

# Farallon Islands Restoration Project

## November 2010 Trial Report

---

November 2010 Trial Report



Prepared by:  
Dan Grout, Island Conservation  
100 Shaffer Road, Santa Cruz, California 95060  
email: [dan.grout@islandconservation.org](mailto:dan.grout@islandconservation.org)  
(831) 420-7825

12/7/2012

## Table of Contents

EXECUTIVE SUMMARY .....	3
1. INTRODUCTION .....	4
2. OBJECTIVES .....	4
3. METHODS .....	5
3.1 Mouse Abundance .....	5
3.1.1 Index of Abundance .....	5
3.1.2 Monthly mouse abundance.....	5
3.2 Mouse Reproductive Status .....	6
3.3 Biomarker Persistence in Mice .....	6
3.4 Bait Palatability and Preference.....	7
3.5 Placebo Bait Broadcast .....	7
3.5.1 Mouse Biomarker Exposure Rates.....	7
3.5.2 Immigration Transects.....	8
3.5.3 Pellet Availability.....	8
3.5.4 Gull Exclosures .....	8
3.5.5 Mouse DNA Sampling .....	8
3.6 Non-target Exposure Studies .....	8
3.6.1 Western Gull Exposure .....	9
3.6.2 Burrowing Owl Studies.....	10
3.6.3 Salamander Surveys .....	10
3.7 Cave and Camel Cricket Assessments .....	10
4. RESULTS AND DISCUSSION.....	11
4.1 Mouse abundance.....	11
4.1.1 Mouse Index of Abundance .....	11
4.1.2 Monthly Index of Abundance Plots .....	12
4.2 Mouse Reproductive Status .....	13
4.3 Biomarker Persistence in Mice .....	13
4.4 Bait Palatability and Food Preference.....	13
4.5 Placebo Bait Broadcast .....	14
4.5.1 Mouse Biomarker Exposure Rates.....	14
4.5.2 Immigration transects .....	14
4.5.3 Bait Availability .....	15
4.5.4 Gull Exclosures .....	18

4.6	Mouse DNA Sampling.....	18
4.7	Non-target studies .....	18
4.7.1	Western Gulls .....	18
4.7.2	Burrowing Owls .....	20
4.7.3	Salamander Surveys .....	20
4.8	Cave and Camel Cricket Assessments .....	21
5.	RECOMMENDATIONS.....	21
6.	References.....	23

## EXECUTIVE SUMMARY

A field trial completed in November 2010 was successful in addressing several objectives identified as important in planning for a proposed eradication of invasive house mice on the South Farallon Islands (SFI) of the Farallon National Wildlife Refuge. The results from the trial will inform the development of eradication alternatives as well as possible non-target mitigation measures to be considered during project planning.

Key findings of the trial were as follows:

- Mice were exceptionally abundant on SFI in November 2010, with over 93% trapping success and more than 250 uniquely marked individual mice captured within a 0.25ha study site. Mark-recapture data indicated mouse densities of up to 1297 mice per hectare, representing one of the highest recorded densities for mice on an island in the world.
- Mice were present throughout the island including West End but variation in density from site to site was high. Many mice were active during the day during the fall months on SFI.
- Although mice in reproductive condition have been trapped year round on SFI, very few mice were found to be reproductively active in November. Reduced breeding activity and the apparent food scarcity at this time of year marks this season as the best in which to undertake a mouse eradication.
- A 1g cereal bait pellet containing the biomarker pyranine was readily accepted and appears to be highly palatable to Farallon mice and the EPA registered application rate for Brodifacoum-25D Conservation of 27kg/ha (at 18 and 9 kg/ha) is most probably sufficient to expose all mice to bait under certain conditions.
- Bait consumption by gulls could reduce the amount of bait available to mice and hazing of gulls may be necessary to ensure operational success.
- If rodent bait is used on SFI, a proportion of Western Gulls are at risk of primary poisoning. Hazing would be required to prevent individual Western Gulls from learning to eat bait pellets. Mice that die above also ground pose a risk of secondary exposure to gulls and raptors.
- No exposure to biomarker was observed in Burrowing Owls.

## 1. INTRODUCTION

As part of the Farallon Islands Restoration Project, the U.S. Fish and Wildlife Service (USFWS) proposes to remove invasive House mice (*Mus musculus*) from the South Farallon Islands (SFI). The South Farallon Islands, comprised of Southeast Farallon Island (SEFI) and West End Island (WEI), provide important habitat for seabirds and pinnipeds, and support some of the world's largest populations of seabird species including Ashy Storm-Petrel (*Oceanodroma homochroa*), Brandt's Cormorant (*Phalacrocorax penicillatus*) and Western Gull (*Larus occidentalis*) (Ainley and Boekelheide 1990, Sydeman et al, 1998, Warzybok and Bradley 2011). On SFI, introduced house mice appear to be directly and indirectly impacting the breeding success of burrow nesting seabirds and are likely impacting the other native and endemic species of plants and animals of the Farallon ecosystem.

House mice were introduced to SFI during the 19<sup>th</sup> century and the islands have experienced considerable ecosystem degradation as result of their presence. As observed on other islands around the world, introduced house mice appear to be indirectly impacting the breeding success of burrow-nesting seabirds on the South Farallon Islands (Ainley and Boekelhide 1990; Sydeman et al. 1998)

On SFI, mice provide a food source for an overwintering population of migratory burrowing owls, which in spring switch to Ashy Storm-Petrels (*Oceanodroma homochroa*) as prey. Ashy Storm-Petrels are a rare species whose largest breeding colony is on SFI (Carter et al 2008). Other impacts of mice include mouse predation on or competition with many native and endemic species of invertebrates, salamanders, native plants, as well as the dispersal of invasive plant species.

Early analysis of options for the removal of house mice identified gulls as a potential non-target species at risk from a mouse eradication (Howald et al 2003). Although widely distributed along the western US seaboard, SFI are home to the world's largest colony of Western Gulls (*Larus occidentalis*) (Ainley and Boekelheide 1990). Prior to commencing with the proposed eradication, a series of work objectives must be met to trial the efficacy of eradication techniques and an assessment of the environmental impacts of the Federal action must be conducted in accordance with the National Environmental Policy Act (NEPA) and its associated regulations.

A field trial implemented on SFI during November 2010 aimed to confirm the applicability of current eradication techniques and assess risks to non-target species specifically Western Gulls. This report summarizes the methods and results of the trial.

