

**Farallon Islands Restoration Project**

**Hazing Western Gulls on the South Farallon Islands**



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**EXECUTIVE SUMMARY**

Introduced mice pose a threat to the Ashy Storm-petrel and other native and endemic species of the Farallons National Wildlife Refuge. To allow species and ecosystem recovery, the removal of mice from the Farallones has been proposed. Methods being considered for removing mice include the aerial application of rodent bait containing a rodenticide. The late fall has been proposed as the best time of year for conducting a mouse eradication because most resident seabirds are absent from the islands at this time. However, risk of exposure to rodenticide exists for some non-target wildlife such as Western Gulls.

Hazing of gulls has been recommended as a means of isolating gulls from rodent bait and mitigating potential risk of exposure. To evaluate the potential for hazing gulls from the South Farallon Islands a gull hazing trial was undertaken in November and December 2012. The hazing trial successfully demonstrated the ability to keep the majority of Western Gulls off the South Farallon Islands for a period of 12 days. The trial also successfully prevented gulls from accessing areas where rodent bait was available. Results from the trial provide a high degree of confidence that a well planned and executed hazing operation could reduce gull mortality to minimal levels during a mouse eradication.

The hazing trial caused minimal disturbance to non-target species. Some bird species were affected including Brandt’s Cormorant, Common Murre, Brown Pelican, Black Oystercatcher and a handful of overwintering shorebirds but the impacts observed to these species were short lived. The hazing trial also had little impact on pinnipeds (seals and sea-lions) hauled out on the islands. Responses of pinnipeds varied depending on the hazing tool employed and the species present but, only rarely did hazing activities result in pinnipeds being flushed into the water.

**ACKNOWLEDGEMENTS**

The Farallon Avian Hazing Trial was designed and conducted by the Farallon Restoration Project Partners (U.S. Fish and Wildlife Service, PRBO Conservation Science and Island Conservation) with the assistance of expert professional avian hazing staff from USDA-APHIS Wildlife Services, CDFG-OSPR, and the Oiled Wildlife Care Network Wildlife Health Center at UC-Davis.

The hazing trial was made possible due to support from the Luckenbach Trustee Council oil spill settlement funds, the National Fish and Wildlife Foundation Coastal California Restoration Settlement Funds Grant #8001.04.034554, and the California Department of Fish and Game’s Oil Spill Response Trust Fund through the Oiled Wildlife Care Network (OWCN) at the Wildlife Health Center, School of Veterinary Medicine, University of California, Davis. Special thanks also go to Todd Weitzman of Bird Gard, LLC for the loan of seven BirdGard biosonic units for the duration of the trial.

Many agencies and individuals were involved in developing the trial plan. We are grateful for the support we received from Jonathan Shore (USFWS), Jim Tietz and Ryan Berger (PRBO), Paul Gorenzel (OWCN), Valerie Burton and Eric Covington (USDA-APHIS WS), and Tommy Hall (IC). We would also like to thank the volunteers who contributed to the trial effort including: John Warzybok, Sara Acosta, Holly Gellerman, Kyra Mills-Parker, Paul Steinberg, Liz Ames, and Lara White. Sansone Company and the U.S. Coast Guard provided invaluable support in transporting supplies and freight to the island.

All actions conducted during the trial complied with the specific permit and authorization requirements specified in the following Hazing Trial permits:

* **NOAA-NMFS: Section 7 Biological Opinion and Incidental Harassment Authorization (IHA)** (Addresses monitoring, avoidance and minimization of impacts to pinnipeds during the trial)
* **ATF:** Permit issued by the Bureau of Alcohol, Tobacco, and Firearms for the use and handling of explosive pest control devices (EPCD) issued on November 9, 2012.
* **USFWS**: Wilderness Determination to allow for access the Wilderness Areas of the Refuge.

Categorical Exemption issued by the USFWS Refuge Manager.

* **Gulf of the Farallones National Marine Sanctuary:** Permit allowing helicopter over flights.

**INTRODUCTION**

The South Farallon Islands of the Farallon National Wildlife Refuge lie 30 miles west of San Francisco, California, and harbor the largest island breeding seabird colony in the continental U.S (Ainley and Boekelheide 1990). The presence of invasive House mice (*Mus musculus*) is having a significant impact on the IUCN-Endangered Ashy Storm-petrel (*Oceanodroma homochroa*) and other native and endemic species of the Farallon Island ecosystem. The USFWS is proposing to remove all introduced mice as part of the Farallon Restoration Project ([www.restorethefarallones.org](file://prbo.org/Data/Home/Petaluma/pwarzybok/Documents/Seabirds%202012/Hazing%20Trial%20Docs/www.restorethefarallones.org)). Proposed mouse removal methods include the aerial application of rodent bait containing a rodenticide.

