present)
- Glaucous-winged gull (11-43 individuals may be present)

Occasional individuals or groups of a few other species are possible during this time period, including:

- Heermann's gull (3-9 individuals may be present)
- Mew gull (3-9 individuals may be present)
- Thayer's gull (3-9 individuals may be present)

Within 30 days of the final aerial bait application, their risk level would again drop to low and would remain low until bait stations are removed. Over time, many more gulls would be at some risk of exposure to brodifacoum in Alternative C than in Alternative B (see Section 4.4.4.2.2), because bait stations (and therefore at least a small amount of bait) would be present through the subsequent gull breeding season. Project staff would opportunistically or systematically remove mouse carcasses throughout the project, which would reduce this risk somewhat.

Overall toxin risk to gulls – The toxicity of brodifacoum to gulls is high. Furthermore, the likelihood of gulls experiencing both primary and secondary exposure to brodifacoum would vary from low to high over a period of more than one year. Overall, for more than one year there would be at least a low risk of mortality or sub-lethal effects in individual gulls on and around the South Farallones as a result of brodifacoum use. Soon after bait stations are first deployed, there would be a high risk of mortality or sublethal effects in individual gulls, but the gull population present would be at its lowest annual level during this period. There would again be a high risk of mortality or sublethal effects in individual gulls during aerial bait application later in the season, when roughly half of the western gull population would be present.

Implementation of mouse eradication activities as described in Alternative C would likely lead to individual mortalities in gulls on the South Farallones. Overall, however, the evidence indicates that significant (population-level) effects on any of the gull species present would be unlikely. On Anacapa Island in Southern California, which is also home to a large western gull colony, a rat eradication project with brodifacoum exposure parameters similar in intensity to Alternative C but over a shorter time period, there were no changes detected in the population size of the gull colony during the subsequent breeding seasons after the operations were complete that could be attributed to the introduction of brodifacoum. The Anacapa project provides the best evidence available for the probable response of the western gulls on the South Farallones after mouse eradication, which indicates that significant (population-level) effects on western gulls would be unlikely, according to the criteria described in Section 4.4.2.

The abundances of other gull species on the South Farallones during the risk period in Alternative C – much longer than in Alternative B – also vary widely. None of these gull species, all of which would be at risk of mortality, are numerous enough on the South Farallones to lead to noticeable population changes in their respective source populations that could be considered significant according to the criteria described in Section 4.4.2.

However, due to the major disturbance events as a result of mouse eradication activities as described in Alternative C, the western gull and California gull populations at the South Farallones would likely be noticeably affected, particularly in the form of reduced breeding success, for up to two breeding seasons. The Service would consider this negative impact to be significant, and if Alternative C is chosen – presumably in order to minimize disturbance from helicopter operations – NEPA regulations would require the preparation of an EIS to examine the negative impacts of this action, particularly on breeding seabirds such as western and California gulls, in greater detail.

4.4.4.3.3. Toxin impacts to marine foragers under Alternative C

Brodifacoum exposure risk – Most of the marine birds, and all of the pinnipeds, present in nearshore waters feed exclusively on marine organisms and do not feed while on land, so the only possible routes for bait ingestion would be accidental. The likelihood of primary exposure to brodifacoum would therefore be negligible (similar to Alternative B), and the likelihood of secondary exposure through fish or other prey species would be negligible as well (as discussed above in Section 4.2.3.2).

There are two exceptions (similar to Alternative B):

1. There are a number of *Larus* gull species that forage at sea, but due to their habits of feeding on land as well they are analyzed separately in Section 4.4.4.3.2.
2. Some pinniped pups that may be present on land may experimentally ingest individual pellets during reflexive suckling, but the low pellet density on land (less than one pellet per yd^2) would make ingestion of multiple pellets extremely unlikely.

Pinnipeds that may be present include:

- California sea lion
- Steller sea lion
- Harbor seal
- Northern fur seal
- Northern elephant seal

A list of regularly-occurring bird species on or near the South Farallones that forage for food exclusively in marine environments and may be present at some point in time during Alternative C is included in Appendix D.

Pelicans and Steller sea lions, each listed under ESA, would be at negligible risk of exposure to brodifacoum. Due to their special status, they are discussed separately below.

Overall toxin risks to marine foragers – The toxicity of brodifacoum to marine birds and pinnipeds is likely high. However, the likelihood of most marine birds, and all pinnipeds, experiencing either primary or secondary exposure to brodifacoum under Alternative C would be essentially negligible (similar to Alternative B, the preferred alternative). Therefore, the overall risk of mortality or any sub-lethal effects in most of the marine birds present in nearshore waters around the South Farallones as a result of brodifacoum use would be negligible. Furthermore, due to their large body sizes even at the smallest end of the range, pinnipeds would need to consume an extremely large dose of brodifacoum in order to be at risk of adverse effects from the toxin. While toxin risks to marine foragers in Alternative C would be negligible similar to Alternative B, disturbance risks would be different in Alternative C than in Alternative B, particularly for pinnipeds. Detailed discussion of these differences can be found in Section 4.4.5.

California brown pelican (Endangered) – California brown pelicans forage and rest in the waters surrounding the South Farallones, and use the islands' terrestrial habitat for roosting. California brown pelicans would be likely to be present during bait station installation and maintenance, as well as during aerial bait broadcast. California brown pelicans are exclusively piscivorous and do not feed while on land, so the only possible routes for bait ingestion would be accidental. The likelihood of primary exposure under Alternative C would therefore be negligible, and the likelihood of secondary exposure through fish or other prey species would be negligible as well (as discussed above in Section 4.2.3.2).

The toxicity of brodifacoum to California brown pelicans is likely high. However, the likelihood of pelicans experiencing either primary or secondary exposure to brodifacoum under Alternative C would be negligible. Therefore, the overall risk of pelican mortality or any sub-lethal effects as a result of brodifacoum use would be negligible.

Steller sea lion (Threatened) – Steller sea lions are marine mammals, but they also use terrestrial habitat year-round. Steller sea lions are likely to be present in the waters surrounding the South Farallones, and may be hauled out on beaches or rocky shoreline at any given time during bait installation and maintenance as well as during aerial bait broadcast. Steller sea lions are carnivorous (almost exclusively piscivorous) and do not feed while on land, so the only possible routes for bait ingestion would be accidental. After aerial bait broadcast, pups may experimentally ingest individual pellets on land during reflexive suckling, but the low pellet density (less than one pellet per yd^2) would make ingestion of multiple pellets unlikely. The likelihood of primary exposure would therefore be negligible, and the likelihood of secondary exposure through fish or other prey species would be negligible as well (as discussed above in Section 4.2.3.2, and similar to Alternative B, the preferred alternative).

The toxicity of brodifacoum to Steller sea lions is likely high. However, the likelihood of Steller sea lions experiencing either primary or secondary exposure to brodifacoum would be negligible. Furthermore, due to their large body size, Steller sea lions would need to consume an extremely large dose of brodifacoum in order to be at risk of adverse effects from the toxin. Therefore, the overall risk of Steller sea lion mortality or any sub-lethal effects as a result of brodifacoum use under Alternative C would be negligible. While toxin risks to Steller sea lions in Alternative C would be negligible similar to Alternative B, disturbance risks would be different in Alternative C than in Alternative B. Detailed discussion of these differences can be found in Section 4.4.5.

4.4.5. Impacts to Species Vulnerable to Disturbance

4.4.5.1. Analysis framework for impacts from disturbance

4.4.5.1.1. Disturbance under Alternative B (preferred alternative)

Helicopter operations – The operation of low-flying aircraft throughout the South Farallones would be likely to result in disturbance to wildlife from sound, the sudden appearance of an aircraft, or a combination of both (Efroymson et al. 2001). Wildlife would be exposed to noises that exceed background levels. Due to the relatively low altitude at which helicopters would fly, the majority of the helicopter noise would be focused in a narrow cone directly underneath them, reducing the area of disturbance for each helicopter pass (Richardson et al. 1995). Animals on shore would likely be exposed to higher-decibel noise than animals in the water.

During one application pulse, all points on South Farallon Island would likely be subject to two helicopter passes. In addition, coastal areas would be subject to a "dry-run" surveillance flight focused on potential pinniped haulouts. Within one bait application pulse, there would be no more than three consecutive operating days. Over the course of bait application operations, which may entail multiple pulses, there would likely be fewer than 10 days during which the helicopter would operate. The responses of animals to aircraft disturbance, and the adverse effects of this disturbance, vary considerably between species and between different seasons.

Personnel activities – Additional wildlife disturbance could result from personnel traveling by foot across the island (e.g., when hand-broadcasting bait, surveying for non-target mortality, and collecting mouse carcasses), or traveling in small boats in the nearshore waters. Personnel dedicated to mouse eradication would be based on the South Farallones for around one month under Alternative B. Following eradication, there would be monitoring visits to the island for at least two years. There are personnel on the South Farallones conducting ongoing research, monitoring, and other management activities year-round, but mouse eradication would increase the number of personnel on the island and the extent of impact. Most current monitoring activities take place in discrete and limited areas of the island, whereas mouse eradication operations would require personnel to travel throughout the South Farallones. Personnel would be briefed on strategies and techniques to reduce wildlife disturbance, but disturbance events would still be likely to occur.

4.4.5.1.2. Disturbance under Alternative C

Bait station installation and maintenance, and general personnel presence – Bait stations would need to be placed on a grid that covers the majority of the islands' land area, spaced 33 to 66 ft (10-20 m) apart – a total of between several hundred and several thousand stations. Paths and vegetation clearings, boardwalks, and in some cases anchor points, ladders, or fixed lines would be installed in some cases to make each station accessible over the course of more than one year of visits. Each bait station would be secured to the ground with anchors placed into the soil or in some cases drilled into the rock. The anchors would be durable enough to hold the stations in place for more than one year, but they would be removable and not a permanent fixture on the islands. Personnel would then visit stations, primarily to refill them with fresh bait but also to conduct maintenance on the stations or other infrastructure, first at least bi-weekly and then more sporadically over the course of the operation. Personnel would be briefed on strategies and techniques to reduce wildlife disturbance whenever possible, but personnel presence and activities during bait station installation and maintenance would nevertheless cause some level of wildlife disturbance. Disturbance would be greatest during the seabird breeding season.

Helicopter operations – Helicopter operations in Alternative C would be limited to land areas that cannot be reached with the bait station grid. However, this would include 25 percent or more of the total land area. Disturbance within these areas would be similar to that described for Alternative B (the preferred alternative), but the total extent and duration of helicopter disturbance would be less than in Alternative B.

4.4.5.2. Disturbance impacts under Alternative B (preferred alternative): Mouse eradication with aerial bait broadcast as primary technique

4.4.5.2.1. Disturbance to birds under Alternative B (preferred alternative)

The most common response of most landbirds, shorebirds, and waterfowl to disturbance, outside of the breeding season, is to flush and fly away. Frequent flushing over an extended period of time may be harmful to individual birds, but the short duration of the activities proposed in Alternative B would not be likely to affect most birds on the Farallones.

Seabirds are generally more sensitive to disturbance than other bird taxa. Similar to other birds, their most common response to disturbance is to flush and fly away. During past helicopter operations on the Farallones, researchers have described the flushing behavior of gulls and pelicans as leaving the roost, circling overhead for a period of minutes or about an hour, and then returning to roost (J. Buffa, pers. comm.). Repeated flushing may reduce the fitness of individual animals. However, the short duration of the activities proposed in Alternative B would not be likely to affect roosting seabirds. Disturbance to seabirds during the breeding season can lead to major negative impacts on breeding success, but none of the activities proposed in Alternative B would occur during breeding season.

Overall, the level of disturbance to birds from the operations described in Alternative B would not be anticipated to have an effect on the overall energy balance or fitness of any individual animals.

Disturbance to pelicans – The most common observed response of pelicans on the South Farallones to visual and/or auditory disturbance is for birds to flush from a roost and return within minutes or hours (USFWS unpubl. data). Outside of the breeding season, leaving the roost is part of pelicans' normal behavior, and disturbance events that are short in duration and infrequent likely have little effect on individual animals. Overall, the level of disturbance to California brown pelicans from the operations described in Alternative B would not be anticipated to have an effect on the fitness of any individual animals.

4.4.5.2.2. Disturbance to pinnipeds under Alternative B (preferred alternative)

Some pinnipeds are also particularly sensitive to disturbance. Approaching aircraft and the sudden appearance of humans generally flush animals into the water. While entering the water from a haulout is generally part of pinnipeds' normal behavior, repeated disturbance or disturbance during the sensitive behavioral periods of breeding and molting can stress or physically injure individual animals.

During breeding season, a disturbance event that led to all or most of the animals on a haulout or rookery entering the water would leave pups vulnerable to crushing from larger animals. However, none of the activities proposed in Alternative B would occur during the breeding season for Steller sea lions, California sea lions, harbor seals, or northern fur seals, and any pups of these species that are present would likely be mobile enough to avoid trampling. The helicopter application would be timed to be complete before the first northern elephant seal pup of the season is born.

The short duration of the activities proposed in Alternative B would not be likely to affect pinnipeds on the South Farallones. Furthermore, the inclusion of a "dry-run" surveillance flight over pinniped haulouts would allow the helicopter pilot to facilitate a more controlled disturbance event, which would likely cause sensitive animals to flush and largely remain in the water during the actual bait application a short time later, reducing the overall level of disturbance to pinnipeds. Overall, the level of disturbance to the pinnipeds analyzed here from the operations described in Alternative B would not be anticipated to have any effect on overall energy balance or fitness of any individual animals.

Disturbance to Steller sea lions – The response of Steller sea lions to visual and/or auditory disturbances varies from no discernable reaction to completely vacating haulouts (Calkins 1983; Efroymson and Suter 2001). Low overflying aircraft and the close approach of humans generally flush animals into the water. Entering the water is generally part of Steller sea lions' normal behavior, and disturbance events that are short in duration and infrequent likely have little effect on the overall energy balance or fitness of individual animals (Richardson et al. 1995). During the breeding season, a disturbance event that led to all or most of the animals on a haulout or rookery entering the water would leave pups vulnerable to crushing from larger animals. However, the actions proposed in Alternative B would occur entirely outside of the Steller sea lion breeding season and any pups that are present should be mobile enough to avoid trampling. Furthermore, the inclusion of a "dry-run" surveillance flight over pinniped haulouts would allow the helicopter pilot to facilitate a more controlled disturbance event, which would likely cause sensitive animals to flush and largely remain in the water during the actual bait application a short time later, reducing the overall level of disturbance. Overall, the level of disturbance to Steller sea lions from the operations described in Alternative B would not be anticipated to have any effect on overall energy balance or fitness of any individual animals.

4.4.5.2.3. Disturbance to other wildlife under Alternative B (preferred alternative)

Helicopter operations would not affect salamanders. Personnel activities including boat travel and terrestrial monitoring activities would also expose some salamanders to low levels of disturbance, but no more than current monitoring activities on the islands. Overall, the level of disturbance to salamanders from the operations described in Alternative B would not be anticipated to have an effect on the fitness of any individual animals.

None of the invertebrates are anticipated to be directly affected by helicopter operations or personnel activities.

4.4.5.2.4. Disturbance to vegetation under Alternative B (preferred alternative)

Helicopter operations would have a negligible effect on vegetation. Alternative B would result in minor, temporary, and highly localized direct vegetation impacts from project crews traveling by foot.

4.4.5.3. Disturbance impacts under Alternative C: Mouse eradication with bait station delivery as primary technique

4.4.5.3.1. Disturbance to birds under Alternative C

One major difference between Alternative C and Alternative B (the preferred alternative) is that the project activities in Alternative C would take place over a much longer duration. Alternative B would only take place during late fall and early winter months, when the bird community at the South Farallones is much smaller than in other seasons. On the other hand, Alternative C would require activities extending across multiple migratory cycles in which a large diversity of birds would be likely to arrive on the islands.

The most common response of most landbirds, shorebirds, and waterfowl to disturbance, outside of the breeding season, is to flush and fly away. Frequent flushing over an extended period of time may be harmful to individual birds. However, most of the landbirds, shorebirds, and waterfowl that visit the South Farallones stay only a few days at maximum. The exception to this rule is black oystercatchers, which are year-round island residents. During the spring, summer, and fall months, when most visitant birds arrive on the islands, project activities would consist of bait station installation and maintenance by project staff. Staff presence would be likely to flush some visitant landbirds, shorebirds, and waterfowl, but it would not be likely to negatively affect these visitant birds over such a short time period. Black oystercatchers would again be an exception: disturbance to oystercatchers during the summer breeding season could lead to breeding failure in individual nesting pairs. Areas that contain breeding pairs of oystercatchers could be excluded from the bait station grid and treated with aerial bait broadcast during the non-breeding season instead, but even with this minimization measure some oystercatchers would likely experience up to two failed breeding seasons. Aerial bait broadcast on inaccessible areas would occur in the late fall or early winter, and would not be likely to affect most birds due to the short duration of broadcast activities. Overall, the potential for disturbance to most landbirds, shorebirds, and waterfowl under Alternative C, although it would occur over a much longer period of time than Alternative B, would not be likely to have any effect on overall energy balance or fitness of any individual animals. Alternative C would result in substantially more disturbance-related effects than Alternative B (see Section 4.4.5.2.1) for black oystercatchers.

Seabirds are generally more sensitive to disturbance than other bird taxa. Similar to other birds, their most common response to disturbance is to flush and fly away. Disturbance to seabirds during the breeding season can lead to major negative impacts on breeding success. Frequent disturbance or even a single dramatic disturbance event can lead to breeding failure in individual birds or even entire colonies. Aerial bait broadcast on inaccessible areas, which would occurs outside of the seabird breeding season, would not be likely to affect seabirds due to the short duration of this activity. However, the installation and maintenance of a bait station grid across much of the island would lead to widespread disturbance of hundreds to tens of thousands of seabirds during the non-breeding season, and tens of thousands to hundreds of thousands of seabirds during the breeding season. Eggs and chicks that are left exposed by birds that flush would be vulnerable to predation by gulls and birds of prey. The eggs of some seabirds, which are often laid on precarious exposed ledges, may be crushed or lost in a major disturbance event. Furthermore, seabird burrows could be damaged or destroyed during bait station installation and maintenance. Birds within those burrows may be injured or killed and eggs may be crushed.

Burrow destruction would reduce the amount of breeding habitat available for burrow-nesting seabirds for decades in the future. Areas that contain breeding pairs of oystercatchers could be excluded from the bait station grid and treated with aerial bait broadcast during the non-breeding season instead, but even with this minimization measure some oystercatchers would likely experience up to two breeding seasons with major disturbances on the islands.