## 2. OBJECTIVES

The November 2010 trial had the following objectives:

- i. Assess mouse abundance by using mark-recapture techniques and establish protocols for tracking seasonal changes in mouse abundance across SEFI;
- ii. Determine the reproductive status of mice;
- iii. Determine the persistence of the biomarker pyranine in mice;
- iv. Evaluate the palatability of proposed bait to mice and their preference for this food over natural food sources;
- v. Apply a placebo bait product to a portion of SEFI in order to assess:
  - a. The availability of bait pellets over time
  - b. The proportion of the mouse population which was exposed to bait pellets;
- vi. Collect and archive samples of DNA from island mice
- vii. Assess which non-target species might be at risk of primary or secondary rodenticide exposure using a placebo bait applied at the target application rate, particularly:
  - a. Western Gulls
  - b. Burrowing Owls
  - c. Arboreal salamanders
- viii. Map and characterize caves

### 3. METHODS

Four IC staff members, assisted at times by available PRBO and USFWS staff, conducted the three week field trial during November 1-22, 2010.

#### 3.1 Mouse Abundance

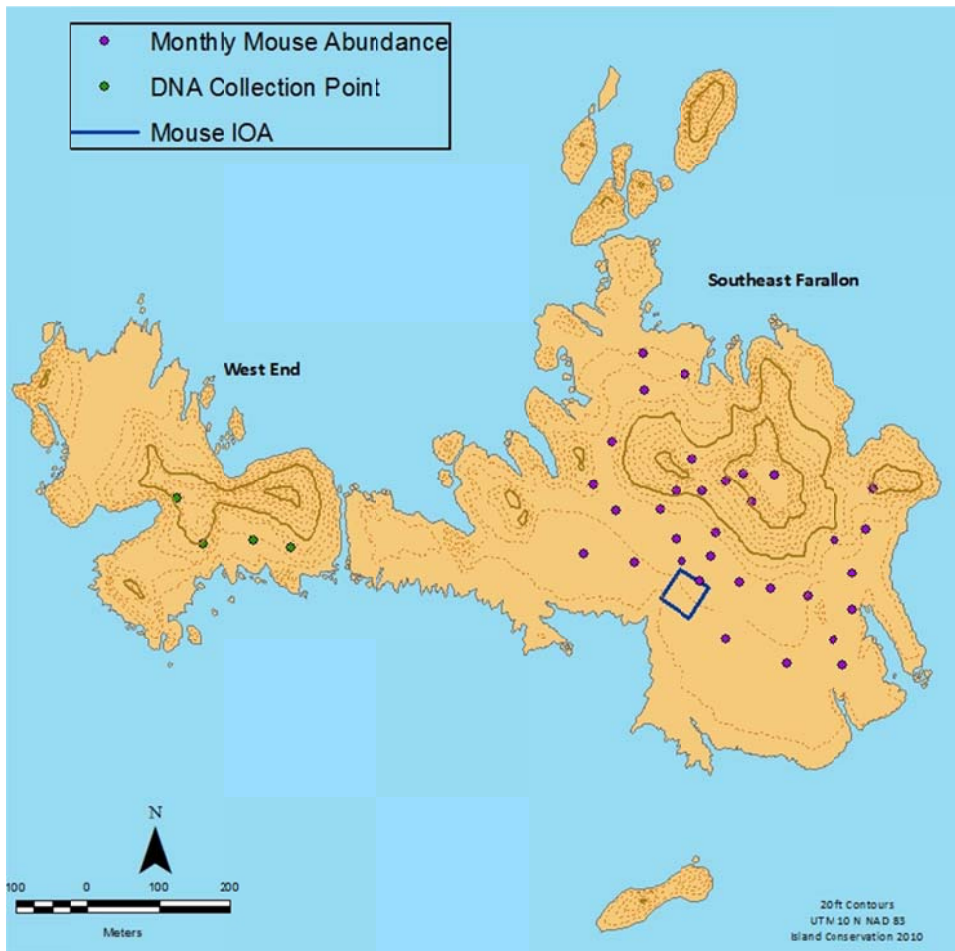
##### 3.1.1 Index of Abundance

Prior to broadcasting bait, a 45m x 45m grid of 100 traps spaced at 5m intervals were set and checked for five consecutive nights within the intended baiting zone in order to develop an Index of Abundance (IOA) for mice (Fig. 1).

##### 3.1.2 Monthly mouse abundance

A set of 33 permanent mouse trapping locations were established on SEFI for conducting monthly mouse trapping as a means of establishing a monthly index of mouse abundance throughout the year as the population cycles. In addition to the 28 sites previously used in USFWS mouse trapping studies conducted from 2001-2004 (Irwin 2006), five new locations were established in the Lighthouse Hill area to obtain a more representative sample from this habitat type.

Sites were marked with white PVC, aluminum tags, and had GPS coordinates recorded (Fig. 1).



**Fig. 1. Locations of Index of Abundance trapping grid and monthly mouse trapping locations. During the course of the November 2010 trial, DNA was collected from mice trapped in abundance surveys, as well as from mice collected on WEI at designated DNA collection points.**

### 3.2 Mouse Reproductive Status

All mice trapped as part of the IOA, monthly mouse abundance, DNA collection, biomarker study, and palatability trials were assessed for reproductive activity, including descended testes in males and perforate vaginas and enlarged mammae in females.

### 3.3 Biomarker Persistence in Mice

Because the use of pyranine as a biomarker in rodenticide pellets is a relatively new development in recent years, laboratory studies on the island were conducted using locally captured mice to determine how long the biomarker persists in the gastrointestinal tract of mice after consuming a food containing the fluorescent dye. Pyranine will fluoresce green upon exposure to ultraviolet light (UV). The placebo or non-toxic form of Brodifacoum-25D Conservation (Bell Laboratories, Inc. Madison, WI, EPA Reg. No. 56228-37) was infused with 0.20% pyranine. A six-day no choice trial was conducted on the island in a lab setting using 12 mice in an exposure group and two mice in a control group.

The three exposure groups consisted of four mice in each group, with two male and two female adults in good condition randomly placed in each group. Mice in each group were fed the approximate equivalent of 0.5LD50 (approximately 0.5 g), 1LD50 (approximately 1 g) and 2LD50 (approximately 2 g) of the placebo bait product on the first day of the study. These quantities were based on estimates that a mouse must eat 1-2.6% of its body weight of 20ppm brodifacoum bait to achieve acute oral toxicity (Fisher 2005). Mice in the exposure group were fed only placebo pellets without biomarker on the second, third, and fourth days of the persistence trial. The two mice in the control group were only fed placebo pellets without biomarker. All mice were individually housed and provided water.

All mice were checked daily for four days for the presence of fluorescence under UV light at both the mouth and the anus.

### 3.4 Bait Palatability and Preference

A two-choice *ad libitum* food preference trial was conducted to determine consumption rates and food preferences. The tests were conducted in a laboratory setting on-island and continued for eight days, with each mouse housed individually.

Ten adult mice were daily given a choice between placebo bait pellets with pyranine and locally occurring food alternatives described by Hagen (2003). Natural food alternatives included coleopteran larvae and fresh local vegetation (endemic *Lasthenia maritima* and invasive *Hordeum murinum leporinum*). Each mouse was daily supplied with 2.8g of bait pellets and 2.06g of the naturally occurring food items, totaling 4.86g of food per day. Every day, the amount of each food type (natural food or bait pellet) consumed by individual mice during the previous 24 hours was determined based on the amount of food remaining in the cage the following day.