The timing of an operation to eradicate mice would likely take place during the fall when most resident seabirds are not present on the Farallones. However, evidence from past eradication projects([e.g. Howald et al. 2005](#_ENREF_4)) and a trial completed in 2010 ([Grout and Griffiths 2012](#_ENREF_3)) indicate that Western Gulls (*Larus occidentalis*) would be at risk of rodenticide exposure. Western Gulls are distributed along the west coast of North America between [British Columbia](http://en.wikipedia.org/wiki/British_Columbia), Canada to [Baja California](http://en.wikipedia.org/wiki/Baja_California), Mexico, are not considered threatened and are listed by the IUCN as Least Concern. Western Gulls are omnivorous and opportunistic feeders and individuals of this species are known to roost on the island in the fall and winter (non-breeding season).

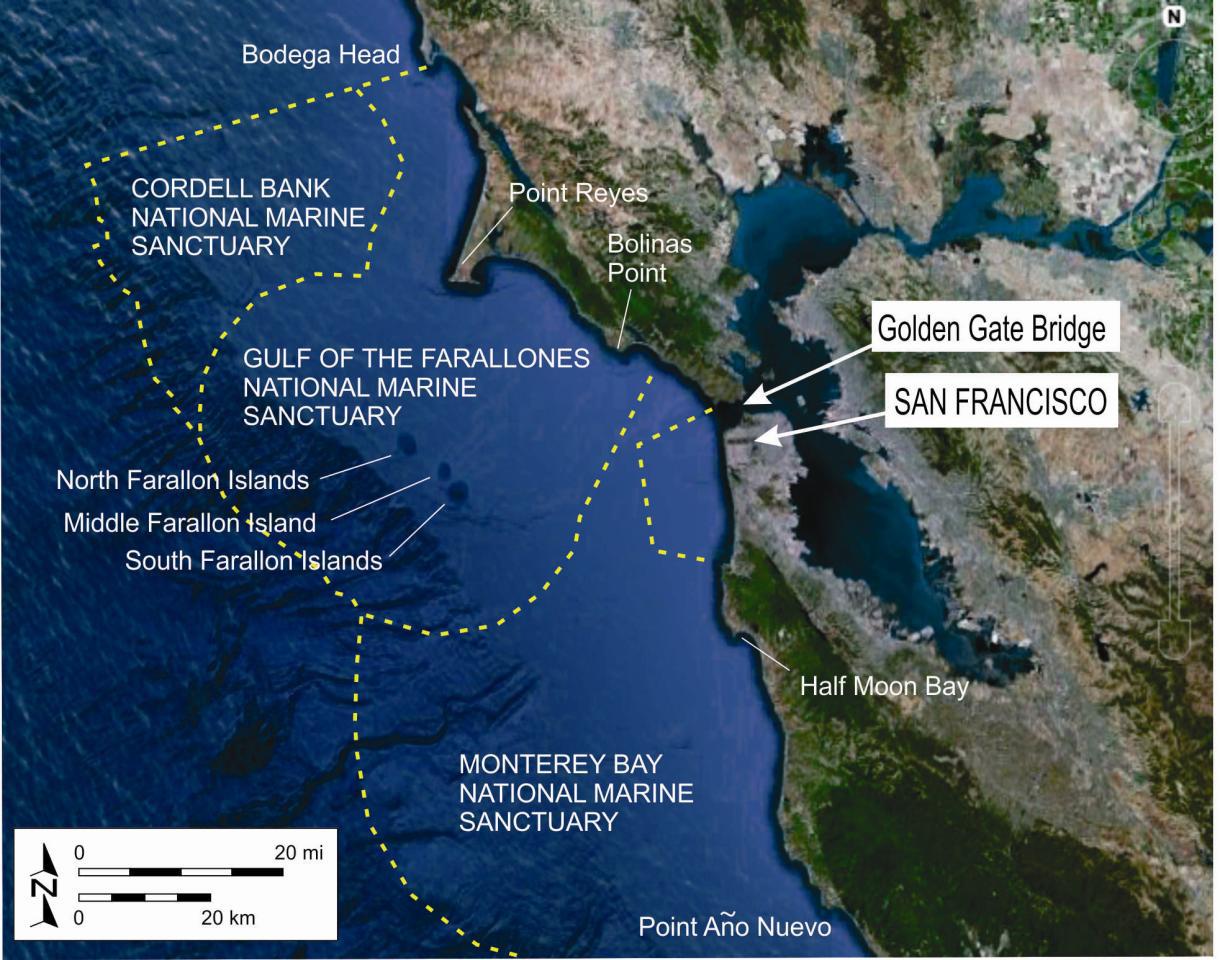
Hazing, or dissuading gulls from remaining on the island, during the period that rodent bait remains available has been proposed as one potential method for minimizing the risk of rodenticide exposure to Western Gulls. Hazing gulls may also be necessary to ensure sufficient bait remains available to mice, a prerequisite to eradication success. Farallon Western Gulls do not breed until April ([Ainley and Boekelheide 1990](#_ENREF_1)), so hazing gulls from the Refuge during late fall and winter when their populations are greatly reduced will likely have no significant impact on the population.