Overall, the operations described in Alternative C would lead to major disturbances to most breeding seabirds on the South Farallones. Some colonies could experience near-complete breeding failure while the bait station grid is in use. Areas that contain an especially high density of breeding seabirds could be excluded from the bait station grid and treated with aerial bait broadcast during the non-breeding season instead, but even with this minimization measure breeding seabirds would experience up to two breeding seasons with major disturbances on the islands. In comparison to Alternative B (the preferred alternative; see Section 4.4.5.2.1), Alternative C would result in substantially more disturbance. The Service would consider this negative impact to be significant to breeding seabirds, and if Alternative C is chosen, NEPA regulations would require the preparation of an EIS to examine the negative impacts of this action on breeding seabirds in greater detail. While this alternative would minimize the disturbance resulting from helicopter overflights of sensitive habitat on the South Farallones, the potentially high levels of repeated disturbances likely to most breeding seabirds would likely make the costs of this alternative much greater than the benefits.

Disturbance to pelicans – Personnel activities during bait station installation and maintenance would likely lead to disturbances to roosting California brown pelicans. The most common response of pelicans to visual and/or auditory disturbances is for birds to flush from a roost and return within minutes or hours, as has been observed on the South Farallones during helicopter operations by the U.S. Coast Guard (USFWS unpubl. data). Leaving the roost is part of pelicans' normal behavior, and disturbance events that are short in duration and infrequent likely have little effect on individual animals. Overall, the potential for disturbance to California brown pelicans under Alternative C would occur over a much longer period of time than in Alternative B. However, disturbances would be infrequent enough to be unlikely to have any effect on overall energy balance or fitness of any individual animals.

4.4.5.3.2. Disturbance to pinnipeds under Alternative C

One major difference between Alternative C and Alternative B (the preferred alternative) is that the project activities in Alternative C would take place over a much longer duration. Alternative C would require activities over a period of up to two years, extending the action into the breeding seasons of each of the five breeding pinniped species on the South Farallones.

Many pinnipeds are particularly sensitive to disturbance, particularly during the breeding season. Approaching aircraft and the sudden appearance of humans generally flush animals into the water. While entering the water from a haulout is generally part of pinnipeds' normal behavior, repeated disturbance or disturbance during the sensitive behavioral periods of breeding and molting can stress or physically injure individual animals. During breeding season, a disturbance event that led to all or most of the animals on a haulout or rookery entering the water would leave pups vulnerable to crushing from larger animals.

Personnel activities during bait station installation and maintenance may lead to pinniped disturbance in coastal areas that are included in the bait station grid. Because of the need to visit bait stations year-round, disturbance to hauled out pinnipeds from personnel presence during breeding season is possible. Each disturbance event during breeding season would have some potential to injure young pups.

In order to reduce the effect of bait station maintenance on breeding pinnipeds, some areas near rookery sites and other persistent pinniped haulouts may be excluded from the bait station grid.

The aerial bait broadcast activities in Alternative C would occur outside of the breeding season for California sea lions, harbor seals, and northern fur seals, and any pups of these species that are present would likely be mobile enough to avoid trampling. The helicopter application would be timed to be complete before the first northern elephant seal pup of the season is born. Furthermore, the inclusion of a “dry-run” surveillance flight over pinniped haulouts would allow the helicopter pilot to facilitate a more controlled disturbance event, which would likely cause sensitive animals to flush and largely remain in the water during the actual bait application a short time later, reducing the overall level of disturbance to pinnipeds.

Overall, the potential for disturbance to pinnipeds, including injury or mortality of pups, is greater under Alternative C than under Alternative B (see Section 4.4.5.2.2). The Service would consider this increased risk of pup mortality to be significant to the pinnipeds that rely on the South Farallones for breeding habitat. If Alternative C is chosen, NEPA regulations would require the preparation of an EIS to examine the negative impacts of this action on pinnipeds in greater detail.

Disturbance to Steller sea lions – The response of Steller sea lions to visual and/or auditory disturbances varies from no discernable reaction to completely vacating haulouts (Calkins 1983; Efroymson and Suter 2001). Low overflying aircraft and the close approach of humans generally flush animals into the water. While entering the water is part of Steller sea lions’ normal behavior, during the breeding season a disturbance event that led to all or most of the animals on a haulout or rookery entering the water would leave pups vulnerable to crushing from larger animals.

In order to reduce the high disturbance potential of bait station maintenance on breeding Steller sea lions, areas near rookery sites would be excluded from the bait station grid. These areas would be treated with an aerial bait broadcast during the same time period identified in Alternative B. However, disturbance from bait station maintenance to Steller sea lions hauled out elsewhere on the islands is still possible.

The aerial bait broadcast activities in Alternative C would occur outside of the breeding season for Steller sea lions, and any pups of these species that are present would likely be mobile enough to avoid trampling. Furthermore, the inclusion of a “dry-run” surveillance flight over pinniped haulouts would allow the helicopter pilot to facilitate a more controlled disturbance event, which would likely cause sensitive animals to flush and largely remain in the water during the actual bait application a short time later, reducing the overall level of disturbance to pinnipeds.

Overall, the potential for disturbance to Steller sea lions, including injury or mortality of pups, is greater under Alternative C than under Alternative B (see Section 4.4.5.2.2). However, modification of the bait station grid to avoid Steller sea lion breeding areas would effectively reduce this risk, although not eliminate it.

4.4.5.3.3. Disturbance to other wildlife under Alternative C

The installation of the bait station grid would likely lead to disturbance of salamander habitat, but ample alternative habitat would be available. Personnel activities would also expose some salamanders to low levels of disturbance, but no more than current monitoring activities on the islands. Overall, the level of disturbance to salamanders from the operations described in Alternative C would not be anticipated to have an effect on the fitness of any individual animals.

None of the invertebrates are anticipated to be significantly affected by the activities under Alternative C.

4.4.5.3.4. Disturbance to vegetation under Alternative C

Vegetation would not be significantly affected by helicopter operations. However, the impact of bait station installation and the presence of personnel on the island on the South Farallones plant communities will be analyzed. Alternative C would result in moderate direct vegetation impacts from the installation of a bait station grid across up to 75 percent of the South Farallones' land area. The vegetation community would likely recover once the bait station grid is removed. However, project crews traveling across the islands could hasten the spread of non-native plant species to new areas on the island.

4.4.6. Indirect Impacts to Biological Resources

4.4.6.1. Indirect effects under Alternative B (preferred alternative): Mouse eradication with aerial bait broadcast as primary technique

Mice may currently play a strong role in the terrestrial ecosystem of the South Farallones. As a result, their removal would likely have indirect impacts to other species. The Service anticipates that the majority of these impacts will be positive. In particular, the removal of mice from the South Farallones ecosystem would be expected to have an indirect positive impact to small burrow- and crevice-nesting seabirds, especially ashy and Leach's storm-petrels.

In addition, mouse eradication would likely have a positive indirect impact to invertebrates, especially populations of terrestrial invertebrates that mice currently depend on for food (Jones and Golightly 2006). On other islands from which mice have been eradicated, invertebrate populations are some of the best-documented beneficiaries of the eradication (Newman 1994; Ruscoe 2001). It is possible that changes in the invertebrate community would in turn affect taxa that depend on invertebrates for food, including birds and salamanders. However, there is no evidence to support this possibility on the South Farallones.

Burrowing owls on the South Farallones rely on mice as an important food source during the fall and early winter seasons, and mouse eradication would substantially reduce the quality of habitat for burrowing owls on the islands. There are no permanently resident burrowing owls on the South Farallones; all owls appear to arrive during the fall migration season. The best available evidence indicates that if mice are eradicated, burrowing owls would simply return to the mainland because the islands would not provide adequate foraging opportunities, rather than attempting to over-winter on the islands as small numbers of them currently do. Therefore, mouse removal would not be expected to have any negative impacts to the mainland burrowing owl populations to which these current island arrivals belong.

4.4.6.2. Indirect effects under Alternative C: Mouse eradication with bait station delivery as primary technique

Similar to Alternative B (the preferred alternative), the expected outcome of Alternative C would be the eradication of mice from the South Farallones. Therefore the indirect impacts of Alternative C would likely be similar to Alternative B (see Section 4.4.6.1).

4.4.7. Summary of Impacts to Biological Resources

4.4.7.1. Effects under Alternative B (preferred alternative): Mouse eradication with aerial bait broadcast as primary technique

The negative impacts of Alternative B to biological resources would be largely limited to effects from toxin use. There would be a high theoretical risk of mortality or sublethal effects from brodifacoum to individuals of a number of bird species on the South Farallones under Alternative B. However, this theoretical risk does not imply that all individuals of any species would be likely to be affected. Evidence from hundreds of rodent eradication efforts indicates that individual mortalities among high-risk birds would be likely, but comparatively few cases of major population-level impacts in birds have been reported. Furthermore, nearly all of the high-risk bird species on the South Farallones belong to a population that is not confined to the islands; most individuals at risk would represent a very small proportion of a much larger mainland population, and impacts to these individuals would not translate to population-level effects.

The notable exceptions are 1) black oystercatchers and 2) western and California gulls. Each of these theoretically high-risk taxa is represented by a breeding population on the South Farallones. However, the level of mortality anticipated in these species would not have more than a minor short-term impact on the breeding population, as demonstrated on Anacapa Island (Howald et al. 2005).

On the balance, Alternative B would have a positive impact on the ecosystem of the South Farallones as a result of the indirect benefits of mouse eradication.

Special considerations under ESA for Alternative B (preferred alternative) – Based on the impacts analysis above, Alternative B may adversely affect California brown pelicans according to the parameters of the ESA due to disturbance from aerial bait application activities. Alternative B may also adversely affect Steller sea lions under NMFS's application of ESA regulations. "Take" of some Steller sea lions through disturbance would likely occur. Furthermore, some project actions would need to occur within Steller sea lion critical habitat.

If Alternative B is chosen for implementation, the Service would enter into intra-agency consultation on impacts to pelicans to ensure compliance with Sections 7 and 9 of the ESA. If California brown pelicans are de-listed before the project is implemented, this consultation may not be necessary but all remaining regulations pertaining to the pelican, including the Migratory Bird Treaty Act, would be followed. If Alternative B is chosen for implementation, the Service would also enter into consultation with NMFS on impacts to Steller sea lions. For Steller sea lions, MMPA regulations would apply in addition to ESA regulations. See below for more details on MMPA considerations.

Special considerations under MMPA for Alternative B (preferred alternative) – With the exception of subsistence harvests, the MMPA regulations generally prohibit the killing, injury or disturbance of marine mammals. However, permits can be granted allowing exceptions to this prohibition for actions that may impact a marine mammal if the impact is incidental to rather than the intention of the action. Carrying out an action that is likely to lead to the disturbance of hauled out marine mammals to the point that they enter the water is often considered "harassment" under the MMPA. Based on the analysis above, some marine mammals would likely be subject to harassment as a result of the activities in Alternative B. In any event, the Service would coordinate with NMFS to apply for an Incidental Harassment Authorization if Alternative B is chosen for implementation.

4.4.7.2. Overall impacts under Alternative C: Mouse eradication with bait station delivery as primary technique

The negative impacts of Alternative C to biological resources would result from both toxin use and disturbance to the natural habitat of the South Farallones. Similar to Alternative B, there would be a high theoretical risk of mortality or sublethal effects from brodifacoum to individuals of a number of bird species on the South Farallones under Alternative B. Less terrestrial habitat would be exposed to brodifacoum bait in Alternative C than in Alternative B. However, a small amount of bait would be present on the islands for a longer period of time in Alternative C. As a result, a larger diversity of species may be put at high risk of impacts from the toxin. This theoretical risk does not imply that all individuals of any species would be likely to be affected. Evidence from hundreds of rodent eradication efforts indicates that individual mortalities among high-risk birds would be likely, but comparatively few cases of major population-level impacts in high-risk birds have been reported. Overall, the risk of negative effects from toxin use would be lower under Alternative C than Alternative B.

Nearly all of the high-risk bird species on the South Farallones belong to a population that is not confined to the islands; most individuals at risk would represent a very small proportion of a much larger mainland population, and impacts to these individuals would not translate to population-level effects. The two notable exceptions are 1) black oystercatchers and 2) western and California gulls. Each of these theoretically high-risk taxa is represented by a breeding population on the South Farallones. However, the level of mortality as a result of toxin use anticipated in these species would not have more than a minor short-term impact to the breeding population, as demonstrated on Anacapa Island (Howald et al. 2005).

The major disturbance events that would occur as a result of bait station installation and maintenance under Alternative C would negatively affect numerous species that rely on the South Farallones for breeding. Disturbance to breeding seabirds at the South Farallones would result in reduced breeding success for up to two breeding seasons. In some cases, accidental destruction of seabird burrows could lead to reduced breeding success in some species for decades. The Service would consider this negative impact to be significant based on the criteria described in Section 4.4.2, and if Alternative C is chosen, NEPA regulations would require the preparation of an EIS to examine the negative impacts of this action, particularly to breeding seabirds, in greater detail.

Similarly, personnel activities during bait station installation and maintenance may lead to breeding-season pinniped disturbance in coastal areas that are included in the bait station grid. Although in some cases the grid would be placed out of view of major pinniped breeding areas to reduce disturbance, such avoidance would not always be possible. The Service would consider the high risk of pup mortality to be significant to the pinnipeds that rely on the South Farallones for breeding habitat. If Alternative C is chosen, NEPA regulations would require the preparation of an EIS to examine the negative impacts of this action on pinnipeds in greater detail.

Special considerations under ESA for Alternative C – Based on the impacts analysis above, Alternative C may adversely affect California brown pelicans according to the parameters of the ESA due to disturbance. Alternative C may also adversely affect Steller sea lions under NMFS's application of ESA regulations. "Take" of some Steller sea lions through disturbance would likely occur. Furthermore, some project actions would need to occur within Steller sea lion critical habitat.

If Alternative C is chosen for implementation, the Service would enter into intra-agency consultation on impacts to pelicans to ensure compliance with Sections 7 and 9 of the ESA. If California brown pelicans are de-listed before the project is implemented, this consultation may not be necessary but all remaining regulations pertaining to the pelican, including the Migratory Bird Treaty Act, would be followed. If Alternative C is chosen for implementation, the Service would also enter into consultation with NMFS on impacts to Steller sea lions. For Steller sea lions, MMPA regulations would apply in addition to ESA regulations. See below for more details on MMPA considerations.

Special considerations under MMPA for Alternative C – With the exception of subsistence harvests, the MMPA regulations generally prohibit the killing, injury or disturbance of marine mammals. However, permits can be granted allowing exceptions to this prohibition for actions that may impact a marine mammal if the impact is incidental to rather than the intention of the action. Carrying out an action that is likely to lead to the disturbance, injury or mortality of marine mammals requires special permission under the MMPA. The Service would coordinate with NMFS to apply for the applicable permits under the MMPA if Alternative C is chosen for implementation.

4.5. Consequences: Social and Economic Environment

The CEQ guidelines at 40 CFR 1508.14 include the human relationship with the natural environment as a category of potential impacts that must be considered in a NEPA analysis. This is interpreted to mean that a NEPA analysis needs to examine the potential effects of an action on any economic and/or social values that are related to the natural environment.

4.5.1. Refuge Visitors and Recreation

4.5.1.1. Analysis framework for Refuge visitors and recreation

Although public access to the South Farallones is prohibited, the waters surrounding the islands are popular with tour boats and private boaters for wildlife viewing as well as recreational fishing. Furthermore, the islands themselves are a high-quality scenic panorama. This analysis will examine the likely changes to visitor experience as a result of both of the action alternatives. The Service would consider any major, long-term changes to the visitor experience to be significant.

4.5.1.2. Alternative A: No action

It is unlikely that the impacts that mice would continue to have to the South Farallones ecosystem would be perceptible to boaters near the islands. While the ashy and Leach's storm-petrel populations would likely continue to be negatively impacted, these birds are nocturnal at the colony and forage far offshore and thus are relatively rarely seen near the islands. Overall, taking no action with regard to non-native mice would be unlikely to have any direct or indirect impacts to the value of the South Farallones to Refuge visitors.

4.5.1.3. Alternative B (preferred alternative): Mouse eradication with aerial bait broadcast as primary technique

The area immediately surrounding the South Farallones would be closed to access by boaters during aerial bait application operations, which would be a minor short-term inconvenience to Refuge visitors. If flocks of roosting seabirds, particularly gulls or pelicans, are flushed during helicopter operations the flocks would be visible to boaters offshore, but only during the short period of actual helicopter operations. The expected recovery of the South Farallones ecosystem after mouse eradication would likely not be perceptible to boaters near the islands. However, interpretive materials on the islands' ecosystem recovery would be available in San Francisco Bay National Wildlife Refuge Complex visitor's center and other appropriate venues.

4.5.1.4. Alternative C: Mouse eradication with bait station delivery as primary technique

The area immediately surrounding the South Farallones would be closed to access by boaters during aerial bait application operations, which would be a minor short-term inconvenience to

Refuge visitors. Additionally, the bait station grid would alter the appearance of the islands for up to two years. If flocks of seabirds, particularly gulls, pelicans, or common murres, are flushed during bait station maintenance or helicopter operations, the flocks would be visible to boaters offshore. The negative impacts to seabird populations on the islands as a result of disturbance in Alternative C would likely not be perceptible to boaters near the islands. The subsequent expected recovery of aspects of the South Farallones ecosystem after mouse eradication would similarly likely not be perceptible to boaters near the islands. However, interpretive materials on the islands' ecosystem recovery would be available in San Francisco Bay National Wildlife Refuge Complex visitor's center and other appropriate venues.

4.5.2. Fishing Resources

4.5.2.1. Analysis framework for fishing resources

The Service would consider any noticeable, long-term changes to fishing resources surrounding the South Farallones that could be attributable to the mouse eradication to be significant.

4.5.2.2. Alternative A: No action

Mice on the South Farallones do not currently affect the fisheries of the nearshore waters, nor would the Service expect any future impacts.

4.5.2.3. Alternative B (preferred alternative): Mouse eradication with aerial bait broadcast as primary technique

The area immediately surrounding the South Farallones would be closed to access by boats during aerial bait application operations, which would be a minor short-term inconvenience to fishing vessels. There would be no further impacts to fishing resources. If the California Department of Fish and Game decides to designate a State Marine Reserve surrounding the Farallones, as is currently proposed, the impact of this action to fisheries would be moot.

4.5.2.4. Alternative C: Mouse eradication with bait station delivery as primary technique

The area immediately surrounding the South Farallones would be closed to access by boats during aerial bait application operations, which would be a minor short-term inconvenience to fishing vessels. There would be no further impacts to fishing resources. If the California Department of Fish and Game decides to designate a State Marine Reserve surrounding the Farallones, as is currently proposed, the impact of this action to fisheries would be moot.