### 3.5 Placebo Bait Broadcast

In order to assess the bait density required to expose all mice to the bait during an operation, placebo bait with biomarker was initially hand broadcast at a density of 36kg/ha over a 0.25 ha plot at North Landing (Fig. 2), prior to baiting a larger portion of the island. Bait uptake rates observed in this calibration area resulted in the larger 6.2 ha plot slated for systematic bait availability monitoring to be split into two study areas: area B (eastern half) measuring 3.2 ha and area A (western half) measuring 3.0 ha. Splitting the larger area into two parcels permitted us to test side by side both the EPA label registration density of 27 kg/ha and a secondary bait density of 36 kg/ha which exceeds the current EPA label registration for the toxic product.

Both area B and area A had bait hand broadcast at a density of 18 kg/ha on the first application. Five days later, area A was hand broadcast at 18 kg/ha (for a total of 36 kg/ha) while area B was hand broadcast at 9 kg/ha (for a total of 27 kg/ha).

#### 3.5.1 Mouse Biomarker Exposure Rates

An indication of efficacy can be gauged by measuring exposure rates to placebo bait infused with biomarker. One core trapping grid was established in each of Area A and B (Fig. 2). Two traps were placed at 2-m intervals across a grid measuring 18m x 18m. On



the second day following each bait application, trapping was initiated and continued for a total of two nights following each bait application. Traps were checked daily and captured mice were assessed for exposure to the biomarker.

### **3.5.2 Immigration Transects**

Immigration transect trapping was conducted concurrent with core grid trapping in both Areas A and B. Each transect extended from the edge of the core trapping plot to at least 90 meters beyond the edge of the baited area (Fig. 2). Two traps were placed at approximately 10-m intervals within the baited area (edge of baited area approximately 40 meters from core grid). Outside of the baited area, two traps were placed at approximately 10-m intervals for 90-140 meters beyond the baited area. Traps were opened concurrently with core trapping grid traps and were checked in an identical fashion.

### **3.5.3 Pellet Availability**

Immediately after hand broadcasting, ten bait availability monitoring plots of 1 m x 50 m were calibrated to contain a representative number of pellets for the bait density used in the baiting zone surrounding each transect. Monitoring plots were checked daily to determine the availability of bait pellets over time (Fig. 2).

### **3.5.4 Gull Enclosures**

In an attempt to assess how the availability of pellets was affected in the absence of gull consumption, four non-target exclusion devices were deployed within the baited area (Fig. 2). The 2.4m x 2.4m gull enclosures made of wood and chicken wire allowed mice to enter and feed on bait pellets, but prevented gulls from accessing bait contained within the enclosure. The persistence of bait pellets within each enclosure was monitored on a daily basis.

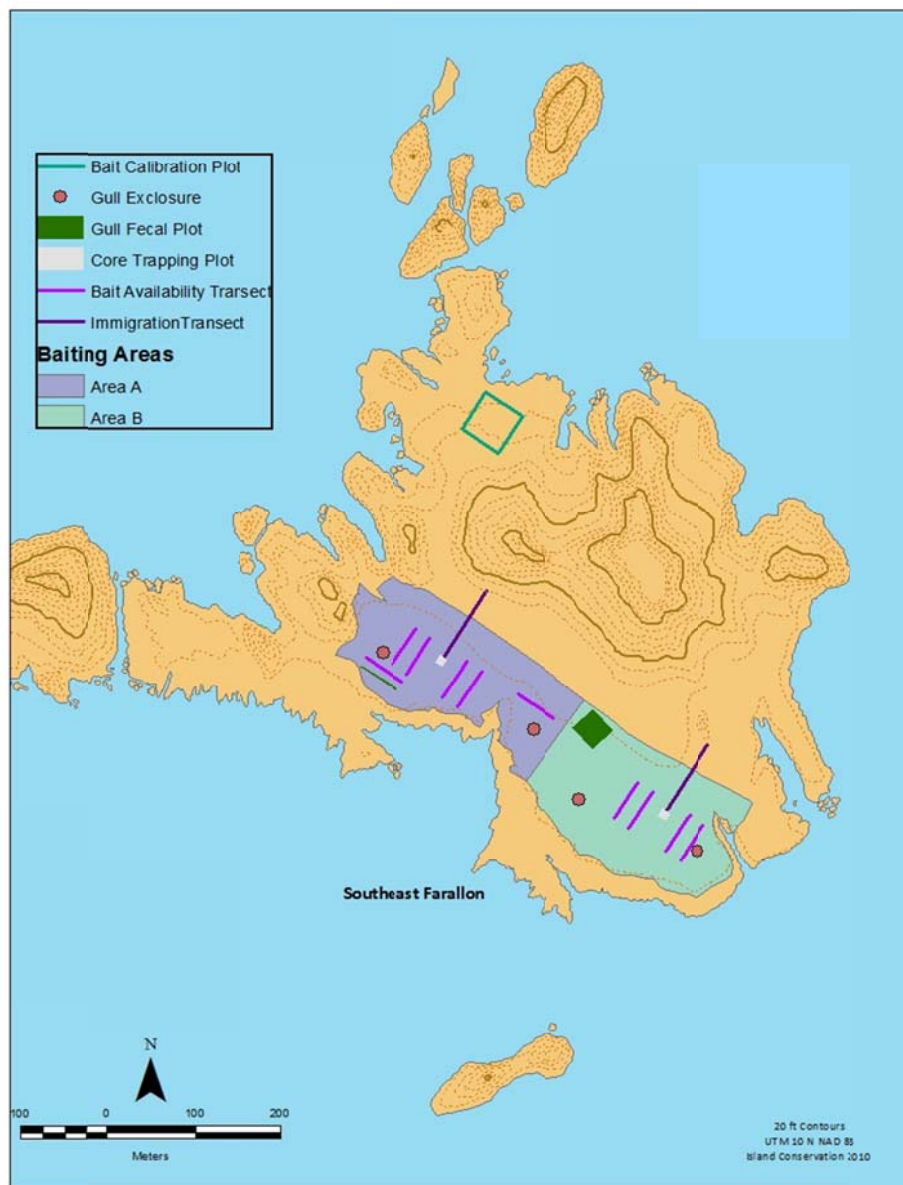
### **3.5.5 Mouse DNA Sampling**

In the event that mice are detected on the islands subsequent to an eradication attempt, archived DNA samples can allow us to determine whether newly discovered mice are a repopulation from the current gene pool (i.e. a failed eradication attempt), or whether they represent a recent invasion from another population of mice (i.e. from the mainland). Tail tissue samples from SFI mice were collected from a number of locations across SEFI and WEI (Fig. 1.). Mice were trapped using Sherman Live traps and had the last 1 cm of tail tissue removed and stored in a buffer solution.