A number of hazing techniques were trialed during a pilot study in 2011 including those used successfully at airports, landfills and sensitive breeding areas on Refuges and other areas throughout California ([Pott and Grout 2012](#_ENREF_5)). Based on recommendations from the 2011 trial, a second more comprehensive study was undertaken in 2012, during the time of year that a proposed mouse removal operation might be conducted, deploying techniques shown to be effective along with several novel hazing methods on the South Farallon Islands (SFI). The 2012 trial aimed to evaluate the potential of hazing as a means of mitigating risk to Western Gulls and in accordance with the Marine Mammal Protection Act provide an assessment of the impact of hazing activities on the species of pinniped that haul out and breed on the South Farallon Islands: [Northern elephant seal](http://en.wikipedia.org/wiki/Northern_elephant_seal) (*Mirounga angustirostris*), Harbor seal (*Phoca vitulina*), Steller sea lion (*Eumetopias jubatus*), Northern fur seal (*Callorhinus ursinus*), and California sea lion (*Zalophus californianus*).

Although the relative effectiveness of hazing methods and the impact of each individual hazing technique on pinnipeds was assessed during the trial, results are only described qualitatively in this report. A quantitative analysis of the relative effectiveness and impact of individual hazing techniques is planned for subsequent reports.

The design and implementation of the avian hazing trial was conducted primarily by the Farallon Restoration Project Partners (U.S. Fish and Wildlife Service, PRBO Conservation Science and Island Conservation) with the assistance of expert professional avian hazing staff from USDA-APHIS Wildlife Services, CDFG-OSPR, and the Oiled Wildlife Care Network Wildlife Health Center at UC-Davis. This report documents the findings of the trial and discusses the ramifications of the study’s results on the proposed mouse eradication attempt.

Fig. 1. Map showing the location of the South Farallon Islands, California.

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**OBJECTIVES**

* Demonstrate the effectiveness of hazing methods to mitigate the risk of exposure by Western Gulls to rodent bait on the South Farallon Islands.
* Document the impacts of hazing activities on pinnipeds and other native species present on the South Farallon Islands.
* Determine the logistics and level of resourcing required to conduct an extended hazing program on the South Farallon islands prior to and during a mouse eradication.

**METHODS**

**Trial timing and schedule**

The trial took place between November 27 and December 15, 2012. This time period was selected to coincide with the likely timing of a mouse eradication operation involving an application of rodent bait, when overall marine bird numbers are at their lowest of the year and before the start of elephant seal breeding. This period also aimed to exploit a low-point in Western Gull presence prior to their return to the islands in increasing numbers. The trial was split into three distinct phases with each phase having its own specific objective (Table 1). Baseline numbers of gulls and pinnipeds were recorded prior to initiation of the hazing trial and post-trial monitoring of gulls and pinnipeds was undertaken to determine the rate at which gulls resumed normal roosting patterns, and to document any lasting impact on pinnipeds. The impact of hazing activity and individual techniques on pinnipeds was assessed throughout the trial.

Phase 1 aimed to evaluate the relative efficacy of specific techniques for hazing gulls and determine the effective range of individual hazing tools. Results from Phase 1 were used to guide the deployment of hazing techniques during subsequent trial phases. However, results from Phase 1 have not yet been analyzed and are not presented within this report. Phase 2 aimed to evaluate the effectiveness of a gull hazing operation at reducing the number of gulls on the South Farallon Islands. Phase 2 simulated the likely hazing activity planned to take place prior to and during a mouse eradication. Hazing techniques and combinations of techniques were deployed as required during Phase 2 with the intention of reducing gull numbers to minimal levels. Hazing activities were continued in Phase 3 but only from SEFI and only by personnel on foot. Due to the greater limitations on access during this phase, gulls were allowed to roost on a few specific islets. Phase 3 aimed to demonstrate that even a scaled back hazing operation could prevent gulls from settling in those areas of the island where bait would be applied during an eradication effort.

Table 1. Trial Phases.

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| --- | --- | --- | --- | --- |
| Phase | Scope | Scope | Duration | Dates |
| 1 | * Assessing the effectiveness of individual hazing methods on gulls on the South Farallon Islands | SEFI and small areas of WE | 5 days | November 28 – December 2, 2012 |
| 2 | * Assessing the effectiveness of a hazing operation to reduce gull numbers across the South Farallon Islands | Island-wide | 9 Days | December 3 – 11, 2012 |
| 3 | * Assessing the effectiveness of hazing from SEFI to reduce gull numbers across the South Farallon Islands | SEFI and most of WE | 3 days | December 11-13, 2012 |

1Although the relative efficacy of hazing techniques was tested during the trial, analysis and interpretation of the results obtained from Phase 1 is not a subject of this report.