4.5.3. Historical and Cultural Resources

4.5.3.1. Analysis framework for historical and cultural resources

The National Historic Preservation Act (NHPA) defines the concept of an "adverse impact" to historical resources, but the regulations make clear that "a finding of adverse effect on a historic property does not necessarily require an EIS under NEPA" (36 CFR 800.8(a)(1)). Section 106 of the NHPA requires agencies to consult with the appointed regional Historic Preservation Officer(s) if adverse impacts to historical or cultural resources are possible. This analysis will describe the potential impacts to historical and cultural resources on the South Farallones as a reference for consultation with the appropriate Historic Preservation Officers.

4.5.3.2. Alternative A: No action

The Service has no evidence that mouse activities affect historical and cultural resources on the island. Mice are burrowing animals, a behavior that has the potential to damage buried artifacts, but there are numerous seabird species that burrow on the island as well, which makes the preservation of buried artifacts on the South Farallones difficult, whether or not mice are present. Mice may continue to cause damage to the historical buildings on Southeast Farallon, but this damage would likely be minor and would not likely be irreversible.

4.5.3.3. Alternative B (preferred alternative): Mouse eradication with aerial bait broadcast as primary technique

Alternative B would not involve activities that would require soil disruption or any other actions that would affect the historical or cultural resources on the South Farallones.

4.5.3.4. Alternative C: Mouse eradication with bait station delivery as primary technique

The bait station grid required under Alternative C could have minor impacts on historical or cultural resources that are buried on the islands. To minimize impacts, the final grid placement would be determined in consultation with experts in the Farallones' historical and cultural resources including the State Historical Preservation Officer.

4.6. Consequences: Cumulative Impacts

4.6.1. Assessing Cumulative Impacts

The NEPA regulations require Federal agencies to consider not just the direct and indirect impacts of an action but also the cumulative impacts to which an action would contribute. Analyzing cumulative impacts on the South Farallones requires consideration of other, unrelated impacts that are occurring simultaneously to those resources, impacts that have occurred in the past, or impacts that are likely to occur in the foreseeable future. The continued presence of mice is likely impacting many of the species on the island, but there are no other clear localized impacts known to be occurring today. Furthermore, there are no foreseeable future human actions on the island that are likely to negatively impact the island's environment, because the land is being managed in perpetuity as a National Wildlife Refuge. However, many of the species of the Farallones are still recovering from severe past impacts, including the impacts of introduced rabbits on the South Farallones, hunters and egg collectors that visited the islands, and past oil spills and other pollution. Also, many of the species that utilize the South Farallones have large ranges. These far-ranging populations may have been impacted in the past, may be currently experiencing unrelated impacts, or may be at risk of impacts from reasonably foreseeable consequences in the future, elsewhere in their ranges.

4.6.2. Cumulative Impacts Under Alternative A (No Action)

The impacts that mice are having to the environment of the South Farallones, particularly on the islands' biological resources, would continue in perpetuity under the no action alternative. These impacts could be additive to other unrelated impacts on these resources in the future. For example, the ongoing indirect impact that mice currently have to storm-petrels at the colony, in combination with possible major future changes in the productivity of the marine waters of the California Current ecosystem on which these storm-petrels depend, could ultimately result in the disappearance of the South Farallones ashy and Leach's storm-petrel colonies. However, the likelihood of this kind of future cumulative impact to the South Farallones' biological resources is difficult to predict with certainty.

The continued presence of mice would not be likely to contribute to cumulative impacts to any other (non-biological) resources on the South Farallones.

4.6.3. Cumulative Impacts Under Alternative B (Preferred Alternative)

There would be no major negative impacts to the environment of the South Farallones under Alternative B. The minor negative impacts to biological resources on the islands as a result of Alternative B would not be likely to contribute additively to any ongoing unrelated impacts. Similarly, the expected positive impacts of Alternative B to the islands' biological resources would not be likely to contribute additively to cumulative impacts.

Alternative B would be limited in scope to the South Farallones, and in duration to the short period of time required for aerial bait application. It would be the first successful island mouse eradication in the United States, which could set a precedent for future actions, but the effects of these future actions would be, at this point, purely speculative.

4.6.4. Cumulative Impacts Under Alternative C

Alternative C could result in major negative impacts to breeding seabirds on the South Farallones. These impacts could be additive to other unrelated impacts on seabirds in the future. However, the likelihood of future impacts to these seabirds is difficult to predict. On the South Farallones, the islands' status as a National Wildlife Refuge would protect seabirds from further harm within the Refuge, assuming that the current restrictions on island access continued. Since seabirds have large ranges, further negative impacts to these birds elsewhere in their ranges are possible but the intensity of these impacts would be difficult to predict.

Alternative C would be limited in scope to the South Farallones, and in duration to the time required for the bait station approach to ensure eradication success. It would be the first successful island mouse eradication in the United States, which could set a precedent for future actions, but the impacts of these future actions would be, at this point, purely speculative.

4.7. Irreversible and Irretrievable Impacts

4.7.1. Alternative A (No Action)

Pressure from non-native house mice could contribute to declines in the native biological resources of the South Farallones to below the level of population viability. For ashy and Leach's storm-petrels in particular, their recent population declines indicate a risk for an irreversible decline in the future. However, at this time there is no strong evidence to support this assertion.

4.7.2. Alternative B (Preferred Alternative)

Mouse eradication would be likely to eliminate the overwintering burrowing owl population on the South Farallones, although this would be to the benefit of the individual owls that arrive on the islands because they would continue their migrations rather than attempting to overwinter in the poor habitat of the South Farallones. Mouse eradication would also be likely to result in positive population-level changes for ashy and Leach's storm-petrels.

Project activities would require a commitment of funds that would then be unavailable for use on other Service projects. At some point, commitment of funds (for purchase of supplies, payments to contractors, etc.) would be irreversible; once used, these funds would be irretrievable. Nonrenewable or nonrecyclable resources committed to the project (such as helicopter fuel, bait, and bait stations) would also represent an irreversible or irretrievable commitment of resources.

4.7.3. Alternative C

Mouse eradication would be likely to eliminate the overwintering burrowing owl population on the South Farallones, although this would be to the benefit of the individual owls that arrive on the islands because they would continue their migrations rather than attempting to overwinter in the poor habitat of the South Farallones. Mouse eradication would also be likely to result in positive population-level changes for ashy and Leach's storm-petrels.

On the other hand, Alternative C would lead to significant impacts to seabird populations on the South Farallones. Seabirds often recover very slowly from negative impacts to their populations. However, the impacts under Alternative C would not be irreversible. After the bait station grid is removed, seabird populations that were significantly affected would be likely to recover in the long term.

Similar to Alternative B, project activities would require a commitment of funds (for purchase of supplies, payments to contractors, etc.) that would be irreversible; once used, these funds would be irretrievable. Nonrenewable or nonrecyclable resources committed to the project (such as helicopter fuel, bait, and bait stations) would also represent an irreversible or irretrievable commitment of resources.

4.8. Short-term Uses and Long-term Productivity

An important goal of the Service is to maintain the long-term ecological productivity and integrity of the biological resources on the Refuge. The action alternatives are designed to contribute to the long-term ecological productivity of the South Farallones, and would not result in short-term uses of the resources that would counteract this long-term productivity. Any short-term negative impacts to the islands' biological resources would be outweighed by the ecosystem's long-term restoration through the eradication of mice.

4.9. Impact Table

Table 4.2. Comparison of the effects of each alternative on the environmental issues considered.

Issue	Sub-issue	Alternative A: No action	Alternative B (preferred alternative): Aerial broadcast	Alternative C: Bait stations w/ limited aerial broadcast
Physical resources	Water resources	No ongoing impacts	Negligible risk of detectable levels of brodifacoum	Negligible risk of detectable levels of brodifacoum
	Geology and soils	Mice and seabirds both create burrows in areas with substantial soil	No detectable soil contamination, negligible contribution to erosion	No detectable soil contamination, negligible contribution to erosion (but more than Alternative B)
	Wilderness character	Mice would continue to contribute to wilderness degradation	Short-term degradation of wilderness (helicopter use); long-term enhancement of wilderness (reestablishment of natural processes)	Short-term degradation of wilderness (helicopter use & bait station installation), greater than Alternative B; long-term enhancement of wilderness (reestablishment of natural processes)
Biological resources	Toxins	No current use of toxins	*Terrestrial/intertidal foragers:* Individual mortalities likely in herbivorous birds, mouse predators/scavengers, some invertebrate-specialist birds, especially *Larus* gulls. Individual mortalities possible among bird-specialist predators, micro-invertebrate specialist birds, intertidal foraging birds. Effects on individual salamanders unknown. No significant (population-level) impacts from toxins. *Marine foragers:* Negligible risk of mortality or sublethal effects in marine foragers	*Terrestrial/intertidal foragers:* Individual mortalities likely among mouse predators/scavengers, especially *Larus* gulls. Individual mortalities possible among herbivorous birds, bird-specialist predators, invertebrate-specialist birds, intertidal foraging birds. Effects on individual salamanders unknown. Wider diversity of species, larger number of individuals at at least a low risk of toxin effects, over longer period of time, in Alternative C than in Alternative B. No significant (population-level) impacts from toxins. *Marine foragers:* Negligible risk of mortality or sublethal effects in marine foragers
	Disturbance	*Birds:* Mice would continue to support	*Birds:* Minor, temporary disturbance to birds	*Birds:* Major disturbance to breeding

Issue	Sub-issue	Alternative A: No action	Alternative B (preferred alternative): Aerial broadcast	Alternative C: Bait stations w/ limited aerial broadcast
		burrowing owls that prey on small seabirds; mice may continue to prey on eggs, chicks, or adults, cause disturbance to breeding seabirds *Pinnipeds:* No ongoing impacts	present during operations. Operations conducted during low point in most bird populations. No significant (population-level) impacts from disturbance. *Pinnipeds:* Minor, temporary disturbances to hauled out animals. Operations conducted outside of all pinniped breeding seasons. No significant impacts from disturbance. *Other wildlife and plants:* Minor, temporary disturbance.	seabirds. Some breeding colonies would be excluded from bait station grid to reduce disturbance. Significant (population-level) impacts to breeding seabirds possible. *Pinnipeds:* Disturbance to breeding pinnipeds likely. Injury or mortality in pups possible. Significant impacts to pinnipeds possible. *Other wildlife and plants:* Minor, temporary disturbance. More disturbance than in Alternative B.
Biological resources (cont.)	Indirect effects	Burrowing owls would continue to be artificially supported by mice and prey on ashy storm-petrels when mice are scarce Mice would continue to prey on invertebrates, possibly affecting invertebrate community makeup Mouse impacts on invertebrates would continue to degrade salamander food resources Mouse impacts on native plants would continue	*Birds:* Mouse eradication would improve habitat for breeding seabirds over long term, especially storm-petrels. Mouse eradication would negatively impact visitant burrowing owls. Mouse eradication may benefit invertebrates, salamanders, native plants.	Same end result (mouse eradication) as Alternative B. Indirect effects would be similar to Alternative B.
Social and economic environment	Refuge visitors/ recreation	No ongoing impacts	Temporary area closures would be a short-term inconvenience. If roosting birds flush, flock would be visible from surrounding waters. No long-term impacts.	Similar to Alternative B. In addition, bait station grid may be visible from surrounding waters. No long-term impacts.
	Fishing resources	No ongoing impacts	Temporary area closures would be a short-term inconvenience. No long-	Similar to Alternative B. No long-term impacts.

Issue	Sub-issue	Alternative A: No action	Alternative B (preferred alternative): Aerial broadcast	Alternative C: Bait stations w/ limited aerial broadcast
			term impacts.	
Social and economic environment (cont.)	Historical/ cultural resources	Mice and native seabirds both create burrows that have the potential to harm buried artifacts.	No impacts to historical/cultural resources.	Alternative C would cause more surface disruption than Alternative B. Historical/cultural resources would be marked and avoided. Negligible impact.
Cumulative impacts		Future impacts to seabirds due to ocean conditions would be additive to current impacts from mice.	No future negative impacts to South Farallones environment expected due to current protected status. Positive impacts to South Farallones seabirds from mouse eradication may counter negative impacts to seabirds at sea. Action may set precedent for future projects (speculative).	Negative impacts to breeding seabirds from bait station maintenance may be additive to negative impacts to seabirds at sea. No future negative impacts to South Farallones environment expected due to current protected status. Over long term, positive impacts to South Farallones seabirds from mouse eradication may counter negative impacts to seabirds at sea. Action may set precedent for future projects (speculative).

5. Consultation and Coordination

5.1. Introduction

TO BE COMPLETED

5.2. Regulatory Framework of the Alternatives

5.2.1. Federal Laws

National Environmental Policy Act
Endangered Species Act
Marine Mammal Protection Act
Migratory Bird Treaty Act
Clean Water Act (CWA), as amended (formally, the Water Pollution Control Act, USC 33 1251 et seq.)
National Historic Preservation Act (NHPA) of 1966, as amended)
Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) of 1947, as amended
Coastal Zone Management Act (CZMA) of 1972, as amended
Archaeological Resources Protection Act of 1979, as amended, 16 USC 470
Wilderness Act of 1964

Archaeological Resources Protection Act, 16 U.S.C. 460, et seq.
Native American Graves Protection and Repatriation Act of 1990 (25 USC 3000-3013, as amended)
Curation of Federally Owned and Administered Archeological Collections (36 CFR 79)
Executive Memorandum – Government-to-Government Relations with Native American Tribal Governments (59 FR 85, April 29, 1994)
Executive Order 13007 – Indian Sacred Sites (61 FR 104, May 24, 1996)
Executive Order 13175 – Consultation and Coordination with Indian Tribal Governments (65 FR 218, November 9, 2000)

5.2.2. California State Laws and Authorities

California Coastal Commission
Regional Water Quality Control Board
Pesticide regulations?

California Department of Fish and Game – The California Department of Fish and Game (CDFG) has jurisdiction over the conservation, protection, and management of fish, wildlife, native plants, and the habitats necessary for biologically sustainable populations of those species (California Fish and Game Code Section 1802). California's fish and wildlife resources, including their habitats, are held in trust for the people of the California by the CDFG (California Fish and Game Code Section 711.7). The CDFG's fish and wildlife management functions are implemented through its administration and enforcement of the Fish and Game Code (Fish and Game Code Section 702). The CDFG is entrusted to protect state-listed threatened and endangered species under the California Endangered Species Act (Fish and Game Code Sections 2050-2115.5) (CESA).

The CDFG generally does not have jurisdiction to manage or regulate natural resources on federal lands, such as the Farallon Islands, where the federal government has exclusive jurisdiction. It also does not regulate federal government agency activities. Although the CDFG does not regulate fish and wildlife resources on the Farallones, the Service regularly coordinates with the CDFG to ensure the proper protection of the island's natural resources. Thus, while CESA restrictions do not apply to the proposed restoration project on the South Farallones, the Service would continue to coordinate with CDFG regarding actions that could potentially affect state-listed species and the proposed conservation measures designed to avoid or minimize adverse effects.

5.3. Inter-Agency Scoping and Review

- U.S. Coast Guard
- Gulf of the Farallones National Marine Sanctuary (NOAA – Sanctuaries)
- Golden Gate National Recreation Area (NPS)
- Natural Resource Agency Trustees for the S.S. Luckenbach and associated oil spills
    - California Department of Fish & Game
    - National Oceanic and Atmospheric Administration
    - U.S. Fish & Wildlife Service
    - National Park Service
- U.S. EPA
- National Wildlife Research Center (USDA-APHIS)
- CA EPA
- National Marine Fisheries Service (NOAA)
- U.S. Fish & Wildlife Service – Ecological Services

5.4. Public Scoping and Review

As part of the project scoping process, the Service opened a 45-day public comment period from April 14, 2006 through May 29, 2006 during which interested members of the public were encouraged to comment on the scope of the project and the important environmental issues to be addressed in NEPA analysis. The Service received substantive comments from 15 individuals or organizations during this comment period, as well as at least three requests to be added to a distribution list for future information on the proposed project. The Service took all substantive comments into consideration during the preparation of this EA.

This Draft Environmental Assessment will be made available for review by the public, and the Service will again open a 45-day comment period to allow the public to provide input on the content of the EA. This comment period will include at least one public information session, during which Service staff and partners will be available to provide information and answer questions in person. Availability of the Draft EA and information on the comment period and public information sessions will be advertised in the Federal Register, by mail to all interested parties who have requested information, and in local media as appropriate. After the comment period closes, the Service will address all substantive comments received, make changes to the EA if necessary, and circulate the Final EA along with all substantive public comments and/or a summary of public comments if a large number are received.