## **3.6 Non-target Exposure Studies**

Attempts were made to identify which non-target species could be at risk of primary or secondary rodenticide exposure by using the placebo biomarker bait applied at the target application rates in the study area. The non-target species considered during the trial on SEFI were the Western Gull, Burrowing Owl (*Athene cunicularia*), and arboreal salamander (*Aneides lugubris farallonensis*). Western Gulls, because of this species' foraging habits, are of greatest concern for non-target impacts from the rodenticide. Effective avoidance measures have and are being considered and are feasible for the burrowing owls and salamanders and there is no scientific evidence to suggest

that the salamanders would be at high risk of consuming the rodenticides being considered. The majority of the non-target field efforts in November 2010 were thus focused on documenting the possible risk and exposure to Western Gulls from a bait broadcast.



**Fig. 2 A map of the baited areas, availability transects, immigration transects, core trapping grids, gull fecal plots, and gull exclosures**

### 3.6.1 Western Gull Exposure

Following each bait broadcast, gulls were allowed to naturally congregate and forage on bait pellets without any human interference. Over the course of eight days following the first bait application, daily observational surveys were conducted in an attempt to document instances of gulls consuming bait pellets. Personnel were stationed on Lighthouse Hill during the early morning and late afternoon hours and observed the baited

area, counting the number of gulls observed within the baited areas and the number of individuals seen feeding within baited areas.

As with mice, gulls which have consumed food containing pyranine will excrete feces which fluoresce under UV light. In an effort to quantify the portion of gulls which have consumed bait, two fecal plots were demarcated—one on the helipad and one on the gull roost west of Mirounga Beach (Fig. 2). Following the first bait application, the total number of fecal deposits was recorded daily, as were the number of deposits which tested positive for biomarker.

In addition to counting the number of gulls within and near the study area, daily island-wide gull counts were conducted by IC and PRBO staff during November 2010 to estimate the number of gulls on SFI each day.

A focused daily gull monitoring program for the fall and winter seasons was initiated in November 2010 to assist in determining the risk posed to gulls by a proposed rodenticide broadcast. Island census surveys were done at least once a day by PRBO, either at dawn or prior to dusk, from November 2010 until April 2011.

### 3.6.2 Burrowing Owl Studies

The pyranine biomarker can be used to detect not only primary but also secondary consumption of placebo pellets (i.e. the consumption by a secondary animal of a mouse which has eaten a pellet containing the biomarker). In conjunction with ongoing research being conducted on the island, Burrowing Owls captured in mist nets were inspected for signs of the pyranine biomarker. Owl fecal pellets were also collected and examined for signs of UV fluorescence.

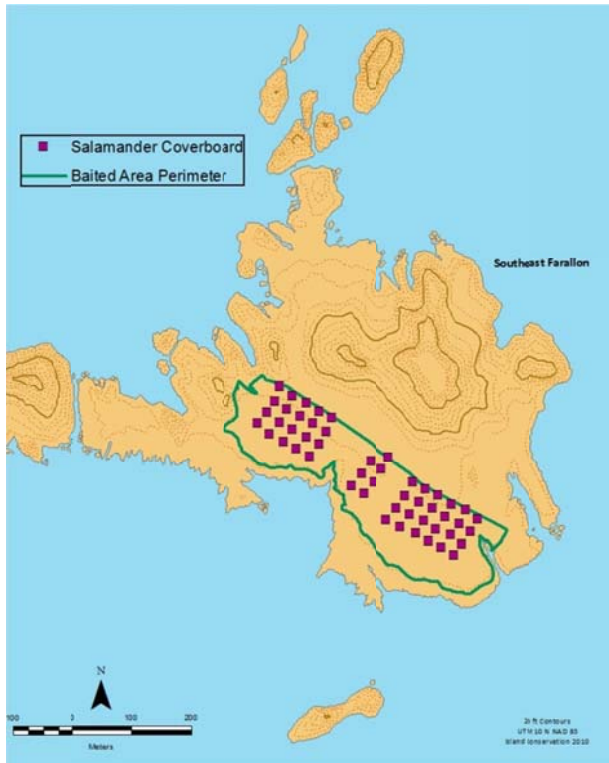
### 3.6.3 Salamander Surveys

A total of 52 cover boards were put out in the Marine Terrace study area in order to assess biomarker bait exposure to the endemic subspecies of arboreal salamander that occurs on the island (Fig. 3). Boards were set out in October 2010, a month prior to the biomarker study in order to allow the salamanders some time to encounter and begin using the boards. Boards were then checked in November 2010 for the presence of salamanders.

## 3.7 Cave and Camel Cricket Assessments

The presence of numerous caves, coves, and coastal features on SFI that may require special baiting treatments during eradication resulted in the field team visiting and mapping the location of many of the caves using GPS equipment. Some rough measurements of the dimensions of the geographic features of some of the caves were made.

Several caves on SEFI are inhabited by the endemic Farallon camel cricket (*Farallonophilus cavernicolus*). Presence and general abundance of these crickets were noted for assistance for designing future invertebrate surveys.



**Fig. 3. Salamander cover board locations in relation to baited areas**

## 4. RESULTS AND DISCUSSION

## 4.1 Mouse abundance

### 4.1.1 Mouse Index of Abundance

Out of 500 possible trap nights, 434 mouse captures were recorded. Trap success averaged 93% on all but the first night, when trap door setting sensitivities may have resulted in a lower trap success rate of 62%.

A total of 250 unique individual mice were captured and marked in the trapping period in the 0.2 ha trapping area. Recapture rates of marked individuals on nights 2 through 5 were: 35%, 40%, 56% and 66%, respectively. Mice were extremely abundant and easily trapped, likely due to a combination of high population levels and a scarcity of other food resources. Mice were commonly seen foraging throughout the daylight hours, as well as at night, but traps were only left open at night.

Closed capture modeling of the data using program MARK 6.1 (White and Burnham 1999) resulted in a density estimate of 1,297 +/- 224 mice per hectare with 95% confidence intervals of 799-1792 (Grout and Vanderwerf, in prep). Mouse densities at these levels have only rarely been reported elsewhere and usually only during plague-level irruptions in a few locales world-wide. Abundance levels

found on SEFI are ten times greater than reported densities in most island or mainland environments. Commonly, house mouse densities range from 10/ha to 50/ha (Mackay et al. 2011) The likelihood that mice were hungry and readily trappable on the island during this time of year bodes well for an eradication attempt undertaken during this period, as it is more likely they will accept bait under stressed and food deprived conditions.