**Gull hazing**

A total of 19 different avian hazing techniques were deployed on the South Farallon Islands during the trial. A short description of each tool and how it was used in the trial is presented in Appendix 1. More detailed information on the tools and methods used can be found in ([Pott and Grout 2012](#_ENREF_5)). Tools were often used together in a variety of combinations to increase effect.

During Phase 1 of the trial, a number of the avian hazing tools listed in Appendix 1 were tested individually on various areas of Southeast Farallon Island where gulls were present. Each hazing tool tested was trialed up to five times to determine an effective range for hazing gulls and to assess how far from pinnipeds it could be used without creating significant disturbance.

Phase 2 of the trial aimed to haze all gulls off the South Farallon Islands. All methods and method combinations listed in Appendix 1 were utilized to prevent gulls from landing or roosting on the islands. A Robinson 22 helicopter allowed team members and equipment to be transported to and stationed at West End (WE) allowing more comprehensive hazing coverage. Hazing techniques were generally deployed as needed rather than all at once and were used in a sequence from least to most aggressive.

Following the departure of several staff and the helicopter on December 11, personnel and hazing equipment were withdrawn from WE. Hazing of most areas of SEFI and portions of WE could still be undertaken so the aim of Phase 3 was to determine if both main islands could still be hazed effectively using only ground-based personnel on SEFI. With the exception of the helicopter, the same hazing tools and hazing tool combinations were used during this portion of the trial. During this time, gulls were allowed to roost in limited locations where bait may not be applied during a mouse eradication operation, including several small off-shore islets and tidally submerged roosts.

Methods such as trained dogs and raptors to deter gulls and lethal removal were not used in the trial. Trained dogs and raptors were not used because of cost limitations and lethal removal was considered unnecessary for the purposes of a trial. Experimentation with unmanned aerial vehicles (UAVs) to monitor gulls and other wildlife and haze gulls on the Farallones was planned. However, permission from the FAA to use UAV’s on the South Farallon Islands was not able to be gained in time.

**Gull distribution and abundance and behavioral responses to hazing**

Dawn gull counts were conducted on a daily basis by experienced ground based observers on the South Farallon Islands between November and March in 2010 and 2011 to establish a baseline population estimate for gulls on the island during the fall and winter. To evaluate the impact of hazing on the islands’ gull population, these counts were continued during the 2012 fall/winter season prior to, during and after the hazing trial. To allow a more detailed assessment of the impact of specific hazing techniques used during the trial, the island was divided into 49 discrete sectors (Fig. 3). During all phases of the trial, gull numbers and their location in each sector were recorded multiple times per day at regular intervals, as well as immediately prior to and after deployment of hazing techniques. The helicopter was used to assist with counts of sectors that were partially obscured to ground based observers on South East Farallon Island (SEFI) and WE.