5.5. Recipients of Requests for Comment

5.5.1. Government Recipients

TO BE COMPLETED

5.5.2. Public Recipients

TO BE COMPLETED

5.6. Comments Received

TO BE COMPLETED

5.6.1. Agency Comments

TO BE COMPLETED

5.6.2. Public Comments

TO BE COMPLETED

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6. Terms, Abbreviations, and References

6.1. Terms

Anticoagulant
Arthropod
Bait station
Carnivorous
Control
Eradication
Farallones
Haulout
Herbivorous
Hopper
Hyperpredation
Intertidal
Invertebrate
LC50
LD50
Molt
Omnivorous
Pinniped
Piscivorous
Seabird
South Farallones
The Refuge
The Service

6.2. Abbreviations

CCP
CDFG
CEQ
CWA
DDT
DPS
EA
EIS
EPA
ESA
FIFRA
FNWR
FONSI
GFNMS
GPS

IHA
MBTA
MMPA
NEPA
NHPA
NOAA
PPE
PRBO
SHPO
USFWS

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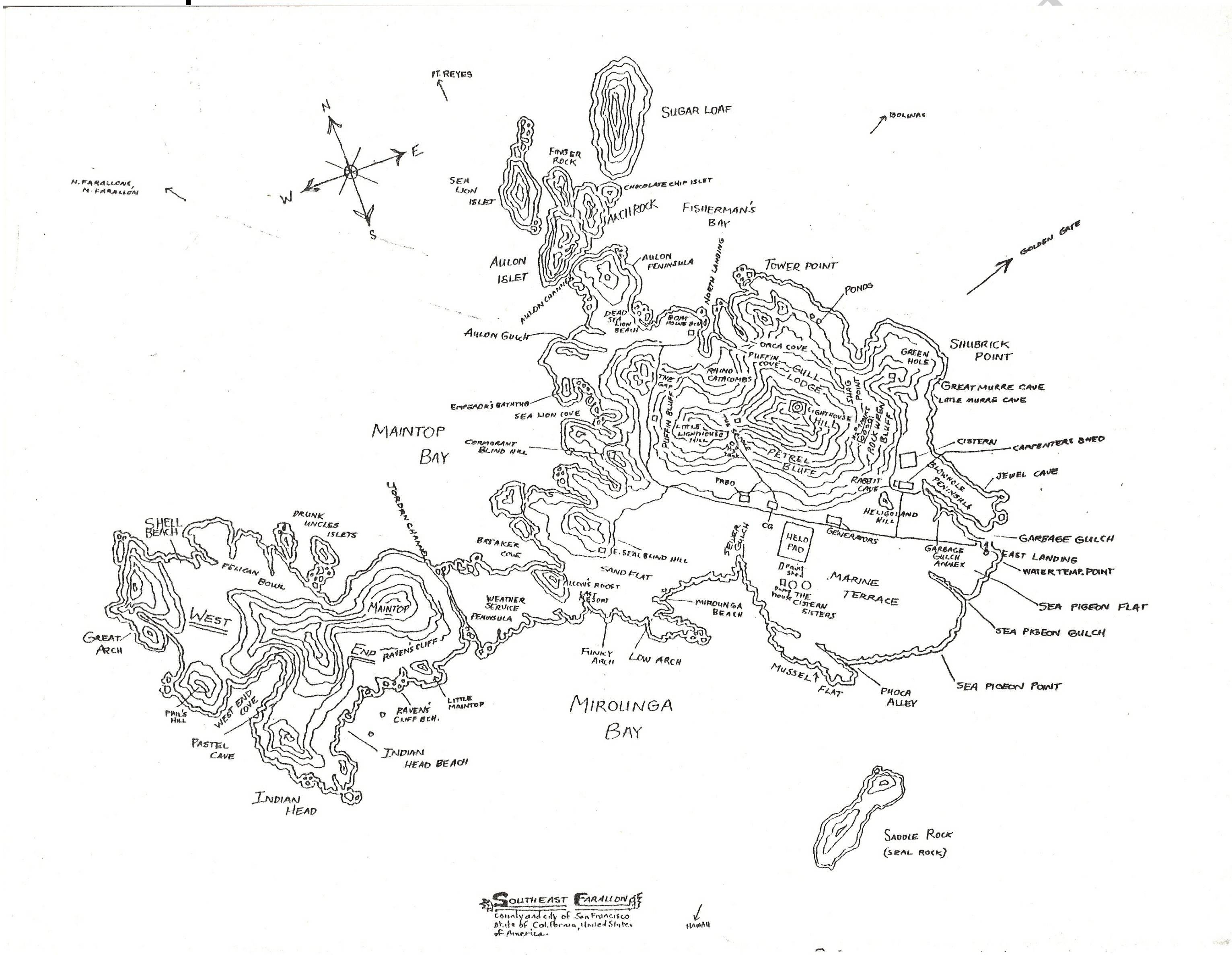
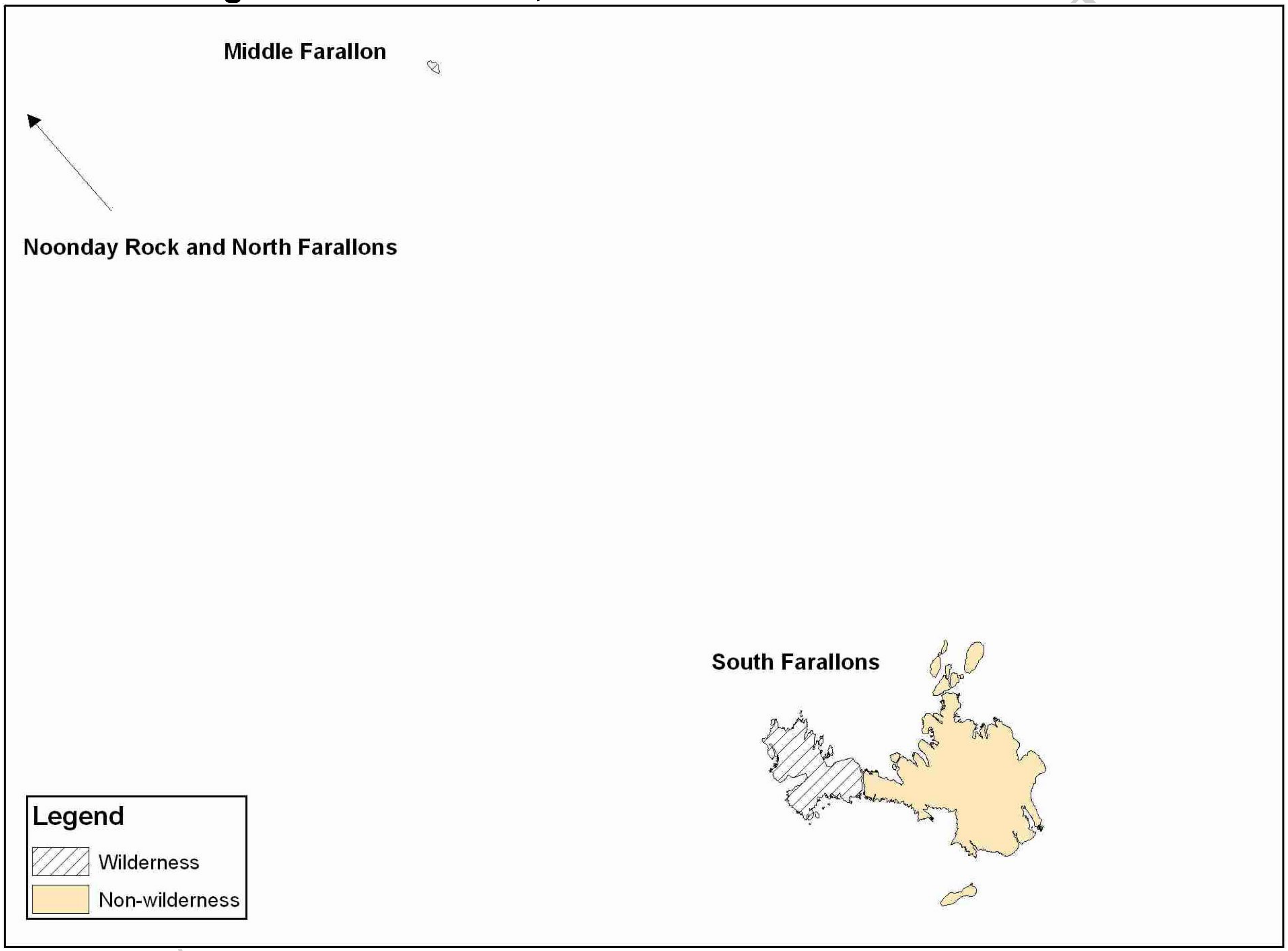
Appendix A. Map of the South Farallon Islands.



Appendix B. Designated Wilderness, South Farallon Islands.



Appendix C. Breeding birds on the South Farallones

Common name	Scientific name
Leach's storm-petrel	*Oceanodroma leucorhoa*
Ashy storm-petrel	*Oceanodroma homochroa*
Brandt's cormorant	*Phalacrocorax penicillatus*
Double-crested cormorant	*Phalacrocorax auritus*
Pelagic cormorant	*Phalacrocorax pelagicus*
Black oystercatcher	*Haematopus bachmani*
California gull	*Larus californicus*
Western gull	*Larus occidentalis*
Common murre	*Uria aalge*
Pigeon guillemot	*Cepphus columba*
Cassin's auklet	*Ptychoramphus aleuticus*
Rhinoceros auklet	*Cerorhinca monocerata*
Tufted puffin	*Fratercula cirrhata*

Appendix D. Risk profiles of birds on the South Farallones

Methods

We synthesized published bird records from DeSante and Ainley 1980, Ainley and Boekelheide 1990, Richardson et al. 2003, and unpublished bird records from PRBO and USFWS, into a single database. The published sources each present bird records grouped roughly into three "seasons" with similar dates. Richardson et al. use the following seasonal definitions, which we used except where noted:

1. Fall = July 15 – December 19
2. Winter = December 20 – February 28 (or 29)
3. Spring = March 1 – July 14

The published sources also specifically identified birds that were present for more than three weeks at a time during the winter, categorized as "winter residents."

We calculated the average occurrence rate of each bird species per season, and assigned abundance "scores" adapted from DeSante and Ainley (1980):

- Abundant = 90 birds per season or greater
- Common = 30-89 birds per season
- Fairly common = 10-29 birds per season
- Uncommon = 3-9 birds per season
- Rare = 1-2 birds per season
- Very rare = 1/3 - 1 bird per season
- Extremely rare = less than 1/3 bird per season

In most cases, we then removed birds that were extremely rare or very rare in all seasons. To identify bird species present under Alternative B, which would occur within a discrete time period, we removed birds that were extremely rare or very rare specifically in winter. However, in some cases, we included birds that were classified as extremely rare or very rare based on published bird records, but were identified by PRBO and/or USFWS biologists as likely to be present.

Birds present under Alternative B

Herbivores (Alternative B risk profile: *initially high-risk*)

		Abundance index		
Bird	**Scientific name**	**Winter**	**Winter residents**	**References**
Canada goose	*Branta Canadensis*	Very rare	Extremely rare	Richardson et al. 2003; FWS pers. comm.
Fox sparrow	*Passerella iliaca*	Very rare	Rare	Richardson et al. 2003; PRBO unpubl. data
White-crowned sparrow	*Zonotrichia leucophrys*	Very rare	Very rare	Richardson et al. 2003; PRBO unpubl. data
Golden-crowned sparrow	*Zonotrichia atricapilla*	Very rare	Uncommon	Richardson et al. 2003; PRBO unpubl. data
Dark-eyed junco	*Junco hyemalis*	Rare	Extremely rare	Richardson et al. 2003
Pine siskin	*Carduelis pinus*	Rare	Extremely rare	Richardson et al. 2003

Predators/scavengers* (Alternative B risk profile: *initially high-risk*)

		Abundance index		
Bird	**Scientific name**	**Winter**	**Winter residents**	**References**
Northern harrier	*Circus cyaneus*	Possible	Absent	Richardson et al. 2003; PRBO unpubl. data
Red-tailed hawk	*Buteo jamaicensis*	Possible	Extremely rare	Richardson et al. 2003; PRBO unpubl. data
Black-bellied plover	*Pluvialis squatarola*	Very rare	Fairly common	Richardson et al. 2003; PRBO unpubl. data
Killdeer	*Charadrius vociferus*	Uncommon	Very rare	Richardson et al. 2003
Black oystercatcher	*Haematopus bachmani*	Common	Common	DeSante & Ainley 1980; Ainley & Boekelheide 1990
Heermann's gull	*Larus heermanni*	Uncommon	Rare	Richardson et al. 2003
Mew gull	*Larus canus*	Uncommon	Very rare	Richardson et al. 2003

Predators/scavengers* (Alternative B risk profile: *initially high-risk*)

		Abundance index		
Bird	**Scientific name**	**Winter**	**Winter residents**	**References**
California gull	*Larus californicus*	Common	Extremely rare	Richardson et al. 2003; PRBO unpubl. data
Herring gull	*Larus argentatus*	Abundant	Fairly common	Richardson et al. 2003; PRBO unpubl. data
Thayer's gull	*Larus thayeri*	Uncommon	Extremely rare	Richardson et al. 2003
Western gull	*Larus occidentalis*	Abundant	Abundant	DeSante & Ainley 1980; Ainley & Boekelheide 1990
Glaucous-winged gull	*Larus glaucescens*	Abundant	Common	Richardson et al. 2003; PRBO unpubl. data
Barn owl	*Tyto alba*	Possible	Extremely rare	PRBO unpubl. data
Burrowing owl	*Athene cunicularia*	Extremely rare	Uncommon	Richardson et al. 2003; PRBO unpubl. data
Long-eared owl	*Asio otus*	Possible	Absent	Richardson et al. 2003; PRBO unpubl. data
Short-eared owl	*Asio flammeus*	Possible	Extremely rare	Richardson et al. 2003; PRBO unpubl. data
Northern saw-whet owl	*Aegolius acadicus*	Possible	Absent	PRBO unpubl. data
Hermit thrush	*Catharus guttatus*	Uncommon	Very rare	Richardson et al. 2003
American robin	*Turdus migratorius*	Fairly common	Extremely rare	Richardson et al. 2003; PRBO unpubl. data
Varied thrush	*Ixoreus naevius*	Rare	Extremely rare	Richardson et al. 2003
Starling	*Sturnus vulgaris*	Abundant	Abundant	Richardson et al. 2003
Western meadowlark	*Sturnella neglecta*	Very rare	Uncommon	Richardson et al. 2003

*Not including specialists in birds, intertidal organisms, flying insects or micro-invertebrates

Other terrestrial birds* (Alternative B risk profile: *initially low risk*)

		Abundance index		
Bird	**Scientific name**	**Winter**	**Winter residents**	
Sharp-shinned hawk	*Accipiter striatus*	Possible	Absent	Richardson et al. 2003; PRBO unpubl. data
Peregrine falcon	*Falco peregrinus*	Very rare	Uncommon	Richardson et al. 2003; PRBO unpubl. data
Wandering tattler	*Tringa incana*	Very rare	Fairly common	Richardson et al. 2003; PRBO unpubl. data
Willet	*Tringa semipalmata*	Extremely rare	Fairly common	Richardson et al. 2003; PRBO unpubl. data
Whimbrel	*Numenius phaeopus*	Extremely rare	Fairly common	Richardson et al. 2003; PRBO unpubl. data
Ruddy turnstone	*Arenaria interpres*	Very rare	Uncommon	Richardson et al. 2003
Black turnstone	*Arenaria melanocephala*	Uncommon	Common	Richardson et al. 2003; PRBO unpubl. data
Black phoebe	*Sayornis nigricans*	Very rare	Uncommon	Richardson et al. 2003; PRBO unpubl. data
Yellow-rumped warbler	*Dendroica coronata*	Fairly common	Uncommon	Richardson et al. 2003; PRBO unpubl. data

*Specialists in birds, intertidal organisms, flying insects or micro-invertebrates

Marine foragers (Alternative B risk profile: *negligible risk*)

		Abundance index		
Bird	**Scientific name**	**Winter**	**Winter residents**	**References**
Surf scoter	*Melanitta perspicillata*	Fairly common	Fairly common	Richardson et al. 2003
Pacific loon	*Gavia pacifica*	Abundant	Rare	Richardson et al. 2003

Marine foragers (Alternative B risk profile: *negligible risk*)

		Abundance index		
Bird	**Scientific name**	**Winter**	**Winter residents**	**References**
Common loon	*Gavia immer*	Fairly common	Extremely rare	Richardson et al. 2003
Eared grebe	*Podiceps nigricollis*	Abundant	Abundant	Richardson et al. 2003
Western / Clark's grebe	*Aechmophorus occidentalis / A. clarkii*	Rare	Very rare	Richardson et al. 2003
Northern fulmar	*Fulmarus glacialis*	Abundant	Absent	Richardson et al. 2003
Sooty shearwater	*Puffinus griseus*	Fairly common	Absent	Richardson et al. 2003
Ashy storm-petrel	*Oceanodroma homochroa*	Abundant	Abundant	DeSante & Ainley 1980; Ainley & Boekelheide 1990
Brown pelican	*Pelecanus occidentalis*	Abundant	Absent	Richardson et al. 2003; PRBO unpubl. data
Brandt's cormorant	*Phalacrocorax penicillatus*	Abundant	Abundant	DeSante & Ainley 1980; Ainley & Boekelheide 1990
Pelagic cormorant	*Phalacrocorax pelagicus*	Abundant	Abundant	DeSante & Ainley 1980; Ainley & Boekelheide 1990
Red phalarope	*Phalaropus fulicarius*	Fairly common	Absent	Richardson et al. 2003
Black-legged kittiwake	*Rissa tridactyla*	Abundant	Absent	Richardson et al. 2003
Common murre	*Uria aalge*	Abundant	Abundant	DeSante & Ainley 1980; Ainley & Boekelheide 1990
Ancient murrelet	*Synthliboramphus hypoleucus*	Fairly common	Rare	Richardson et al. 2003

Marine foragers (Alternative B risk profile: *negligible risk*)

		Abundance index		
Bird	**Scientific name**	**Winter**	**Winter residents**	**References**
Cassin's auklet	*Ptychoramphus aleuticus*	Abundant	Abundant	DeSante & Ainley 1980; Ainley & Boekelheide 1990
Rhinoceros auklet	*Cerorhinca monocerata*	Uncommon	Uncommon	DeSante & Ainley 1980; Ainley & Boekelheide 1990

Birds present under Alternative C

Herbivores (Alternative C risk profile: *primarily low risk; high risk during bait broadcast*)

		Abundance index				
Bird	**Scientific name**	**Fall**	**Winter**	**Winter residents**	**Spring**	**References**
Greater white-fronted goose	*Anser albifrons*	Fairly common	Extremely rare	Absent	Extremely rare	Richardson et al. 2003
Brant	*Branta bernicla*	Abundant	Extremely rare	Extremely rare	Common	Richardson et al. 2003
Canada goose	***Branta canadensis***	**Fairly common**	**Very rare**	**Extremely rare**	**Extremely rare**	**Richardson et al. 2003**
Mourning dove	*Zenaida macroura*	Fairly common	Extremely rare	Absent	Uncommon	Richardson et al. 2003
Horned lark	*Eremophila alpestris*	Uncommon	Absent	Absent	Extremely rare	Richardson et al. 2003
American (Water) pipit	*Anthus rubescens*	Abundant	Extremely rare	Absent	Very rare	Richardson et al. 2003

Herbivores (Alternative C risk profile: *primarily low risk; high risk during bait broadcast*)

		Abundance index				
Bird	**Scientific name**	**Fall**	**Winter**	**Winter residents**	**Spring**	**References**
Spotted towhee	*Pipilo maculates / P. erythrophtalmus*	Fairly common	Absent	Absent	Rare	Richardson et al. 2003
Chipping sparrow	*Spizella passerina*	Common	Extremely rare	Absent	Fairly common	Richardson et al. 2003
Clay-colored sparrow	*Spizella pallida*	Fairly common	Absent	Extremely rare	Rare	Richardson et al. 2003
Brewer's sparrow	*Spizella breweri*	Uncommon	Absent	Absent	Rare	Richardson et al. 2003
Vesper sparrow	*Pooecetes gramineus*	Fairly common	Absent	Absent	Very rare	Richardson et al. 2003
Lark sparrow	*Chondestes grammacus*	Uncommon	Extremely rare	Absent	Very rare	Richardson et al. 2003
Savannah sparrow	*Passerculus sandwichensis*	Abundant	Absent	Extremely rare	Uncommon	Richardson et al. 2003
Fox sparrow	***Passerella iliaca***	**Common**	**Very rare**	**Rare**	**Uncommon**	**Richardson et al. 2003; PRBO unpubl. data**
Lincoln's sparrow	*Melospiza lincolnii*	Common	Absent	Absent	Fairly common	Richardson et al. 2003
White-throated sparrow	*Zonotrichia albicollis*	Fairly common	Absent	Absent	Very rare	Richardson et al. 2003
White-crowned sparrow	***Zonotrichia leucophrys***	**Abundant**	**Very rare**	**Very rare**	**Common**	**Richardson et al. 2003; PRBO unpubl. data**
Golden-crowned sparrow	***Zonotrichia atricapilla***	**Abundant**	**Very rare**	**Uncommon**	**Fairly common**	**Richardson et al. 2003; PRBO unpubl. data**
Dark-eyed junco	***Junco hyemalis***	**Abundant**	**Rare**	**Extremely rare**	**Common**	**Richardson et al. 2003**

Herbivores (Alternative C risk profile: *primarily low risk; high risk during bait broadcast*)

		Abundance index				
Bird	**Scientific name**	**Fall**	**Winter**	**Winter residents**	**Spring**	**References**
Lapland longspur	*Calcarius lapponicus*	Fairly common	Absent	Absent	Extremely rare	Richardson et al. 2003
Lazuli bunting	*Passerina amoena*	Fairly common	Absent	Absent	Uncommon	Richardson et al. 2003
Bobolink	*Dolichonyx oryzivorus*	Uncommon	Absent	Absent	Very rare	Richardson et al. 2003
Pine siskin	***Carduelis pinus***	**Common**	**Rare**	**Extremely rare**	**Rare**	**Richardson et al. 2003**

Species in **bold** may be present during bait broadcast. Species not in bold are unlikely to be present during broadcast.