While specific mouse home-range studies were not conducted during the trial, the five-night mark-recapture study resulted in 101 mice that were captured at least twice, and some as many as five times. The mean maximum distance moved for mice captured two or more times was 11.7m. Of recaptured mice, 82% moved less than 16m between most distant captures. A further 10% of recaptured mice moved as much as 24m. Only six mice moved more than 35m, and the longest recapture distance was 43m.

While the size of the trapping grid (45m) may have biased some of the longer ranging results downward, 95% of the maximum distances moved on SEFI are within the expected diameters (10-29m) for reported mouse home ranges reported for house mice in another temperate island environment (Pickard 1984).

#### 4.1.2 Monthly Index of Abundance Plots

The annual mouse population index of abundance derived from mouse trap success rates in 2010 and 2011 was similar to the trap results from 2001-2004 (Irwin, 2006) with the lowest numbers in March-May and highest abundances in August, September and October. The results of the mouse trapping is presented below.

Year	Month	Raw Success	Number Traps	Trap success
2010	December	84	99	0.848485
2011	January	36	132	0.272727
2011	February	27	99	0.272727
2011	March	9	99	0.090909
2011	April	7	99	0.070707
2011	May	Not Done	Not Done	Not Done
2011	June	28	96	0.291667
2011	July	31	96	0.322917
2011	August	78	96	0.8125
2011	September	89	99	0.89899
2011	October	98	99	0.989899
2011	November	32	99	0.323232
2011	December	9	99	0.090909
2012	January	4	99	0.040404
2012	February	13	99	0.131313
2012	March	0	99	0

## **4.2 Mouse Reproductive Status**

The live-trapping of over 900 individual mice on SFI during the November 1-22 period revealed no pregnant females and only three males that were scrotal and five that were partially scrotal. Thus while some breeding may occur at this time of year, it would be considered a very rare event during this period based on these trap results. This also bodes well for an eradication attempt during this time, as it means that the risk of juvenile weanling mice being missed by any of the bait application events is very low.

## **4.3 Biomarker Persistence in Mice**

During the lab trials, all mice that were given the pyranine-infused bait tested positive for external sign of biomarker fluorescence (on mouth or anus) under UV exposure after 24 and 48 hours. On the third day (72 hours) however, one of the twelve mice tested negative for external biomarker presence. By day four (96 hours) ten of twelve mice tested negative for biomarker; that is to say, only two mice still tested positive for external biomarker sign. These assay results indicate that biomarker trapping efforts in the field should be completed within 72 hours of bait broadcast in order to ensure that false negative results for biomarker do not influence the interpretation of trial data.

## **4.4 Bait Palatability and Food Preference**

Each mouse consumed an average of 3.8g of food each day, with individual daily consumption ranging between 2.7-4.7g. Consumption was on average about 20% of their body weight each day. All ten mice preferred bait pellets over the natural food items. On average, bait pellets constituted 62% of mouse diets (by mass), while naturally occurring foods only made up 38% of their diet. Palatability percentage tended to be lowest on the first day (50%) but climbed quickly to 63% on day two and stayed high for the duration of the study.

Ten random opportunistic observations were also made of five individual mice as to the first food type consumed after the choices were presented. On nine of the ten occasions, the pellets were visited and eaten first, and in the tenth instance, the coleopteran larva was eaten first. In addition, mice were observed eating the 1g pellets in order to determine if this pellet is sufficiently small and light enough for mice to be able to pick up and handle. Visual observations confirmed that the bait pellets were easily picked up, handled and carried by the mice. This was also noticed in the field where pellet caching was seen at burrow entrances.

Overall, bait trial results indicated that the bait being considered was readily accepted by the mice, and that all mice consumed the equivalent of a lethal dose of nontoxic bait within 48 hours.

## 4.5 Placebo Bait Broadcast

### 4.5.1 Mouse Biomarker Exposure Rates

The trap results indicated a very high rate of exposure to bait in the core trapping grids. Four trap nights were conducted in each of the two core trap grids (A and B), making for eight total sampling events. Six of the eight sample events resulted in biomarker exposure in 100% of the mice captured in each core grid. The other two nights resulted in 97% and 96% exposure rates (Table 1).

#### Study Area A

On trap grid A (with 18 kg/ha broadcast for both applications) 100% of the mice captured tested positive for biomarker bait consumption after each of the two applications. A total of 13 mice were captured in grid A, amounting to 2% trap success.

#### Study Area B

On trap grid B (with 18 kg/ha and 9 kg/ha application rates) mouse trap success rates were much higher, with 25 mice captured after the first application (6.5% trap success), and 129 mice captured after the second bait application (32% trap success). All 25 mice captured on grid B after the first bait application tested positive for biomarker (100% exposure). After the second application, 124 of the 129 mice captured in area B were positive for biomarker, resulting in an overall exposure rate of 97% for grid B.

**Table 1. Mouse Trap Results for Biomarker Presence**

Trap Area	# Traps Set	# Mice	# Positive	% Positive	# Negative	% Negative
Core Grid A Nov. 12	200	2	2	100	0	0
Core Grid A Nov. 13	200	2	2	100	0	0
Core Grid A Nov. 17	200	3	3	100	0	0
Core Grid A Nov. 18	200	6	6	100	0	0
<b>Core Grid A - Total</b>	<b>800</b>	<b>13</b>	<b>13</b>	<b>100</b>	<b>0</b>	<b>0</b>
Core Grid B Nov. 12	200	16	16	100	0	0
Core Grid B Nov. 13	200	9	9	100	0	0
Core Grid B Nov. 17	200	32	31	97	1	3
Core Grid B Nov. 18	200	97	93	96	4	4
<b>Core Grid B Total</b>	<b>800</b>	<b>154</b>	<b>149</b>	<b>97</b>	<b>5</b>	<b>5</b>
Inner Immigration A	40	16	16	100	0	0
Inner Immigration B	40	17	16	94	1	6
Outer Immigration A	16	11	1	9	10	91
Outer Immigration B	40	25	0	0	25	100

### 4.5.2 Immigration transects

Immigration trapping revealed positive test results for biomarker in all but one mouse captured in traps within the baited zone, and just a few negative exposure results for those



mice trapped well outside of the baited zone. Table 1 summarizes the trap results for immigration transects.

#### **4.5.3 Bait Availability**

Results from the bait monitoring plots indicate that bait remained available to mice for four nights, which has been the target exposure period for most rodent eradication projects. Bait was virtually gone by the fifth night after the first application (Figs 4 and 5). Thus, bait was removed at an average rate of 3.6kg/ha/day, with daily uptake rates per plot ranging from 1.6-6.3 kg/ha/day over five days.