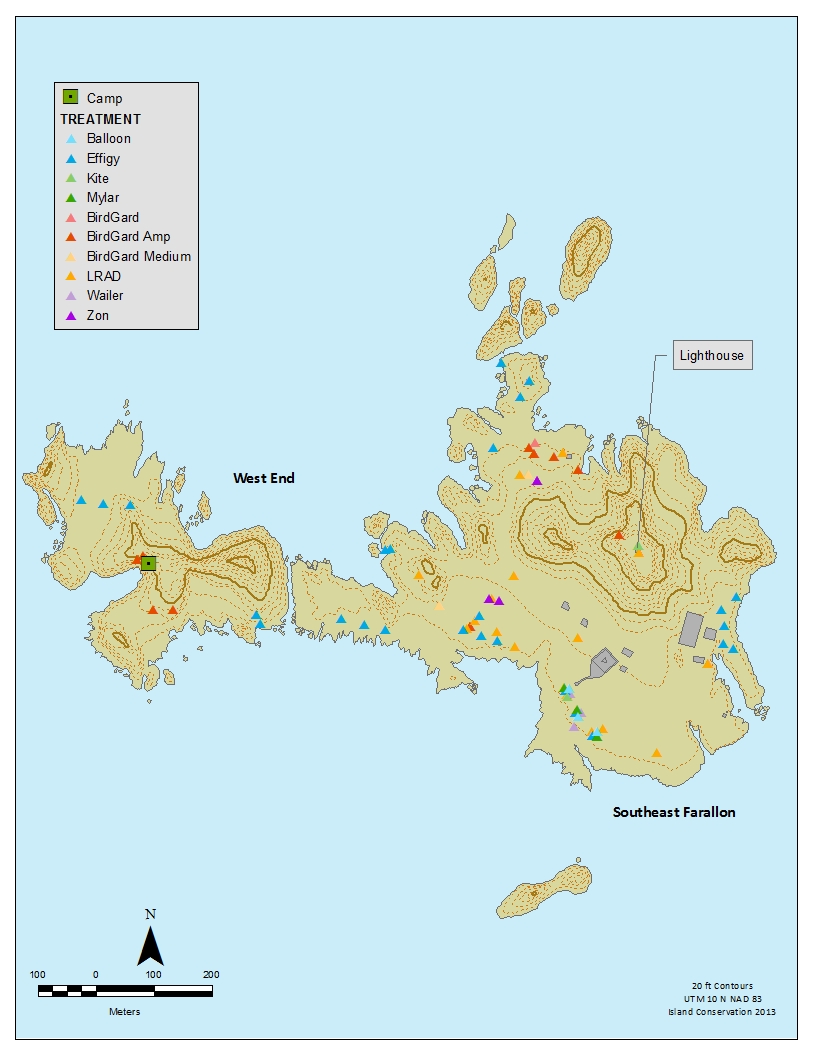


Fig. 2 Location of hazing tools used during a 2012 gull hazing trial on the South Farallon Islands.

A complete count of the targeted area was completed prior to any hazing activity and the level of response by gulls was determined from the percentage of the original number remaining after the conclusion of hazing activity. Responses of gulls to a hazing activity were categorized into one of two possible behaviors: 1) no response and; 2) flushed. If a gull’s response fell into the ‘flushed’ category then it was noted what percentage of those gulls 1) immediately departed the area or 2) immediately circled and returned to the same site. Any sign of gull habituation as defined by Bejder et al ([2009](#_ENREF_2)) was noted, including the following:

* Gulls not responding to hazing and continuing to roost in target area
* Gulls becoming less responsive to hazing and returning to roost more quickly
* Decreasing range of effectiveness of hazing techniques
* Decreasing percentage of gulls responsive to hazing tools
* If the use of pyrotechnics had to be more frequent to maintain roosts free of gulls

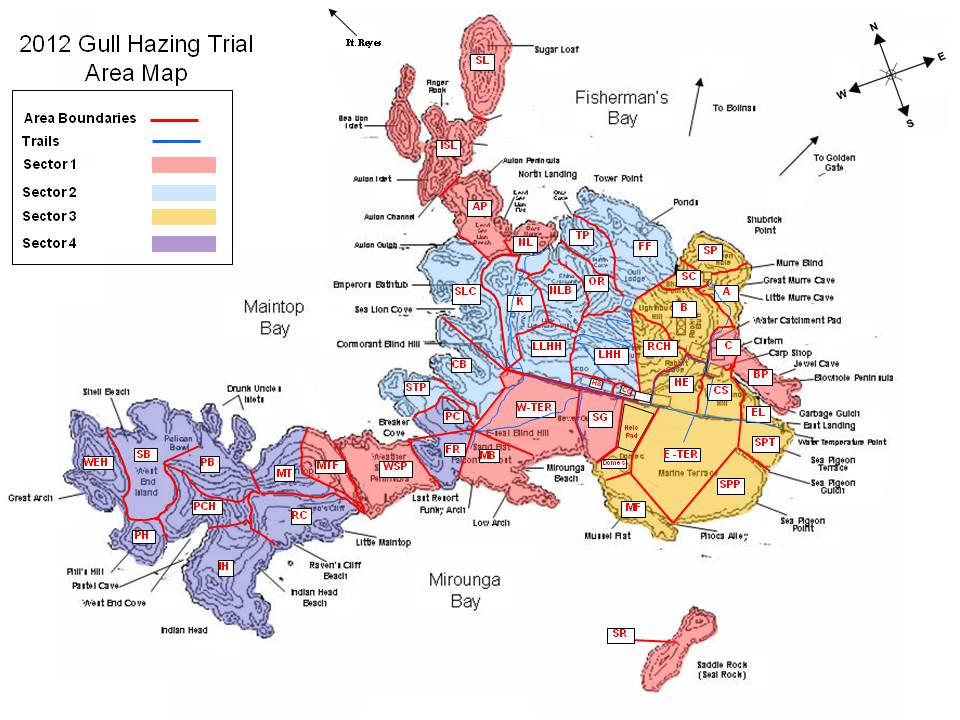


Fig. 3. Sectors used for monitoring gull numbers and behavior during a hazing trial conducted on the South Farallon Islands in 2012.

Gull monitoring generally required at least two individuals for each of SEFI and WE. At least one observer was stationed at the lighthouse and the other on the ground closer to where hazing activity was conducted. Each observer was responsible for tracking the behavior, location and movement of gulls. Hazing staff and observers worked together, so that all hazing impacts were accurately monitored. In the evening, after gull hazing activities had ceased, periodic nighttime patrols were conducted to confirm no roosting gulls were present on the island. Patrols consisted of surveying the island from the lighthouse.