Predators/scavengers* (Alternative C risk profile: *primarily low risk; high risk during bait broadcast*)

		Abundance index				
Bird	**Scientific name**	**Fall**	**Winter**	**Winter residents**	**Spring**	**References**
American wigeon	*Anas americana*	Uncommon	Absent	Absent	Absent	Richardson et al. 2003
Mallard	*Anas platyrhynchos*	Uncommon	Absent	Absent	Extremely rare	Richardson et al. 2003
Northern pintail	*Anas acuta*	Abundant	Extremely rare	Absent	Extremely rare	Richardson et al. 2003
Green-winged teal	*Anas crecca*	Fairly common	Extremely rare	Absent	Absent	Richardson et al. 2003

Predators/scavengers* (Alternative C risk profile: *primarily low risk; high risk during bait broadcast*)

		Abundance index				
Bird	**Scientific name**	**Fall**	**Winter**	**Winter residents**	**Spring**	**References**
Black-bellied plover	***Pluvialis squatarola***	**Common**	**Very rare**	**Fairly common**	**Rare**	**Richardson et al. 2003; PRBO unpubl. data**
Semipalmated plover	*Charadrius semipalmatus*	Fairly common	Absent	Absent	Absent	Richardson et al. 2003
Killdeer	***Charadrius vociferus***	**Fairly common**	**Uncommon**	**Very rare**	**Very rare**	**Richardson et al. 2003**
Black oystercatcher	***Haematopus bachmani***	**Common**	**Common**	**Common**	**Common**	**DeSante & Ainley 1980; Ainley & Boekelheide 1990**
Spotted sandpiper	*Actitis macularius*	Uncommon	Absent	Extremely rare	Very rare	Richardson et al. 2003
Wandering tattler	*Tringa incana*	Common	Very rare	Fairly common	Fairly common	Richardson et al. 2003; PRBO unpubl. data
Willet	*Tringa semipalmata*	Fairly common	Extremely rare	Fairly common	Very rare	Richardson et al. 2003; PRBO unpubl. data
Whimbrel	*Numenius phaeopus*	Common	Extremely rare	Fairly common	Uncommon	Richardson et al. 2003; PRBO unpubl. data
Marbled godwit	*Limosa fedoa*	Fairly common	Absent	Absent	Extremely rare	Richardson et al. 2003
Ruddy turnstone	*Arenaria interpres*	Fairly common	Very rare	Uncommon	Rare	Richardson et al. 2003
Black turnstone	*Arenaria melanocephala*	Abundant	Uncommon	Common	Uncommon	Richardson et al. 2003; PRBO unpubl. data
Surfbird	*Aphriza virgata*	Uncommon	Very rare	Very rare	Very rare	Richardson et al. 2003
Western sandpiper	*Calidris mauri*	Common	Extremely rare	Absent	Absent	Richardson et al. 2003

Predators/scavengers* (Alternative C risk profile: *primarily low risk; high risk during bait broadcast*)

		Abundance index				
Bird	**Scientific name**	**Fall**	**Winter**	**Winter residents**	**Spring**	**References**
Least sandpiper	*Calidris minutilla*	Fairly common	Extremely rare	Absent	Extremely rare	Richardson et al. 2003
Pectoral sandpiper	*Calidris melanotos*	Fairly common	Absent	Absent	Extremely rare	Richardson et al. 2003
Short-billed dowitcher	*Limnodromus griseus*	Common	Absent	Absent	Very rare	Richardson et al. 2003
Long-billed dowitcher	*Limnodromus scolopaceus*	Fairly common	Extremely rare	Absent	Extremely rare	Richardson et al. 2003
Northern flicker (yellow- + red-shafted)	*Colaptes auratus*	Fairly common	Very rare	Very rare	Uncommon	Richardson et al. 2003
Swainson's thrush	*Catharus ustulatus*	Common	Absent	Absent	Uncommon	Richardson et al. 2003
Hermit thrush	***Catharus guttatus***	**Common**	**Uncommon**	**Very rare**	**Fairly common**	**Richardson et al. 2003**
American robin	***Turdus migratorius***	**Fairly common**	**Fairly common**	**Extremely rare**	**Uncommon**	**Richardson et al. 2003; PRBO unpubl. data**
Varied thrush	***Ixoreus naevius***	**Fairly common**	**Rare**	**Extremely rare**	**Uncommon**	**Richardson et al. 2003**
Northern Mockingbird	*Mimus polyglottos*	Uncommon	Extremely rare	Absent	Rare	Richardson et al. 2003
Starling	***Sturnus vulgaris***	**Abundant**	**Abundant**	**Abundant**	**Uncommon**	**Richardson et al. 2003**
Cedar waxwing	*Bombycilla cedrorum*	Common	Very rare	Absent	Uncommon	Richardson et al. 2003
Western tanager	*Piranga ludoviciana*	Fairly common	Absent	Absent	Uncommon	Richardson et al. 2003

Predators/scavengers* (Alternative C risk profile: *primarily low risk; high risk during bait broadcast*)

		Abundance index				
Bird	**Scientific name**	**Fall**	**Winter**	**Winter residents**	**Spring**	**References**
Rose-breasted grosbeak	*Pheucticus ludovicianus*	Uncommon	Absent	Absent	Uncommon	Richardson et al. 2003
Black-headed grosbeak	*Pheucticus melanocephalus*	Uncommon	Absent	Absent	Uncommon	Richardson et al. 2003
Red-winged blackbird	*Agelaius phoeniceus*	Fairly common	Extremely rare	Absent	Rare	Richardson et al. 2003
Western meadowlark	***Sturnella neglecta***	**Common**	**Very rare**	**Uncommon**	**Rare**	**Richardson et al. 2003**
Brewer's blackbird	*Euphagus cyanocephalus*	Common	Very rare	Extremely rare	Uncommon	Richardson et al. 2003
Brown-headed cowbird	*Molothrus ater*	Common	Absent	Absent	Fairly common	Richardson et al. 2003
Bullock's oriole	*Icterus bullockii*	Fairly common	Absent	Absent	Uncommon	Richardson et al. 2003
Purple finch	*Carpodacus purpureus*	Fairly common	Extremely rare	Extremely rare	Uncommon	Richardson et al. 2003
House finch	*Carpodacus mexicanus*	Fairly common	Extremely rare	Absent	Fairly common	Richardson et al. 2003
Lesser goldfinch	*Carduelis psaltria*	Common	Extremely rare	Absent	Rare	Richardson et al. 2003

*Not including *mouse predators*, specialists in birds, intertidal organisms, flying insects or micro-invertebrates
Species in **bold** may be present during bait broadcast. Species not in bold are unlikely to be present during broadcast.

Mouse predators/scavengers (Alternative C risk profile: *initially high risk; high risk again during bait broadcast; otherwise low risk*)

		Abundance index				
Bird	**Scientific name**	**Fall**	**Winter**	**Winter residents**	**Spring**	**References**
Great blue heron	*Ardea herodias*	Uncommon	Extremely rare	Extremely rare	Very rare	Richardson et al. 2003
Northern harrier	*Circus cyaneus*	Uncommon	Possible	Absent	Extremely rare	Richardson et al. 2003; PRBO unpubl. data
Red-tailed hawk	*Buteo jamaicensis*	Possible	Possible	Extremely rare	Extremely rare	Richardson et al. 2003; PRBO unpubl. data
Rough-legged hawk	*Buteo lagopus*	Rare	Extremely rare	Extremely rare	Absent	Richardson et al. 2003
American kestrel	*Falco sparverius*	Fairly common	Very rare	Very rare	Extremely rare	Richardson et al. 2003
Heermann's gull	*Larus heermanni*	Abundant	Uncommon	Rare	Uncommon	Richardson et al. 2003
Mew gull	*Larus canus*	Fairly common	Uncommon	Very rare	Rare	Richardson et al. 2003
Ring-billed gull	*Larus delawarensis*	Uncommon	Very rare	Absent	Very rare	Richardson et al. 2003
California gull	*Larus californicus*	Abundant	Common	Extremely rare	Common	Richardson et al. 2003; PRBO unpubl. data
Herring gull	*Larus argentatus*	Abundant	Abundant	Fairly common	Common	Richardson et al. 2003; PRBO unpubl. data
Thayer's gull	*Larus thayeri*	Uncommon	Uncommon	Extremely rare	Uncommon	Richardson et al. 2003
Western gull	*Larus occidentalis*	Abundant	Abundant	Abundant	Abundant	DeSante & Ainley 1980; Ainley & Boekelheide 1990
Glaucous-winged gull	*Larus glaucescens*	Abundant	Abundant	Common	Abundant	Richardson et al. 2003; PRBO unpubl. data

Barn owl	*Tyto alba*	Possible	Possible	Extremely rare	Extremely rare	PRBO unpubl. data
Burrowing owl	*Athene cunicularia*	Uncommon	Extremely rare	Uncommon	Very rare	Richardson et al. 2003; PRBO unpubl. data
Long-eared owl	*Asio otus*	Rare	Possible	Absent	Extremely rare	Richardson et al. 2003; PRBO unpubl. data
Short-eared owl	*Asio flammeus*	Uncommon	Possible	Extremely rare	Extremely rare	Richardson et al. 2003; PRBO unpubl. data
Northern saw-whet owl	*Aegolius acadicus*	Possible	Possible	Absent	Absent	PRBO unpubl. data

Other terrestrial birds* (Alternative C risk profile: *low to negligible risk*)

		Abundance index				
Bird	**Scientific name**	**Fall**	**Winter**	**Winter residents**	**Spring**	**References**
Sharp-shinned hawk	*Accipiter striatus*	Fairly common	Possible	Absent	Absent	Richardson et al. 2003; PRBO unpubl. data
Merlin	*Falco columbarius*	Uncommon	Absent	Absent	Absent	Richardson et al. 2003
Peregrine falcon	*Falco peregrinus*	Fairly common	Very rare	Uncommon	Uncommon	Richardson et al. 2003; PRBO unpubl. data
Wandering tattler	*Tringa incana*	Common	Very rare	Fairly common	Fairly common	Richardson et al. 2003; PRBO unpubl. data
Willet	*Tringa semipalmata*	Fairly common	Extremely rare	Fairly common	Very rare	Richardson et al. 2003; PRBO unpubl. data
Whimbrel	*Numenius phaeopus*	Common	Extremely rare	Fairly common	Uncommon	Richardson et al. 2003; PRBO unpubl. data
Ruddy turnstone	*Arenaria interpres*	Fairly common	Very rare	Uncommon	Rare	Richardson et al. 2003

Other terrestrial birds* (Alternative C risk profile: *low to negligible risk*)

		Abundance index				
Bird	**Scientific name**	**Fall**	**Winter**	**Winter residents**	**Spring**	**References**
Black turnstone	*Arenaria melanocephala*	Abundant	Uncommon	Common	Uncommon	Richardson et al. 2003; PRBO unpubl. data
Vaux's swift	*Chaetura vauxi*	Common	Absent	Absent	Very rare	Richardson et al. 2003
Anna's hummingbird	*Calypte anna*	Fairly common	Very rare	Absent	Rare	Richardson et al. 2003
Rufous / Allen's hummingbird	*Selasphorus rufus/S. sasin*	Uncommon	Absent	Absent	Fairly common	Richardson et al. 2003
Western wood pewee	*Contopus sordidulus*	Fairly common	Absent	Absent	Common	Richardson et al. 2003
Willow flycatcher	*Empidonax traillii*	Fairly common	Absent	Absent	Uncommon	Richardson et al. 2003
Western flycatcher	*Empidonax difficilis / E. occidentalis*	Common	Absent	Absent	Fairly common	Richardson et al. 2003
Black phoebe	*Sayornis nigricans*	Fairly common	Very rare	Uncommon	Very rare	Richardson et al. 2003; PRBO unpubl. data
Say's phoebe	*Sayornis saya*	Uncommon	Absent	Extremely rare	Very rare	Richardson et al. 2003
Cassin's Vireo	*Vireo plumbeus / V. cassinii / V. solitaries*	Uncommon	Absent	Absent	Rare	Richardson et al. 2003
Warbling vireo	*Vireo gilvus*	Fairly common	Absent	Absent	Uncommon	Richardson et al. 2003
Tree swallow	*Tachycineta bicolor*	Uncommon	Absent	Absent	Uncommon	Richardson et al. 2003
Violet-green swallow	*Tachycineta thalassina*	Common	Absent	Absent	Uncommon	Richardson et al. 2003

Other terrestrial birds* (Alternative C risk profile: *low to negligible risk*)

		Abundance index				
Bird	**Scientific name**	**Fall**	**Winter**	**Winter residents**	**Spring**	**References**
Rough-winged swallow	*Stelgidopteryx serripennis / S. ruficollis*	Uncommon	Absent	Absent	Very rare	Richardson et al. 2003
Cliff swallow	*Petrochelidon pyrrhonota*	Uncommon	Absent	Absent	Very rare	Richardson et al. 2003
Barn swallow	*Hirundo rustica*	Fairly common	Absent	Absent	Uncommon	Richardson et al. 2003
Red-breasted nuthatch	*Sitta canadensis*	Common	Absent	Absent	Rare	Richardson et al. 2003
Winter wren	*Troglodytes troglodytes*	Uncommon	Extremely rare	Extremely rare	Very rare	Richardson et al. 2003
Golden-crowned kinglet	*Regulus satrapa*	Common	Absent	Absent	Uncommon	Richardson et al. 2003
Ruby-crowned kinglet	*Regulus calendula*	Abundant	Very rare	Extremely rare	Common	Richardson et al. 2003; PRBO unpubl. data
Tennessee warbler	*Vermivora peregrina*	Uncommon	Absent	Absent	Uncommon	Richardson et al. 2003
Orange-crowned warbler	*Vermivora celata*	Fairly common	Absent	Extremely rare	Common	Richardson et al. 2003
Nashville warbler	*Vermivora ruficapilla*	Fairly common	Absent	Absent	Rare	Richardson et al. 2003
Yellow warbler	*Dendroica petechia*	Common	Absent	Absent	Fairly common	Richardson et al. 2003
Chestnut-sided warbler	*Dendroica pensylvanica*	Uncommon	Absent	Absent	Rare	Richardson et al. 2003
Magnolia warbler	*Dendroica magnolia*	Uncommon	Absent	Absent	Uncommon	Richardson et al. 2003

Other terrestrial birds* (Alternative C risk profile: *low to negligible risk*)

		Abundance index				
Bird	**Scientific name**	**Fall**	**Winter**	**Winter residents**	**Spring**	**References**
Yellow-rumped warbler	*Dendroica coronata*	Abundant	Fairly common	Uncommon	Common	Richardson et al. 2003; PRBO unpubl. data
Black-throated gray warbler	*Dendroica nigrescens*	Fairly common	Absent	Extremely rare	Rare	Richardson et al. 2003
Townsend's warbler	*Dendroica townsendi*	Common	Extremely rare	Extremely rare	Fairly common	Richardson et al. 2003
Hermit warbler	*Dendroica occidentalis*	Uncommon	Absent	Absent	Uncommon	Richardson et al. 2003
Palm warbler	*Dendroica palmarum*	Common	Absent	Extremely rare	Rare	Richardson et al. 2003; PRBO unpubl. data
Blackpoll warbler	*Dendroica striata*	Fairly common	Absent	Absent	Rare	Richardson et al. 2003
American redstart	*Setophaga ruticilla*	Fairly common	Absent	Absent	Uncommon	Richardson et al. 2003
Ovenbird	*Seiurus aurocapilla*	Uncommon	Absent	Absent	Uncommon	Richardson et al. 2003
MacGillivray's warbler	*Oporornis tolmiei*	Fairly common	Absent	Absent	Uncommon	Richardson et al. 2003
Common yellowthroat	*Geothlypis trichas*	Fairly common	Absent	Absent	Fairly common	Richardson et al. 2003
Wilson's warbler	*Wilsonia pusilla*	Common	Absent	Absent	Abundant	Richardson et al. 2003

*Specialists in birds, intertidal organisms, flying insects or micro-invertebrates

Marine foragers (Alternative C risk profile: *negligible risk*)

		Abundance index				
Bird	**Scientific name**	**Fall**	**Winter**	**Winter residents**	**Spring**	**References**
Greater scaup	*Aythya marila*	Uncommon	Extremely rare	Absent	Extremely rare	Richardson et al. 2003
Surf scoter	*Melanitta perspicillata*	Common	Fairly common	Fairly common	Common	Richardson et al. 2003
Pacific loon	*Gavia pacifica*	Abundant	Abundant	Rare	Abundant	Richardson et al. 2003
Common loon	*Gavia immer*	Common	Fairly common	Extremely rare	Uncommon	Richardson et al. 2003
Eared grebe	*Podiceps nigricollis*	Abundant	Abundant	Abundant	Abundant	Richardson et al. 2003
Western/Clark's grebe	*Aechmophorus occidentalis / A. clarkii*	Fairly common	Rare	Very rare	Uncommon	Richardson et al. 2003
Black-footed albatross	*Phoebastria nigripes*	Rare	Extremely rare	Absent	Uncommon	Richardson et al. 2003
Northern fulmar	*Fulmarus glacialis*	Abundant	Abundant	Absent	Common	Richardson et al. 2003
Pink-footed shearwater	*Puffinus creatopus*	Abundant	Absent	Absent	Common	Richardson et al. 2003
Buller's shearwater	*Puffinus bulleri*	Abundant	Absent	Absent	Absent	Richardson et al. 2003
Sooty shearwater	*Puffinus griseus*	Abundant	Fairly common	Absent	Abundant	Richardson et al. 2003
Short-tailed shearwater	*Puffinus tenuirostris*	Fairly common	Extremely rare	Absent	Extremely rare	Richardson et al. 2003
Black-vented shearwater	*Puffinus opisthomelas*	Abundant	Extremely rare	Absent	Very rare	Richardson et al. 2003