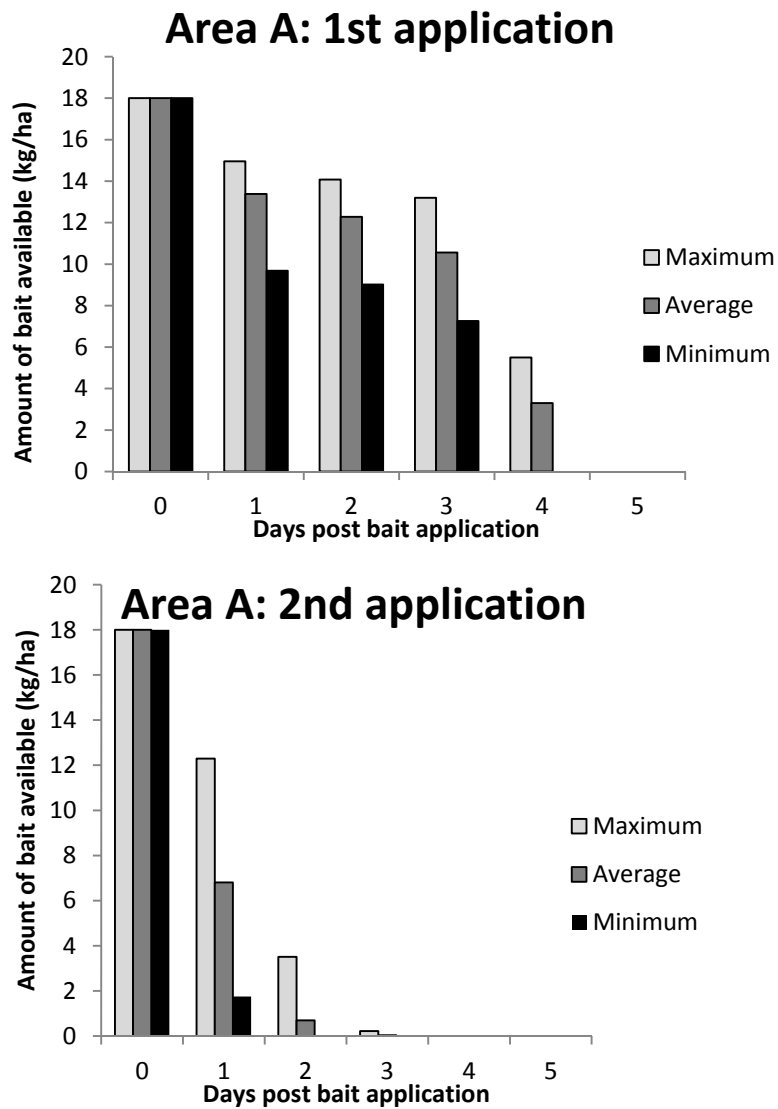
Within two days of the second application, most of the bait was gone from the four uptake plots in area B, which received the lower application rate of 9kg/ha. Much of this uptake was likely due to the greater abundance of mice here compared to area A, as the number of mice captured in area B was over ten times higher than in area A. On the second application, area A received twice the amount of bait (18kg/ha) that area B received (9kg/ha), yet most of the bait pellets in the availability transects in area A were also consumed in two days.

It is likely that some of the bait consumption was due to non-target uptake of the bait, as by this time, some of the Western Gulls roosting in this area had learned to identify the pellets as a food item and were observed foraging heavily on bait in area A, and to a lesser extent in area B. The relative abundance of mice in area B was much higher than in area A, and so mouse uptake of bait was likely higher in area B than in area A.

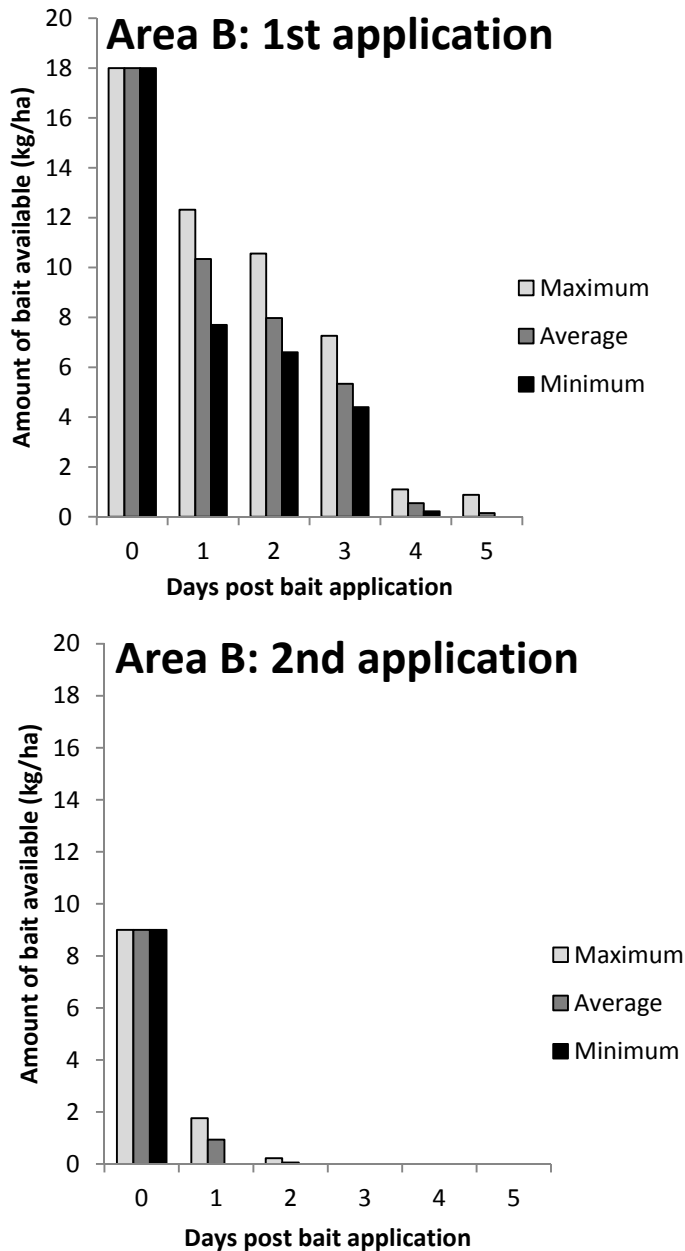
The high mouse exposure rates indicate that the bait pellet used would have a high chance of success at exposing all mice on SFI when applied at the densities used. While 100% exposure in mice was not achieved every night, this is likely due to edge effects inherent in the trial design, and which would not be present during an eradication.

The perimeter of the baited zone created an edge effect and allowed for migration of individual mice into the trapping area from outside of the bait zone, and mice could have been trapped before being exposed to bait. The data seem to support this hypothesis, as the total number of mice trapped on grid B during the second two trap nights was 32 and 97, respectively. This increase in abundance suggests that mice may have moved into the trapping grid over time, perhaps attracted by the introduced food sources (bait pellets and oats in traps), which were not present outside the baited zone. Most of the five unexposed mice were caught in traps closest to the non-baited area, within 50m of the northern edge of the trap grid.