The impact of hazing activity on inter-annual gull population abundance was evaluated by comparing averaged weekly counts made between the last week of November and the first week of January in 2010 and 2011 with those conducted prior to, during and after the hazing trial. We also examined the overall effectiveness of the hazing effort in reducing the number of gulls roosting on the island. We did this by comparing the number of gulls present in the 10 day period immediately prior to hazing activity with 1) the number of gulls present during the Phase 2 of the trial, and 2) a 10 day period in early January. We expected that by early January gulls would have re-acclimated to the island after cessation of hazing. We used the daily maximum number of gulls present at dawn in the period prior to, during and after the hazing trial for all comparisons. Daily morning surveys were conducted for two weeks prior to the initiation of hazing activities and again for several weeks after the conclusion of hazing. During the hazing trial, maximum dawn numbers were determined by summing gull counts made during the earliest period of hazing activity in each area on each day.

Finally, we determined effective daily hazing rates by calculating the percent difference between the daily maximum gull count and the daily minimum gull count (as determined by the hourly surveys). By this method, days on which we were able to clear all gulls off the island were considered to be an effective hazing rate of 100%. It is acknowledged that daily counts of gulls prior to and during the trial are not independent i.e. counts are likely influenced by size of the gull population present the previous day. However, this was an unavoidable constraint of the trial design. Paired *t-tests* were used to evaluate the difference in gull numbers between time periods to counter this lack of independence between samples.

We originally intended to evaluate changes in the proportion of gulls roosting within breeding territories during the trial period relative to those observed in intertidal areas and on small wave washed off-shore islets. The aim was to demonstrate that a hazing operation could prevent gulls from settling in those areas of the island where bait would be applied during an eradication effort. However, no territorial gulls were detected during the trial period (presumably because of hazing activity) so we were not able to evaluate the effectiveness of keeping them off territories.

Quantitative analysis of the behavioral response by gulls to hazing was considered beyond the scope of this report but general patterns of the behaviors observed are reported. Similarly, spatial changes in gull distribution observed during the trial are displayed graphically rather than analytically.

**Bait consumption by gulls**

In an attempt to recreate conditions that would be present during a mouse eradication operation, two different types of non-toxic (placebo) rodent bait were applied in different areas on SEFI and bait consumption by gulls recorded. Rodent bait was applied at application rates proposed for mouse eradication ([Grout and Griffiths 2012](#_ENREF_3)) at four sites on SEFI (Fig. 4). Plots were selected because they were accessible, easily monitored and either in or near active gull roosting sites. The total area treated was approximately 3 ha. Two plots were baited at 18kg/ha with non-toxic Brodifacoum-25D Conservation (Bell Laboratories Inc.) rodent bait and two plots at 42kg/ha with non-toxic Diphacinone-50 Conservation (HACCO Inc.) rodent bait. Bait remained in all four plots at close to the original application rate for the duration of the trial. Plots were monitored continuously each day and during the night throughout the hazing trial for signs of gull foraging activity. Boundaries of baited areas were clearly marked with PVC poles and flags so observers could monitor the areas from the Lighthouse. Observers tracked any gull activity within plots during regularly-scheduled surveys.