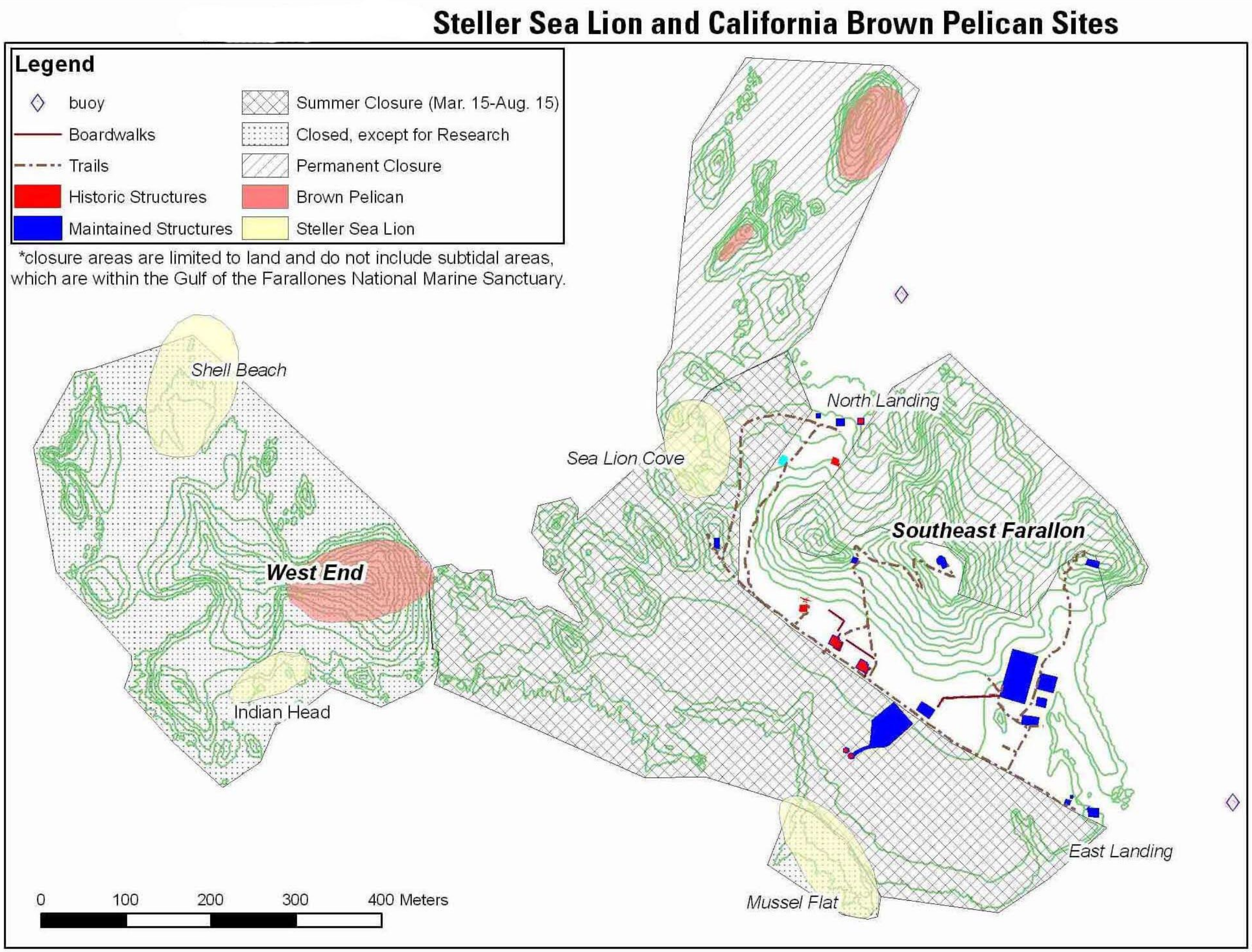
Marine foragers (Alternative C risk profile: *negligible risk*)

		Abundance index				
Bird	**Scientific name**	**Fall**	**Winter**	**Winter residents**	**Spring**	**References**
Leach's storm-petrel	*Oceanodroma leucorhoa*	Absent	Absent	Absent	Abundant	DeSante & Ainley 1980; Ainley & Boekelheide 1990
Ashy storm-petrel	*Oceanodroma homochroa*	Abundant	Abundant	Abundant	Abundant	DeSante & Ainley 1980; Ainley & Boekelheide 1990
Brown pelican	*Pelecanus occidentalis*	Abundant	Abundant	Absent	Abundant	Richardson et al. 2003; PRBO unpubl. data
Brandt's cormorant	*Phalacrocorax penicillatus*	Abundant	Abundant	Abundant	Abundant	DeSante & Ainley 1980; Ainley & Boekelheide 1990
Double-crested cormorant	*Phalacrocorax auritus*	Rare	Absent	Absent	Common	DeSante & Ainley 1980; Ainley & Boekelheide 1990
Pelagic cormorant	*Phalacrocorax pelagicus*	Abundant	Abundant	Abundant	Abundant	DeSante & Ainley 1980; Ainley & Boekelheide 1990
Red-necked phalarope	*Phalaropus lobatus*	Abundant	Absent	Absent	Abundant	Richardson et al. 2003
Red phalarope	*Phalaropus fulicarius*	Abundant	Fairly common	Absent	Abundant	Richardson et al. 2003
Black-legged kittiwake	*Rissa tridactyla*	Common	Abundant	Absent	Abundant	Richardson et al. 2003
Elegant tern	*Thalasseus elegans*	Abundant	Absent	Absent	Absent	Richardson et al. 2003
Pomarine jaeger	*Stercorarius pomarinus*	Fairly common	Extremely rare	Absent	Extremely rare	Richardson et al. 2003
Parasitic jaeger	*Stercorarius parasiticus*	Uncommon	Extremely rare	Absent	Extremely rare	Richardson et al. 2003
Common murre	*Uria aalge*	Abundant	Abundant	Abundant	Abundant	DeSante & Ainley 1980; Ainley & Boekelheide 1990

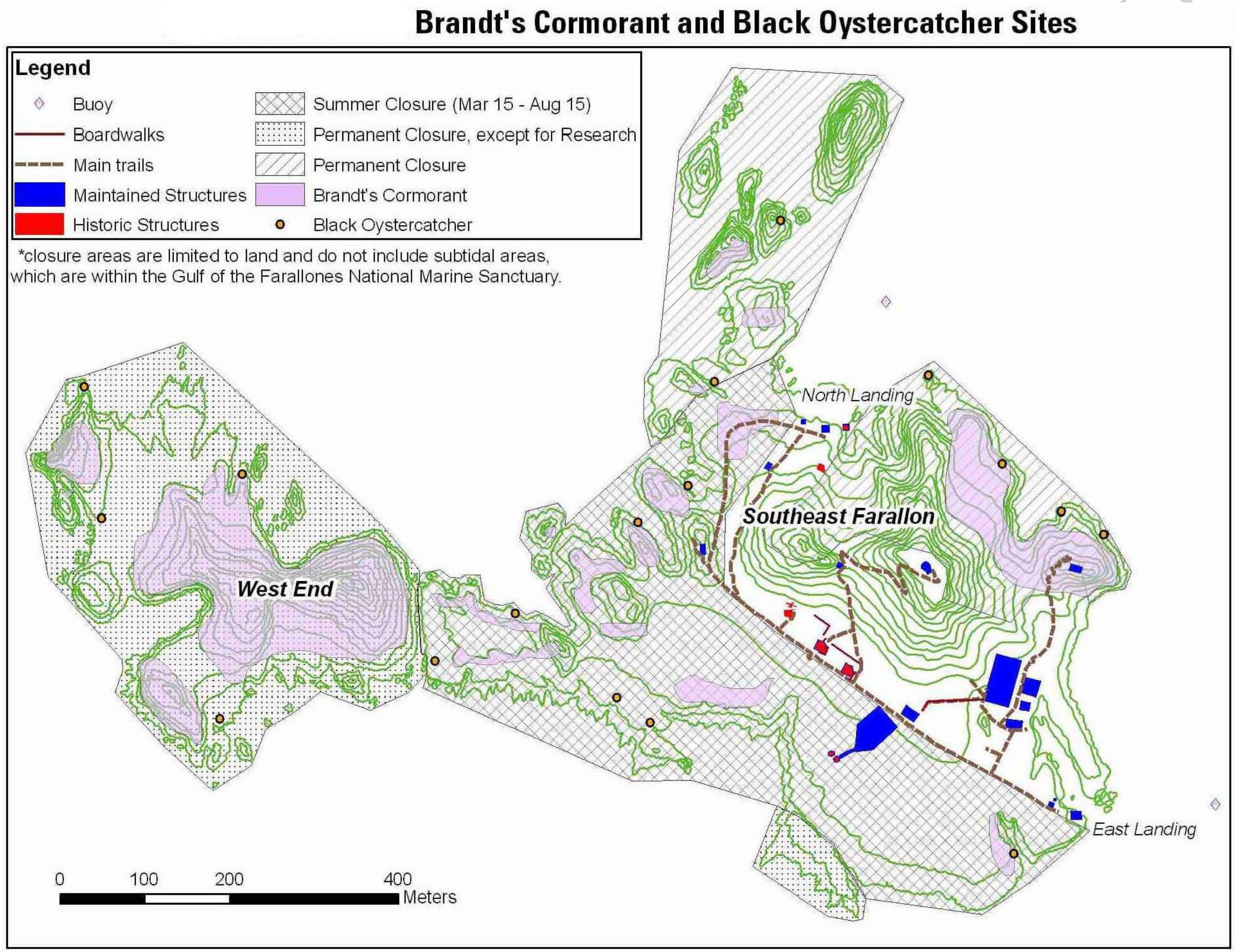
Marine foragers (Alternative C risk profile: *negligible risk*)

		Abundance index				
Bird	**Scientific name**	**Fall**	**Winter**	**Winter residents**	**Spring**	**References**
Pigeon guillemot	*Cepphus columba*	Abundant	Very rare	Very rare	Abundant	DeSante & Ainley 1980; Ainley & Boekelheide 1990
Ancient murrelet	*Synthliboramphus hypoleucus*	Uncommon	Fairly common	Rare	Rare	Richardson et al. 2003
Cassin's auklet	*Ptychoramphus aleuticus*	Abundant	Abundant	Abundant	Abundant	DeSante & Ainley 1980; Ainley & Boekelheide 1990
Rhinoceros auklet	*Cerorhinca monocerata*	Uncommon	Uncommon	Uncommon	Uncommon	DeSante & Ainley 1980; Ainley & Boekelheide 1990
Tufted puffin	*Fratercula cirrhata*	Common	Absent	Absent	Common	DeSante & Ainley 1980; Ainley & Boekelheide 1990
Belted kingfisher	*Megaceryle alcyon*	Uncommon	Extremely rare	Very rare	Very rare	Richardson et al. 2003

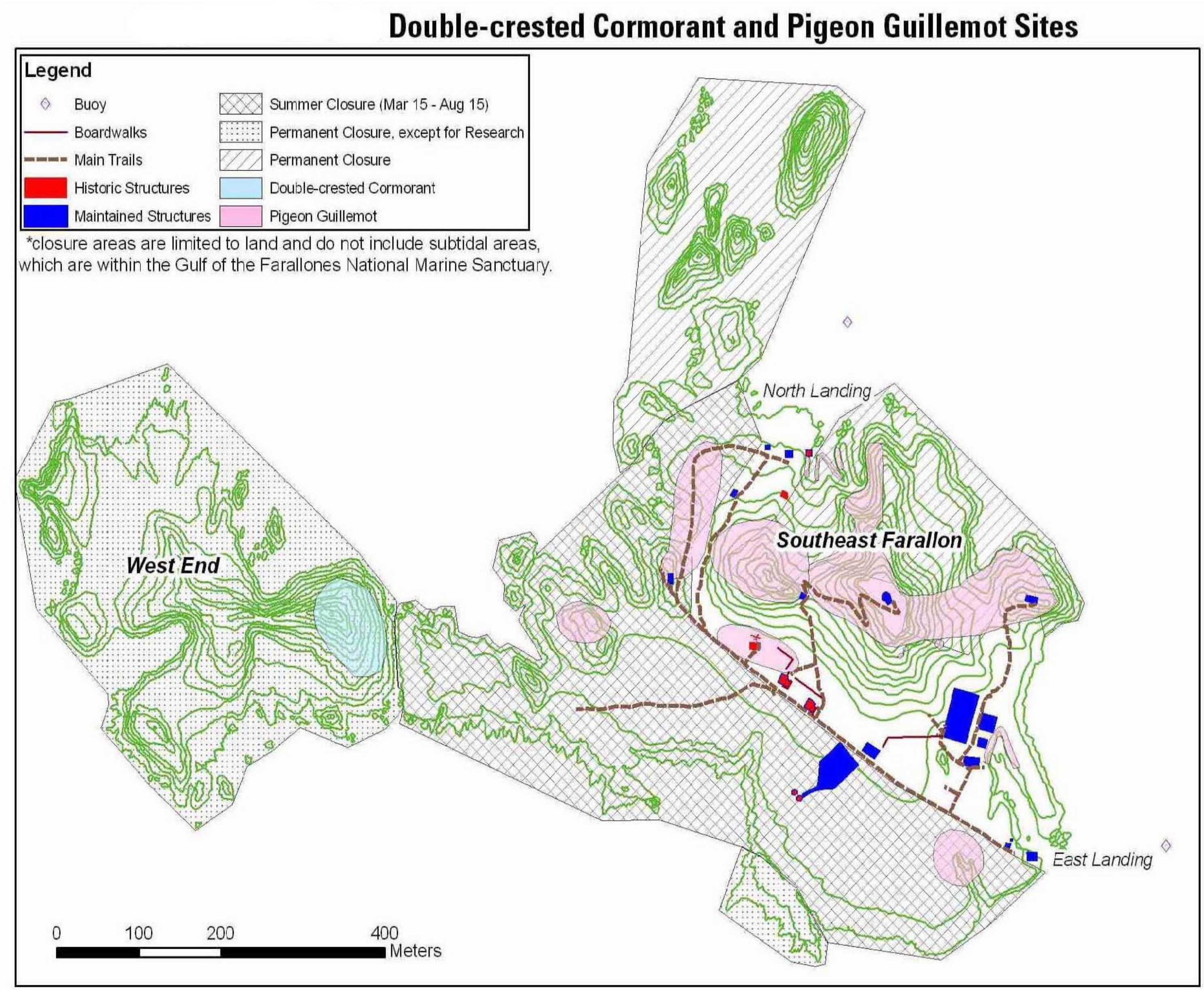
Appendix E. Distribution of ESA-listed species, South Farallon Islands



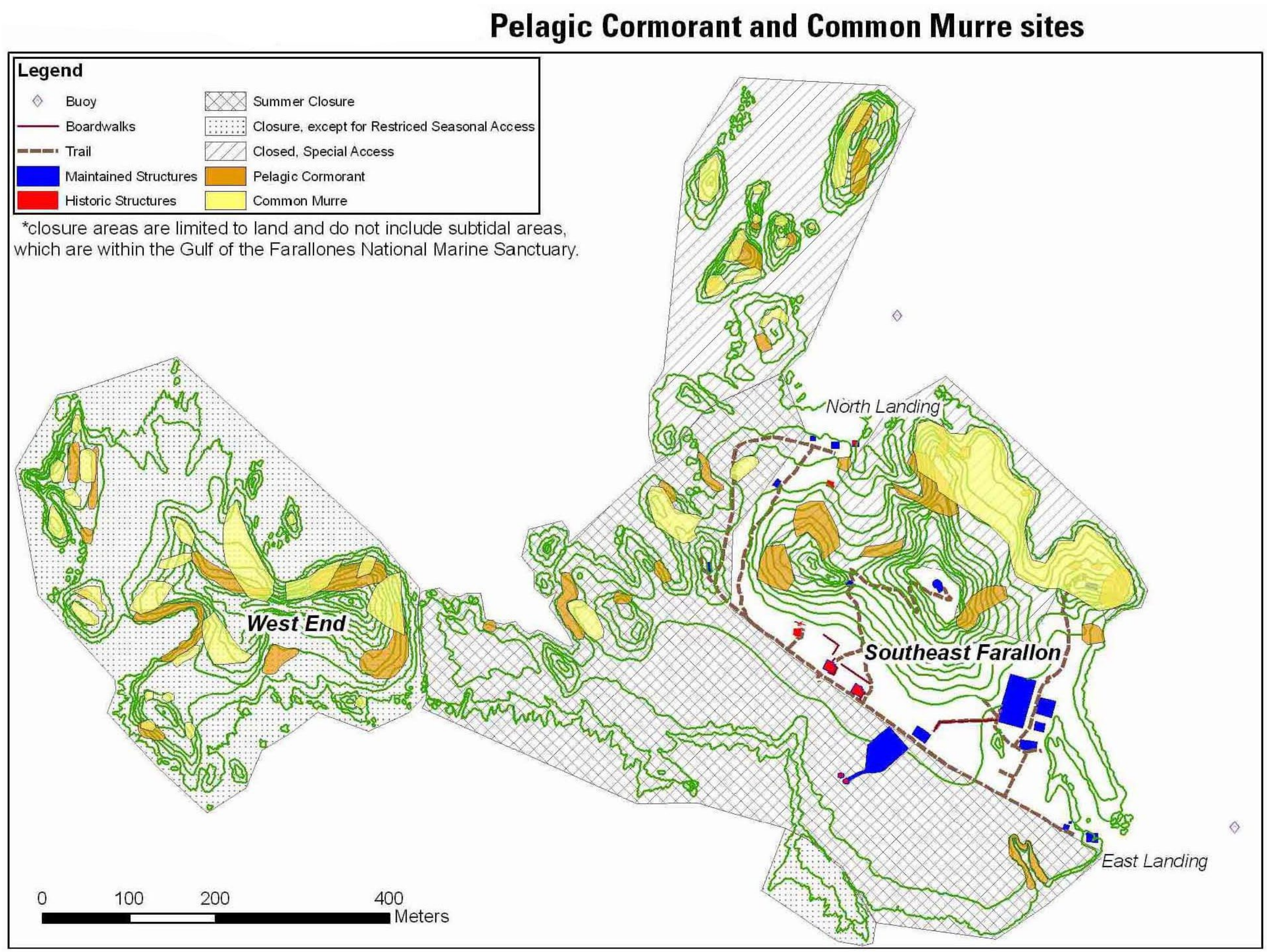
Appendix F. Seabird nesting and roosting areas, South Farallon Islands