**Fig. 4. Bait availability over time in area A on SEFI following two applications of rodent bait (1g pellets) at 18kg/ha across a 3 ha trial area.**



**Fig. 5 Bait availability in area B over time on SEFI following two applications of rodent bait (1g pellets) at 18kg/ha and 9kg/ha across a 3.2ha trial area.**

There is the additional possibility that bait uptake in this area at this time was so fast that not all resident mice had access to bait before it was completely removed from the environment. The non-target (gull) bait uptake in this area during the days leading up to and following the second bait application, in combination with the lower application rate, could have contributed to the five mice not having access to pellets at the time of capture. The fact that all bait was gone within two days in this area lends credence to these as causal factors, as three to four nights is the target exposure period for the product tested.

The fact that mouse captures increased 300% over one night in this area might indicate that a wave of immigration may have occurred into the baited zone, especially since all mice testing positive for exposure were removed from the population each day.

#### **4.5.4 Gull Enclosures**

The use of gull enclosures resulted in some bait pellets being present for as long as 9 days after bait application in areas of lower mouse abundance (area A). Bait inside these exclusion devices lasted for three to four days longer than in the surrounding area where bait was accessible to gulls and where gulls were roosting nearby in large numbers. Gull enclosures in area B, where mouse abundance was several times higher than area A, had bait completely removed by mice in as few as one to two days—a removal rate which does not differ greatly from that observed in bait monitoring plots, where gulls were observed foraging.

Although the small size and small number of the gull exclusion devices limits the ability to extrapolate the results to an island-wide scenario, the results indicate that it is possible that gulls could consume significant amounts of the bait if no gull avoidance measures are taken.

### **4.6 Mouse DNA Sampling**

A total of 100 DNA tissue samples were collected during the trial, with 50 from each of SEFI and WEI. These samples have been stored for future analysis.

### **4.7 Non-target studies**

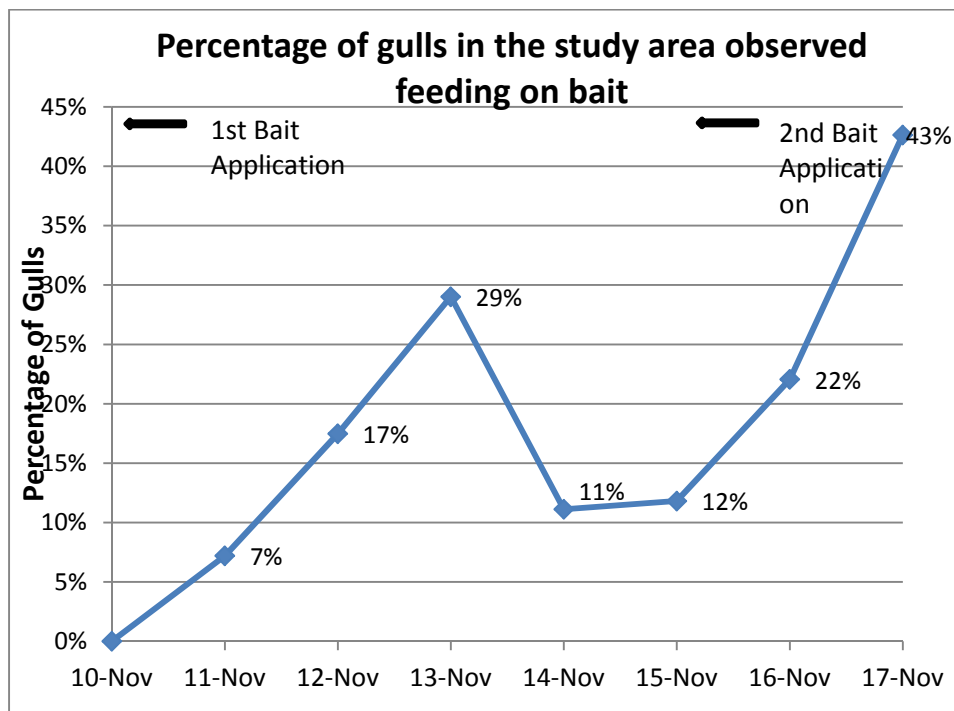
#### **4.7.1 Western Gulls**

A total of 324 hours of visual observations of gull foraging within the baited area were recorded. Within a day of the first application fewer than 12 Western Gulls were seen beginning to forage on the bait in a few small areas. By the second day, 188 gulls were detected consuming pellets in the bait zone and by the third day, a maximum of 233 gulls were consuming pellets. On days four and five, the fraction of foraging gulls dropped below 12% of those present, perhaps due to a paucity of remaining bait (Fig. 6).

Following the second application of bait, however, the number of pellet-foraging gulls grew from 22% to 43% of the gulls present in the study area, likely a response to the second bait application. On average, 27% of gulls were observed foraging on bait over the course of the eight days bait was available in the study area.

Data from the four gull exclusion devices demonstrated that gulls were a factor in consuming bait in the baited area. Observational data indicate that Western Gulls were responsible for a measurable fraction of pellet removal from the environment and that foraging by roosting Western Gulls increased each day that bait was readily available. It should be noted that the study areas happened to occur in the area of SEFI where the roosting gull population is generally highest and most dense, so these results and foraging rates may not be indicative of the potential exposure rates elsewhere on the islands.

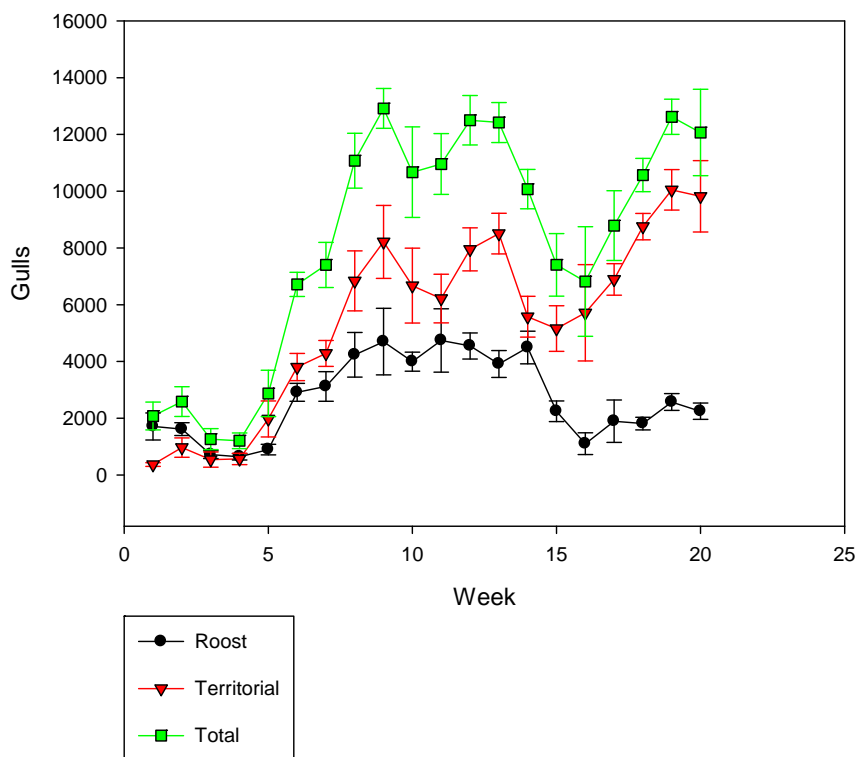
The gull foraging behavior on the placebo pellets was a learned behavior that seemed to attract additional gulls as they witnessed the foraging motions of nearby gulls. If most gulls could be kept from learning that the bait is a food source, this type of density-dependent mass foraging behavior may be significantly reduced or avoided. In addition, the majority of the gull foraging occurred in the first two hours after sunrise and during the two hours preceding sunset. This behavioral pattern could be useful when applying any gull-avoidance measures during any eradication effort.