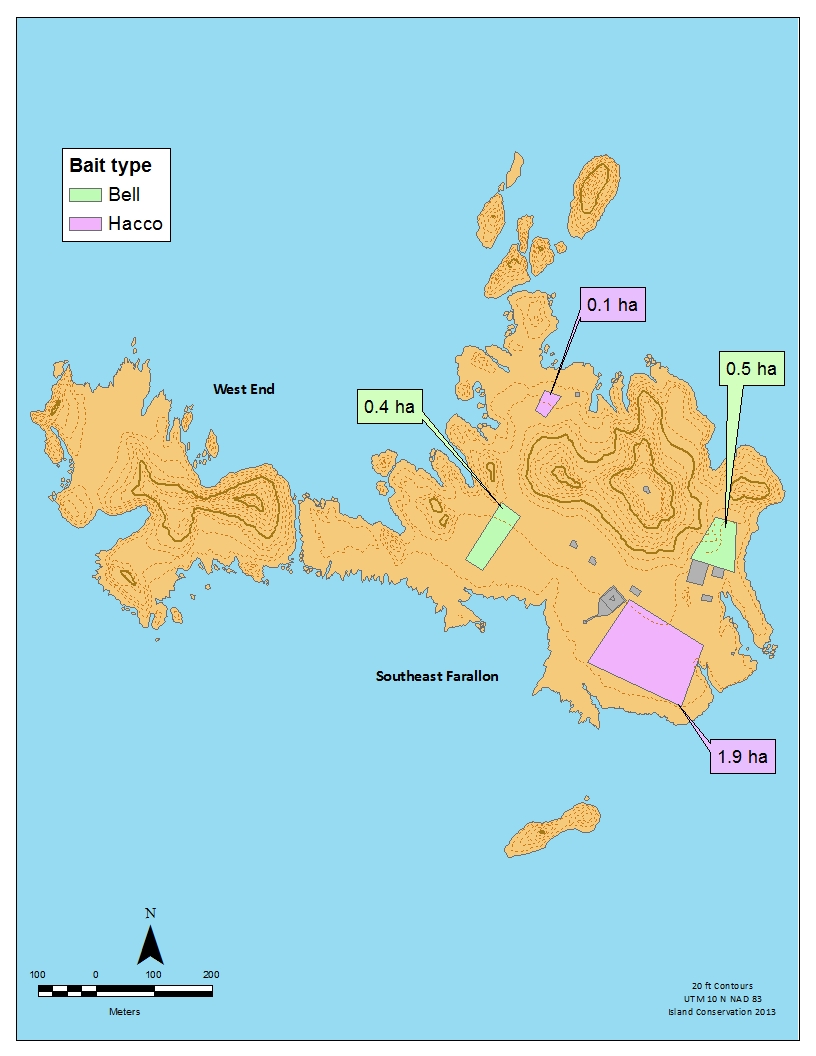


Fig. 4 Areas broadcast with non-toxic rodent bait during a gull hazing trial on the South Farallon Islands. All plots were monitored for signs of any gull presence or foraging.

**Monitoring of impacts to non-target species**

As part of an ongoing research program, weekly surveys of all pinnipeds present on land at the South Farallones are conducted throughout the year. Data from the last five years (2007-2011) were averaged to determine ‘historical’ attendance patterns. To evaluate the impact of gull hazing on pinniped abundance and distribution, we compared these historical numbers with pinniped counts prior to and after the hazing trial. We tested for a significant effect of hazing on overall numbers by comparing the 2012 pre and post hazing trial counts (after controlling for seasonal trends) as well as comparing the 2012 counts with the historical mean (Figs 10-12). Comparisons were made separately for each of the five pinniped species present on the island. We did not conduct the standard weekly surveys during the active hazing period because any response to hazing activities would have biased counts.

Behavioral responses of pinnipeds during the hazing trial were documented by counting all animals present in the target area (area targeted for hazing treatment) immediately prior to the initiation of any hazing technique and recording the proportion of the animals that reacted. Responses of pinnipeds were categorized into four possible behaviors: 1) no response; 2) alert (animal raised head, looked around or shuffled position); 3) moved (moved > 1m from initial location); and 4) flushed (animal moved to the water). Hazers worked closely with designated observers to track and record all pinniped responses to hazing activities. Additional observers were occasionally required to record responses.

During Phase 1 of the trial, a range finder was used to gauge the tolerance as defined by Bejder et al ([2009](#_ENREF_2)) of pinnipeds to biosonic and pyrotechnic hazing tools from varying distances. Hazers deployed these hazing tools at decreasing distances from pinnipeds while an observer assessed the response of the closest animals. Pyrotechnics and biosonics were only used when it was possible to observe pinniped behavior. Data collected on the response of pinnipeds to particular hazing techniques will be presented in later reports.

The impact of the trial on other non-target species present on the South Farallones Islands was recorded as part of other long term monitoring programs and anecdotal observations. Species of interest included Common Murre, Brandt’s Cormorant, Brown Pelican, Black Oystercatcher, other shorebirds and raptors.

**Trial staffing and organization**

Staffing for the hazing trial was provided primarily by the core Farallon Restoration Project Partners (Island Conservation, USFWS, and PRBO conservation Science), with supplemental expert hazing professionals provided by the Oiled Wildlife Care Network, CDFG-OSPR and USDA-APHIS Widlife Services. Generally between 10 and 12 people were deployed each day to conduct all monitoring and hazing activities. PRBO staff stationed on the Farallones maintained daily gull and weekly pinniped monitoring from December 15, 2012 until February 28, 2013.

To ensure that the field trial actions were well coordinated, an Incident Command Structure (ICS) was utilized for the duration of the trial. The ICS allowed for the controlled flow of information and supervision up and down the command structure.

**RESULTS**

**Gull hazing**

The gull hazing trial was completed as planned from December 3 - 13, 2012. Based on the number of gulls responding, the most effective hazing techniques appeared to be the use of lasers at night, at dawn and at dusk, effigies, pyrotechnics, biosonics, helicopters and a combination of these same tools. Kites appeared only mildly effective and were heavily dependent on wind conditions. Zons were also less effective and were hampered by the damp conditions present on the Farallones. Placement of tools varied between and within days, but Fig. 2 shows where most stationary tools were deployed. More mobile devices like pyrotechnics, lasers, LRAD and helicopter were used from many different locations at many different times.