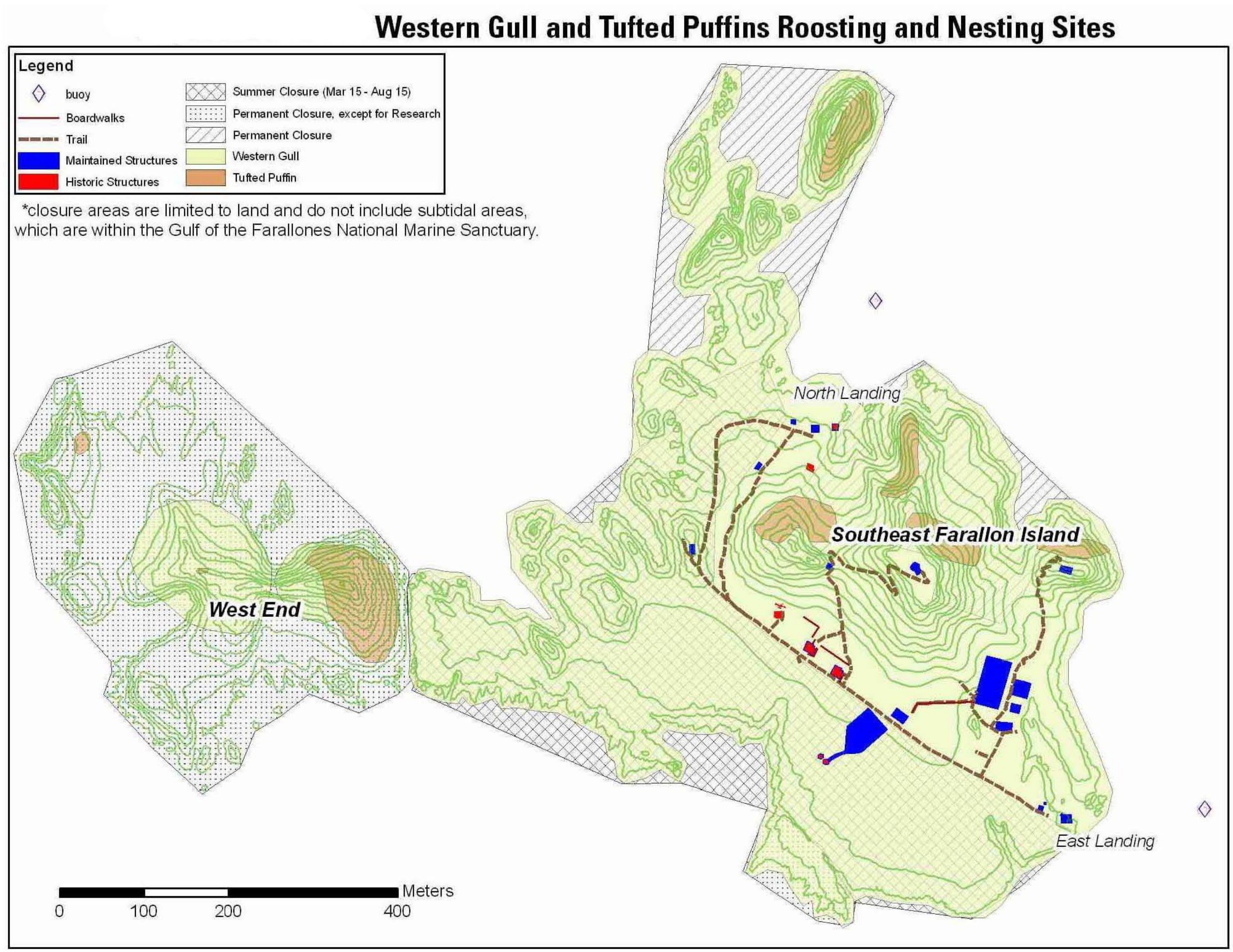
F. Seabird nesting and roosting areas



F. Seabird nesting and roosting areas

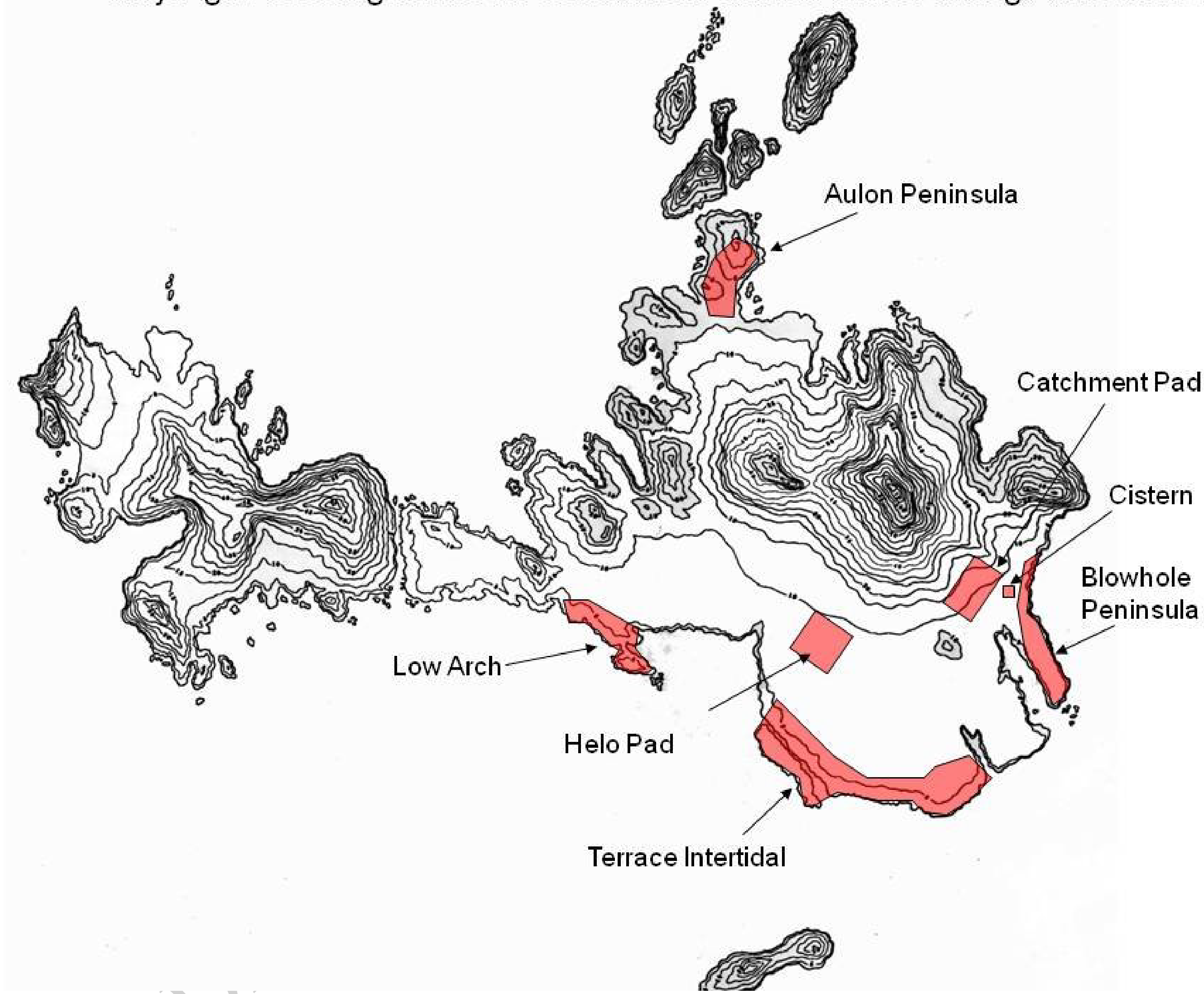


F. Seabird nesting and roosting areas

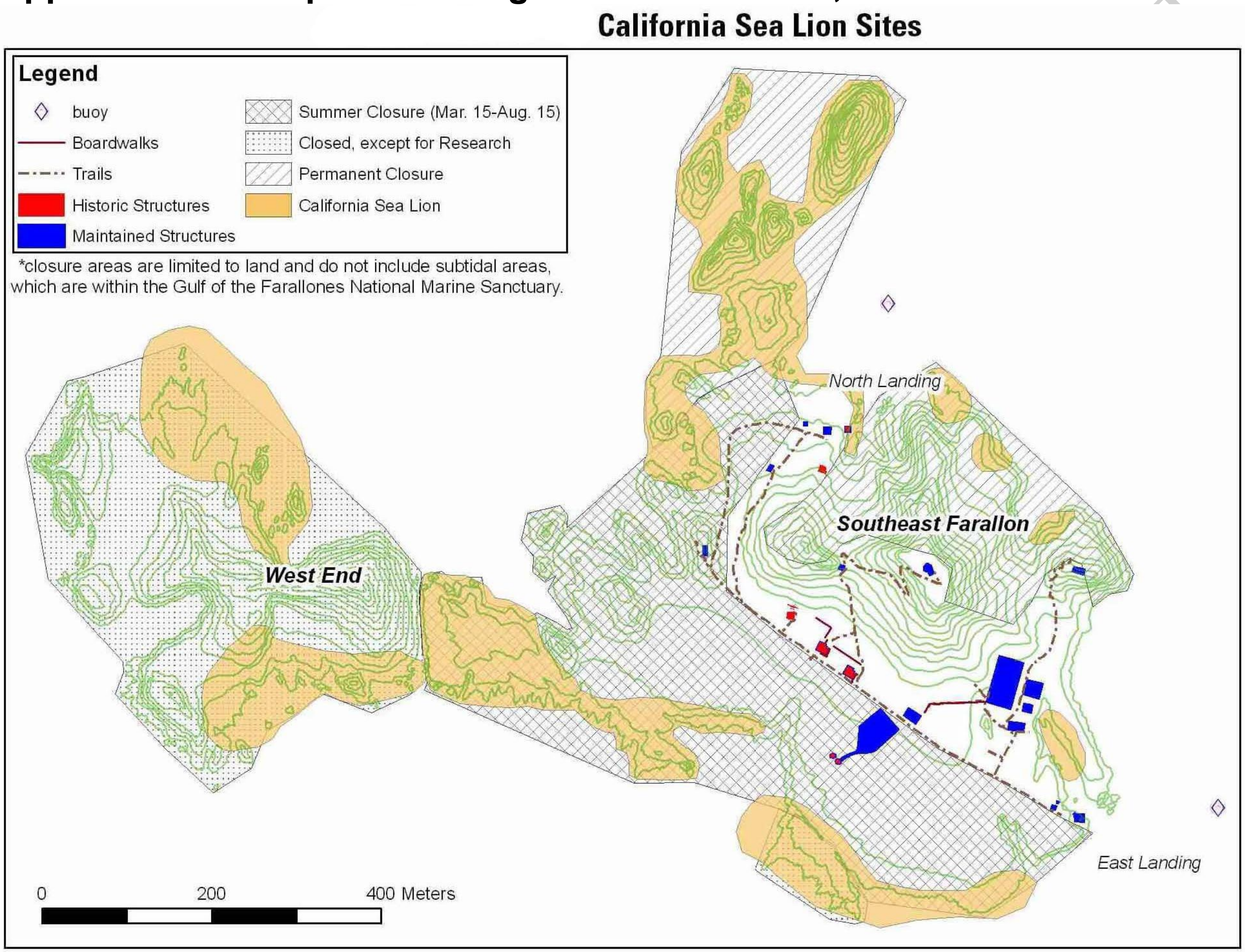


F. Seabird nesting and roosting areas

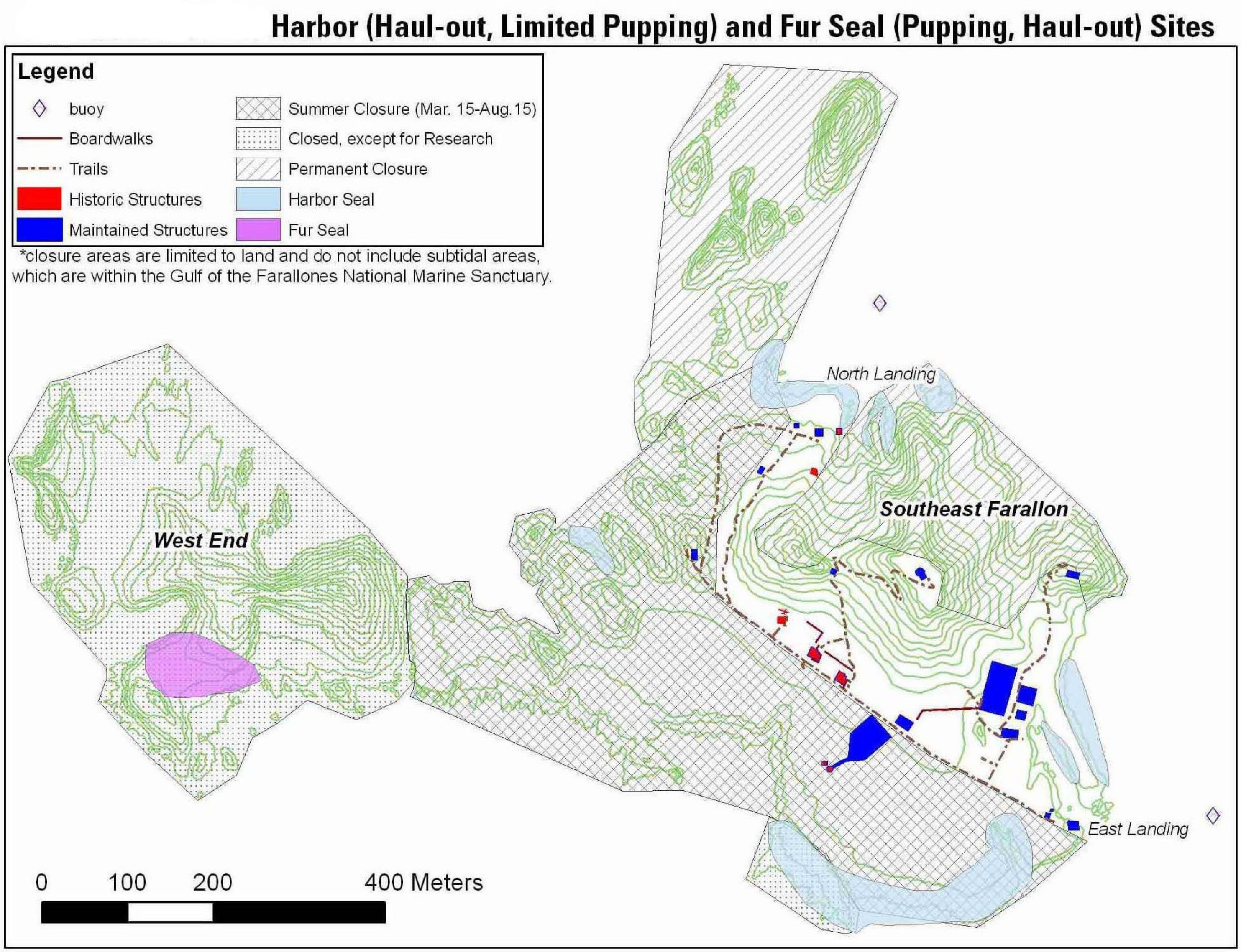
Major gull roosting areas on Southeast Farallon Island during Alternative B



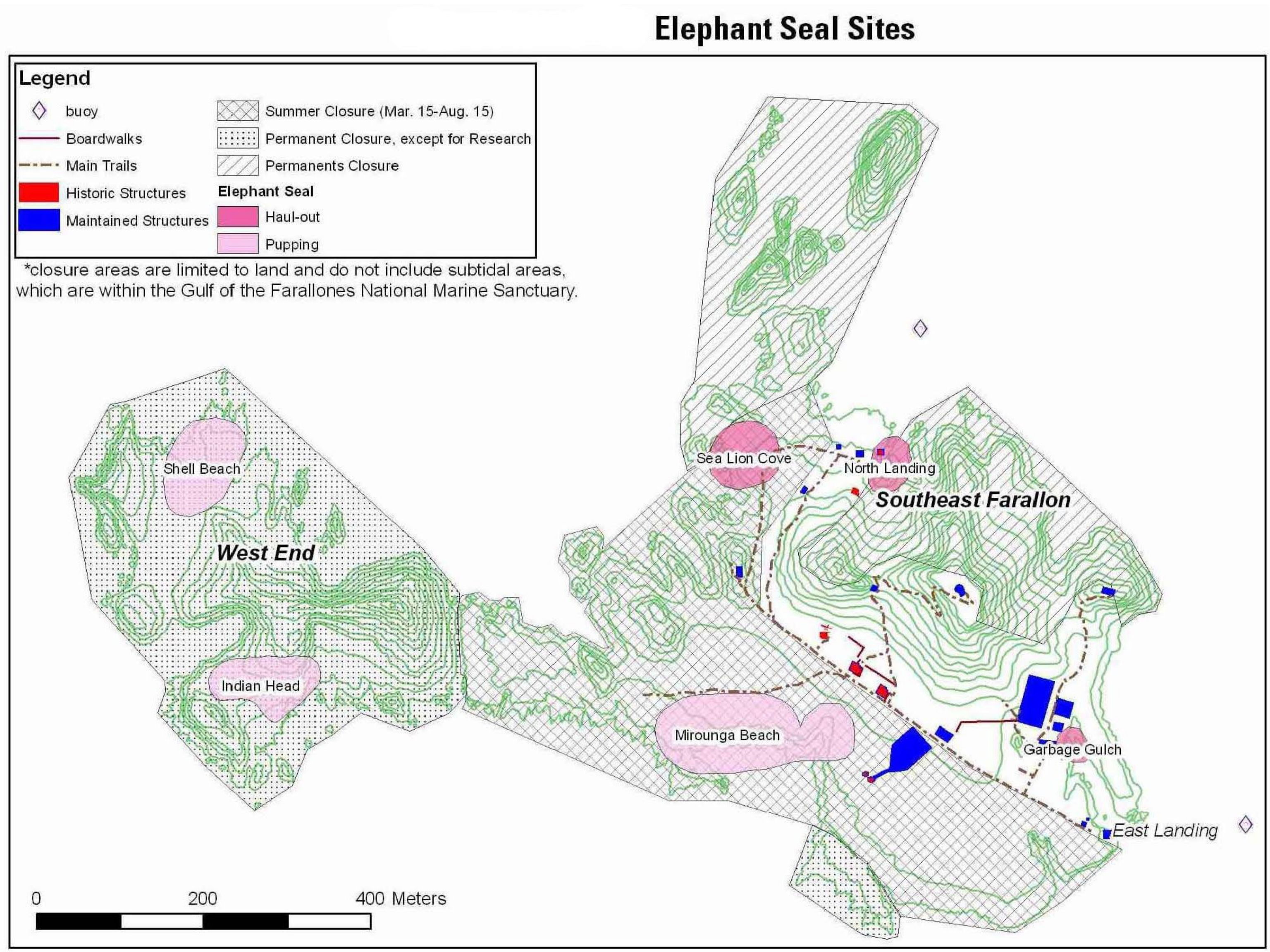
Appendix G. Pinniped breeding and haulout sites, South Farallon Islands