**Fig. 6 Percentage of gulls in study area observed feeding on bait**

The percentage of gull fecal deposits that were positive for biomarker in the fecal plots averaged 25%. The total number of Western Gulls was highly variable from day to day, ranging from approximately 500 to 4000 individuals a day, and generally increased as the month progressed. The population is thought to shift sporadically from mostly non-breeding, intertidal-roosting gulls in November to a larger percentage of territorial, breeding gulls later in December and January. Breeding birds begin to spend more time on potential breeding sites throughout the island in advance of their breeding season, with the earliest egg-laying dates generally occurring in late April, when up to 17,000 gulls may be present on the island. Daily gull counts on the Farallones conducted by PRBO from November 1 through April indicate that the mean number of gulls present each week from November 1<sup>st</sup> (week 1) through December 31<sup>st</sup> (week 8) of 2010 was as low as 1206, and as high as 11,074 (Figure X). The average number of gulls present from November through week 5 (mid December) 2010 was 2002.

2010/2011 (Nov through Mar)  
Weekly means and standard error



Daily fall gull counts continue to be conducted by PRBO staff.

#### 4.7.2 Burrowing Owls

A total of 10-12 Burrowing Owls were likely present on island during the November trial, many of which had been captured and banded and/or fitted with a radio-transmitter by PRBO as part of an ongoing research project. A total of two owls were captured in mist nets and examined under UV light for primary or secondary exposure to the biomarker, but neither individual showed any external fluorescence due to pyranine. A total of 26 fresh Burrowing Owl casts were collected from over 10 locations within and near the study area both before and after the biomarker bait broadcasts. None showed any fluorescence that would have indicated biomarker exposure.

It is very likely that at least some of the mice eaten by owls during the trial period were exposed to pyranine, but it is thought that it is not likely that the water-soluble dye is detectable in owl cast deposits after having gone through both mouse and owl digestive processes.

#### 4.7.3 Salamander Surveys

Inspection of coverboards before and after the bait broadcasts in November revealed that no salamanders had moved under them as of November 20, 2010. The arboreal salamander on the island seems to prefer moist habitats with rocks and talus, so the relatively exposed

## 4.8 Cave and Camel Cricket Assessments

Map of Southeast Farallon Island showing sampling locations. The map includes contour lines indicating elevation, with labels for Corm Cave 2, Comblind Cave, Driftwood Cove, Soler Cove, Breaker Cove, Rabbit Cave, and Orchel Cave. A scale bar (0-200 meters) and a north arrow are provided. The map is credited to USFWS and dated 2010.

## 5. RECOMMENDATIONS

1. Conduct a gull hazing trial on SFI which should include support from agencies or organizations which have expertise in hazing birds, such as the Oiled Wildlife Care Network and/or USDA-APHIS Wildlife Services
2. Conduct an extended bait degradation study on SEFI (> 4 weeks)
3. Conduct invertebrate surveys, including Farallon camel cricket surveys and cave mapping
4. Conduct salamander bait exposure studies on the island
5. Map the distribution & abundance of native/non-native vegetation before eradication

6. Continue owl monitoring and telemetry to assess numbers, location, stay length
7. Continue daily gull counts (September through April)
8. Continue monthly mouse index of abundance trapping
9. Develop and implement a Biosecurity Plan for SFI
10. Develop a plan for commensal areas to address the increased risks this area poses to an eradication operation
11. Develop a comprehensive Non-Target Mitigation Plan, which includes:
  - a. Raptor capture and hold/release protocols
  - b. Passerine capture protocols
  - c. Gull hazing plan (upon completion of a hazing trial)
  - d. Salamander and camel cricket surveys and mitigation protocols

## 6. REFERENCES

- Ainley, D. and R. Boekelheide. 1990. Seabirds of the Farallon Islands: Ecology, Dynamics, and Structure of an Upwelling-system Community. Stanford University Press, Stanford, CA
- Carter, H.R., W.R. McIver, and G.J. McChesney. 2008. Ashy Storm-Petrel (*Oceanodroma homochroa*) in Shuford, W. D., and T. Gardali, editors. 2008. *California Bird Species of Special Concern: A ranked assessment of species, subspecies, and distinct populations of birds of immediate conservation concern in California*. Studies of Western Birds 1. Western Field Ornithologists, Camarillo, California, and California Department of Fish and Game, Sacramento.
- Fisher, P. 2005. Reveiw of house mouse (*Mus musculus*) susceptibility to anticoagulant poisons. DOC Science Internal Service Report 198, New Zealand Department of Conservation, Wellington, NZ.
- Hagen, A. 2003. An evaluation of house mouse diet on Southeast Farallon Island. Report prepared by the Department of Wildlife Management, Humbolt State University, Arcata, CA, USA.
- Howald, G., A. Samaniego, B. Tershy, P. Pyle, J. Buffa, B. Keitt, and H. Jones. 2003. Options for removing house mice (*Mus musculus*) from the Farallon Islands, Farallon National Wildlife Refuge, California. Report for the U.S. Fish and Wildlife Service.
- Irwin, J. 2006. The impact of house mice on ashy-storm petrels on Southeast Farallon Island, Unpublished report to U.S. Fish and Wildlife Service. Farallon National Wildlife Refuge, Freemont, CA.
- Pickard, C. 1984. The population ecology of the house mouse (*Mus musculus*) on Mana Island. Victoria University, Wellington, New Zealand.
- Sydeman, W., N. Nur, E. McLaren, and G. McChesney. 1998. Status and trends of the ashy-storm petrel on Southeast Farallon Island, California, based upon capture-recapture analysis. *Condor* **100**:438-447.
- Warzybok, P. and R. Bradley. 2011. Status of seabirds on Southeast Farallon Island during the 2011 breeding season. PRBO Conservation Science. Petaluma, CA. December 2011.