G. Pinniped breeding and haulout sites



G. Pinniped breeding and haulout sites



Appendix H. Intertidal organisms of the Farallones

Intertidal Species List Compilation, February 1993 through November 2006

Abietinaria sp.
Acanthomysis sp.
Acarnus erithacus
Achelia chelata
Achelia nudiscula
Achelia spinoseta
Acmaea mitra
Acrochaetium prophyrae
Acrochaetium sp.
Acrosiphonia coalita
Aglaophenia inconspicua
Aglaophenia latrirostris
Ahnfeltia cornucopiae
Ahnfeltia fastigiata
Ahnfeltiopsis leptophylla
Ahnfeltiopsis linearis
Alaria marginata
Alia carinata
Allopora porphyra
Allorchestes anceps
Alpheus dentipes
Ammothea hilgendorfi
Amphiodia occidentalis
Amphipholis squamata
amphipod
Amphissa columbiana
Amphissa versicolor
Anaata spongigartina
Analipus japonicus
Anatanais normani
Anisodoris noblis
annelid
Anotrichium furcellatum
Antho lithophoenix
Anthopleura elegantissima
Anthopleura xanthogrammica
Antithamnion dendroidum
Antithamnion densum
Aplidium californicum
Aplysilla glacialis
Aplysilla polyraphis
Arabella iricolor
Archidistoma ritteri
arthropod
ascidian (biege)
Audouinella subimmersa
Aurelia aurita
Axocielita originalis
Balanophyllia elegans
Balanus amphitrite
Balanus cariosus
Balanus glandula
Balanus nubilus
Balanus sp.
Balcis thersites
Bangia sp.
Barentsia benedeni
Barleeia haliotiphila
Barleeia subtenuis
Bittium purpureum
Bittium schrichtii
Blidingia minima var. vexata
blue green algae
Bornetia californica
Bossiella corymbifera
Bossiella dichotoma
Bossiella plumosa
Bossiella schmittii
Branchioglossum bipinnatifidum
Branchioglossum undulatum
Bryopsis corticulans
bryozoan
Cadlina modesta
Calliarthron tuberculosum
Calliostoma canaliculatum
Callithamnion biseriatum
Callithamnion pikeanum
Callophyllis cheilosporioides
Callophyllis crenulata
Callophyllis flabellulata
Callophyllis heanophylla
Callophyllis linearis
Callophyllis obtusifolia
Callophyllis pinnata
Callophyllis sp.
Callophyllis violacea
Cancer antennarius
Cancer magister
Cancer productus
Caprella californica
Centroceras clavulatum
Ceramium eatonianum
Ceramium gardneri
Ceramium pacificum
Cerithiopsis carpenteri
Chama arcana
Chiharaea bodegensis
Chondracanthus canaliculatus

H. Intertidal organisms

Chondracanthus corymbiferus
Chondracanthus exasperatus
Chondracanthus harveyanus
Chondracanthus spinosus
Chthamalus dalli
Cirolana harfordi
Cirrilicarpus sp.
Cladophora columbiana
Cladophora graminea
Cladophora sp.
Clathria sp.
Clathromorphum parcum
Codium fragile
Codium setchellii
Coilodesme californica
Colpomenia peregrina
Compsonema serpens
Constantinea simplex
Corallina officinalis
Corallina pinnatifolia
Corallina vancouveriensis
Corallophila eatoniana
Corolla spectabilis (Pteropod)
Corynactis californica
Costaria costata
Crepidula adunca
Crepidula nummaria
Crepidula perforans
Crepipatella lingulata
crustose coralline
Cryptochiton stelleri
Cryptomya californica
Cryptoplerua farlowiana
Cryptopleura corallinara
Cryptopleura crispa
Cryptopleura lobulifera
Cryptopleura rosacea
Cryptopleura ruprechtiana
Cryptopleura violacea
Cumagloia andersonii
Cymakra aspera
Cystodytes lobatus
Cystoseira osmundacea
Daphana californica
Delesseria decipiens
Derbesia marina
Dermasterias imbricata
Desmarestia herbacea
Desmarestia ligulata
Desmarestia munda
diatom
Diaulula sandiegensis
Dictyoneurum californicum
Didemnum carnulentum
Dilsea californica
Diplodonta orbella
Dirona picta
Discurria scutum
Doto columbiana
Egregia menziesii
Elasmopus serricatus
Endocladia muricata
Endocladia viridis
Endophyton ramosum
Entermorpha flexuosa
Enteromorpha clathrata
Enteromorpha compressa
Enteromorpha intestinalis
Epiactis prolifera
Epitonium tinctum
Erythrophyllum delesserioides
Erythrotrichia carnea
Erythrotrichia pulvinata
Eurystomella bilabiata
Exosphaeroma inornata
Fabia subquadrata
Farlowia compressa
Farlowia conferta
Farlowia mollis
Fauchea fryeana
Fauchea laciniata
Faucheocolax attenuata
Flustrellidra corniculata
Gastroclonium subarticulatum
gastropod
Gelidium coulteri
Gelidium purpurascens
Gelidium pusillum
Gelidium robustum
Gelidium sp.
Geodia mesotriaence
Goniotrichopsis sublittoralis
Gracilariophila oryzoides
Gracilariopsis lemaneiformis
Granula margaritula
Grateloupia doryphora
Grateloupia filicina
Griffithsia pacifica
Gymnogongrus chiton
Halichondria panicea
Haliclona (biege)
Haliclona (biege, gold)
Haliclona (gold)
Haliclona (purple)
Haliclona permollis
Haliclona sp.
Halicystis ovalis
Haliotis cracherodii

H. Intertidal organisms

Haliotis racherodii
Haliotis rufescens
Halosaccion glandiforme
Halymenia schizymenioides
Halymenia templetonii
Hemigrapsus nudus
Henricia leviuscula
Hermissenda crassicornis
Herposiphonia parva
Herposiphonia plumula
Hiatella arctica
Higginsia sp.
Hildenbrandia occidentalis
Hildenbrandia prototypus
Hildenbrandia rubra
Hildenbrandia sp.
Hincksia sandriana
Hinnites giganteus
Hipponix craniodes
Hommersandia palmatifolia
Hopkinsia rosacea
Hyale grandicornis
hydrozoans (brown)
Hymenena coccinea
Hymenena flabelligera
Hymenena multiloba
Ianiropsis kincaidi
Idotea fewkesi
Idotea resecata
Idotea schmitti
Idotea sp.
Idotea stenops
Idotea urotoma
Idotea wosnesenskii
Irus lamellifer
Ischnochiton regularis
Janczewskia gardneri
Katharina tunicata
Kellia laperousii
Lacuna cistula
Lacuna marmorata
Lacuna porrecta
Lacuna sp.
Lacuna unifasciata
Laminaria ephemera
Laminaria farlowii
Laminaria setchellii
Laminaria sinclarii
Laminaria sp.
Lasaea subviridis
Leachiella pacifica
Leathesia difformis
Leathesia sp.
Lecythorychus hilgendorfi
Lepidochitona dentiens
Leptasterias hexactis
Leptasterias puscilla
Leptasterias sp.
Leucandra heathi
Leucilla nuttingi
Leucosolenia eleanor
Ligia occidentalis
Ligia pallasii
Ligia sp.
Limnoria algarum
Lissodendoryx topsenti
Lithophyllum dispar
Lithophyllum grumosum
Lithophyllum proboscideum
Lithothamnium sp.
Lithothrix aspergillum
Littorina keenae
Littorina planaxis
Littorina scutulata
Littorina sitkana
Littorina sp.
Littorophiloscia richardsonae
Lophopanopeus leucomanus
Lottia asmi
Lottia digitalis
Lottia gigantea
Lottia instabilis
Lottia limantula
Lottia pelta
Lottia strigatella
Lottia sp.
Lottia triangularis
Loxorhyncus crispatus
Macclintockia scabra
Macrocystis integrifolia
Macrocystis pyrifera
Maripelta rotata
Mastocarpus jardinii
Mastocarpus papillatus
Mazzaella affinis
Mazzaella californica
Mazzaella cordata
Mazzaella cornucopiae
Mazzaella flaccida
Mazzaella heterocarpa
Mazzaella leptorhynchos
Mazzaella linearis
Mazzaella rosea
Mazzaella splendens
Mazzaella volans
Melanosiphon intestinalis
Melita californica
Melobesia marginata
Melobesia mediocris
Membranoptera dimorpha
Mesophyllum conchatum

Mesophyllum lamellatum
Metacaprella anomala
Microcladia borealis
Microcladia coulteri
Milneria minima
Mitrella tuberosa
Modiolus capax
Modiolus carpenti
Mopalia ciliata
Mopalia muscosa
Musculus pygmaeus
Mycale psila
Myriogramme sp.
Myriogramme spectabilis
Myriogramme variegata
Mytilus californianus
Mytilus edulis
Myxilla incrustans
Neoptilota densa
Neoptilota hypnoides
Neoptilota sp.
Neorhodomela larix
Nereis guberi
Nereocystis luetkeana
Nienburgia andersoniana
Nienburgia sp.
Nitophyllum sp.
Notoacmea insessa
Notoacmea persona
Nucella canaliculata
Nucella emarginata
Nucella sp.
Nuttallina californica
Nymphopsis spinosissima
Obelia sp.
Ocenebra atropurpurea
Ocenebra interfossa
Ocenebra lurida
Octopus dofleini
Octopus rubescens
Odonthalia floccosa
Odostomia sp.
Oedignathus inermis
Oligochinus lighti
Onchidella borealis
Opalia wroblewskyi
Ophiopholis aculeata
Ophiothrix spiculata
Ophlitaspongia pennata
Opuntiella californica
Osmundea spectabilis
Pachygrapsus crassipes
Pachygrapsus nudus
Pagurus hirsutiusculus
Pagurus samuelensis
Pagurus sp.
Palciphorella velatta
Paracerceis cordata
Parallorchestes ochotensis
Paraxanthia taylorii
Patiria miniata
peanut worm
Penitella conradi
Petaloconchus montereyensis
Petalonia fascia
Petricola carditoides
Petrocelis phase
Petrolisthes cinctipes
Petrospongium rugosum
Peyssonelliopsis epiphytica
Peyssonnelia meridionalis
Peyssonnelia pacifica
Peyssonnelia sp.
Phascolosoma agassizii
Philobrya setosa
Phragmatopoma californica
Phycodrys setchellii
Phyllochaetopterus prolific
Phyllospadix scouleri
Pikea californica
Pikea pinnata
Pilayella sp.
Pisaster giganteus
Pisaster ochraceus
Pleonosporium vancouverianum
Plocamium cartilagineum var. *pacificum*
Plocamium oregonum
Plocamium pacificum
Plocamium sp.
Plocamium violaceum
Pollicipes polymerus
Polycheria osborni
Polyneura latissima
Polysiphonia hendryi
Polysiphonia pacifica
Polysiphonia saraticeri
Polysiphonia sp.
Porcellio americanus
Porifera sp.
Porphyra gardneri
Porphyra lanceolata
Porphyra nereocystis
Porphyra perforata
Porphyra sp.
Postelsia palmaeformis
Prasiola sp.
Prasiola meridionalis
Prionitis australis
Prionitis cornea

Prionitis angusta (formerly *filiformis*)
Prionitis lanceolata
Prionitis linearis
Prionitis lyallii
Pronitis sp.
Protothaca staminea
Pseudolithophyllum neofarlowii
Pterochondria woodii
Pterocladia caloglossoides
Pterocladia capillacea
Pterosiphonia baileyi
Pterosiphonia bipinnata
Pterosiphonia dendroidea
Pterothamnion villosum
Pterygophora californica
Ptilota filicina
Ptilothamnionopsis lejolisea
Pugetia fragilissima
Pugetia fragilissima
Pugettia gracilis
Pugettia producta
Pugettia sp.
Pycnoclayella stanleyi
Pycnogonum rickettsi
Pycnogonum stearnsi
Pycnopodia helianthoides
Ralfsia sp.
Rhodochorton purpureum
Rhodymenia californica
Rhodymenia callophyllidoides
Rhodymenia pacifica
Rhodymenia sp.
Ritterella aequalisphonis
Rhodymeniocolax botryoides
Rostanga pulchra
Sahlingia subintegra
Sarcodiotheca gaudichaudii
Schimmelemannia plumosa
Scinaia confusa
Scypha sp.
Scyra acutifrons
Scytosiphon dotyii
Scytosiphon lomentaria
Scytosiphon simplicissimus
Semibalanus cariosus
Semibalanus sp.
Serpula vermicularis
Smithora naiadum
Spirorbis borealis
Spongia idia
Spongonema tomentosum
Stelletta clarella
Stenogramma interrupta
Streblonema sp.
Strongylocentrotus droebachiensis
Strongylocentrotus franciscanus
Strongylocentrotus purpuratus
Styela montereyensis
Stylantheca prophyra
Stylonema alsidii
Suberites sp.
Tealia crassicornis
Tealia lofotensis
Tectura persona
Tectura scutum
Tedania gurjanovae
Tegula brunnea
Tegula funebralis
Tethya aurantia
Tetraclita rubescens
Thelepus crispus
Tiffaniella snyderae
Titanoderma dispar
Tonicella lineata
Toxidocia sp.
Transennella tantilla
Trimusculus reticulatus
Triopha catalinae
Triopha maculata
tropical green
tunicate
Ulothrix flacca
Ulothrix laetevirens
Ulothrix pseudoflacca
Ulva californica
Ulva conglobata
Ulva lactuca
Ulva lobata
Ulva sp.
Ulva taeniata
Urospora sp.
Weeksia reticulata

October 2007 addendum – DRAFT Species Identification

Weeksia reticulata, range extension
Chondria nidifica, range extension

H. Intertidal organisms

Codiales (unknown species from the Order)
Cryptoleura ruprectian

Appendix I. Brodifacoum toxicity model

For the purpose of estimating individual impacts, representative LD50 values can be used to generalize potential toxicity for birds and mammals respectively (adapted from Erickson and Urban 2004):

- For birds, an LD50 value of 0.26 mg/kg will be used – this is the average LD50 value for the mallard (*Anas platyrhynchos*).
- For mammals, an LD50 value of 0.4 mg/kg will be used – this is the average LD50 value for the laboratory rat (*Rattus norvegicus*)

In comparison to real-world values that toxicologists have obtained from a wide class of species, the values used in this document are conservative; the output of this toxicity model would most likely under-estimate the amount of bait that an individual animal would need to consume to have a 50 percent chance of mortality. This model assumes that an animal's body mass is the primary determinant of how much brodifacoum is required for that animal to reach an LD50 threshold, within each taxonomic category (in this case, birds and mammals). In reality, there are other variables that affect LD50 as well, but using conservative LD50 values such as those above decreases the possibility that the model will under-estimate the risk to individual animals.

Erickson and Urban (2004) use another general model to determine the amount of bait needed to reach an LD50 threshold for birds at a mass of 25 g (e.g.sparrow), 100 g (e.g. turnstone), and 1000 g (e.g. western gull), compared to average daily food intakes for each of these size classes:

Bird size class:	Amt of bait for LD50:	% of daily food intake:
25 g	0.26 g	4.2
100 g	1.04 g	10.8
1000 g	10.4 g	19.2

Erickson and Urban use a similar model to determine the amount of bait needed to reach an LD50 threshold for mammals, using these same size classes. Other than mice, bats are the only mammal taxon on the islands that would fall within the size range of these estimates. All bat species potentially present on the Farallones (see Section 3.4.3.3) are less than 25 g. Erickson and Urban's (2004) model estimates that mammals in this size class would need to consume roughly 10% of their daily food intake as bait pellets to reach an LD50 threshold. This food-intake model is not applicable to pinnipeds, which are orders of magnitude larger than 1000 g.

The following table lists the estimates provided by these models for a number of species present at the South Farallones:

I. Brodifacoum toxicity model

Taxon	Est. mass	Appr. amt of bait to reach LD50 of 0.4 mg/kg	% avg. daily food intake#
Greater white-fronted goose	2,075 g (4.57 lb)	21.6 g (0.76 oz)	>20%
California brown pelican*	Small adult: 1.83 kg (4.03 lb)	19 g (0.67 oz)	>20%
Double-crested cormorant*	2,000 g (4.41 lb)	20.8 g (0.73 oz)	>20%
Red-necked phalarope*	32 g (0.07 lb)	0.33 g (0.01 oz)	~4%
California gull**	432 g (0.95 lb)	4.49 g (0.16 oz)**	10-20%
Western gull**	879 g (1.94 lb)	9.14 g (0.32 oz)**	~20%
Glaucous-winged gull**	Similar to WEGU	Similar to WEGU**	~20%
Allen's hummingbird***	3 g (0.007 lb)	0.03 g (0.001 oz)	<4%
Steller sea lion*	Pup: 45 kg (100 lb)	720 g (1.6 lb)	NA
	Adult: 1,088 kg (2,400 lb)	17,400 g (38.4 lb)	NA
Northern elephant seal*	Pup: 34 kg (75 lb)	544 g (1.2 lb)	NA
	Adult: 2,300 kg (5,071 lb)	36,800 g (81.1 lb)	NA

* These figures are presented for comparative purposes only, because these species are carnivorous and forage exclusively in the marine ecosystem and brodifacoum ingestion would need to occur either accidentally or through an intermediate prey species (such as fish) that previously consumed bait pellets, an unlikely scenario (Section 4.2.3.2).

** Because these birds may be subject to both primary and secondary exposure to brodifacoum, individual birds could reach an LD50 threshold through the consumption of prey animals even if they did not consume this much bait directly.

*** These figures are presented for comparative purposes only, because these birds would only be exposed to brodifacoum indirectly through prey animals.

Appendix J. Special Considerations under MMPA

In addition, the Service and its contractors would monitor the response of pinnipeds to all activities, including helicopter operations, bait station installation and maintenance, and other project tasks to ensure compliance with the Marine Mammal Protection Act (MMPA) and the ESA. This observational monitoring is discussed in detail in Appendix J.

Appendix K. Minimum Requirements Analysis Under the Wilderness Act

See Appendix K for a detailed "Minimum Requirements Analysis" for non-native house mouse eradication on the South Farallones.