Hazing effectiveness was sustained through Phase 3 and the efficacy of SEFI based hazing remained high (Fig. 6), even though the majority of WE was only hazed at dawn and dusk using lasers from the Lighthouse. Those islets where gulls were allowed to roost included Sea Lion Islet, Saddle Rock and Sugarloaf (Fig. 8). The presence of small numbers of gulls roosting in these refugia did not appear to attract other gulls, so allowing some roosting refugia may be an option in areas where bait application is not planned during an operation.

**Gull distribution and abundance and behavioral responses to hazing**

Overall gull numbers before the hazing trial were intermediate between the previous two years (Fig 5). The average number of gulls on the South Farallon Islands during the 10 days immediately prior to the hazing trial (Nov. 19-28) was 3,716 birds in 2012. This is approximately 32% lower than the same period in 2011, but more than three times greater than 2010.



Fig. 5. Mean number of gulls present on the South Farallon Islands during the 2010, 2011 and 2012 fall/winter seasons. Active gull hazing was conducted during the first two weeks of December.

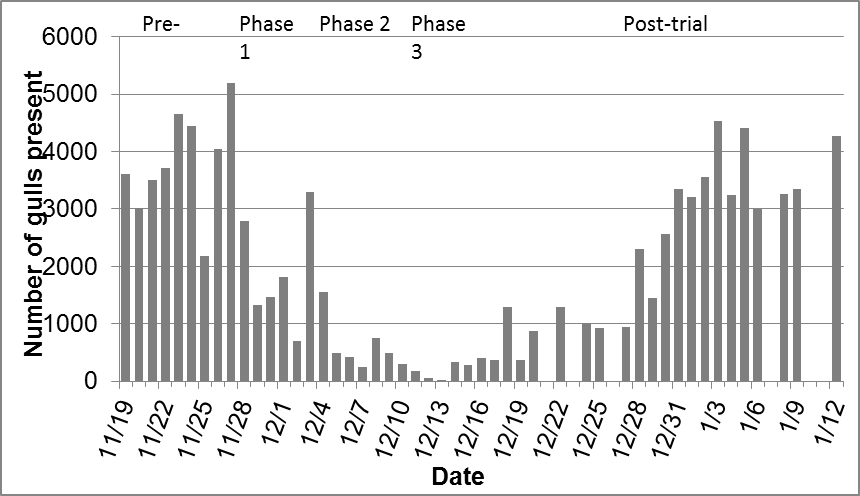


Fig. 6. The maximum number of gulls present at dawn throughout the course of the gull hazing trial. The dashed vertical lines delineate the different phases of the trial (see Table 1). Full island active hazing efforts occurred during Phase 2.

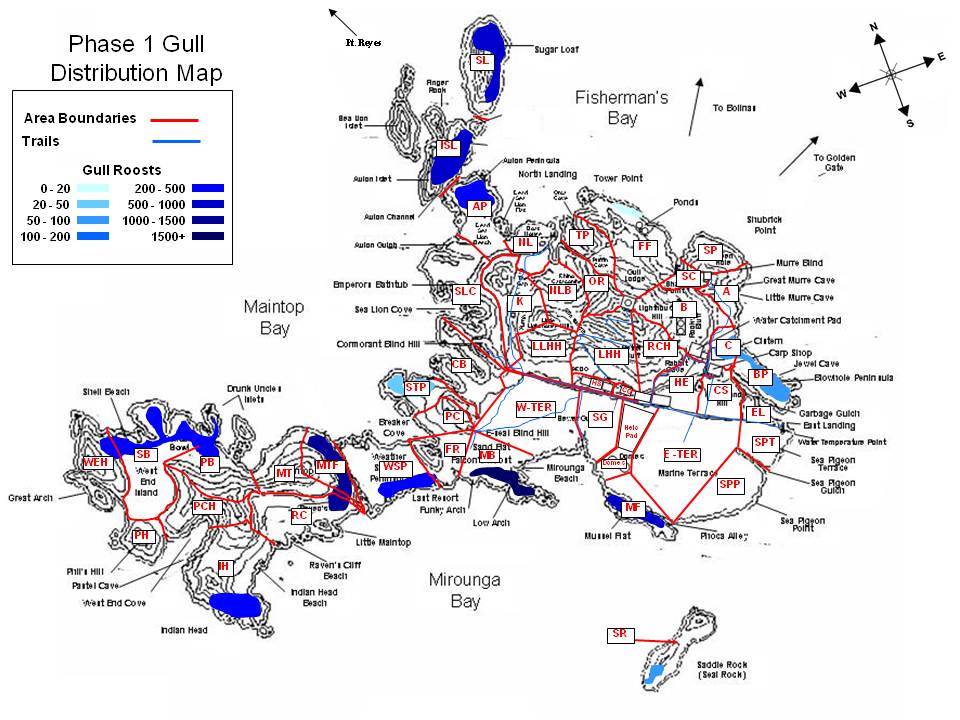
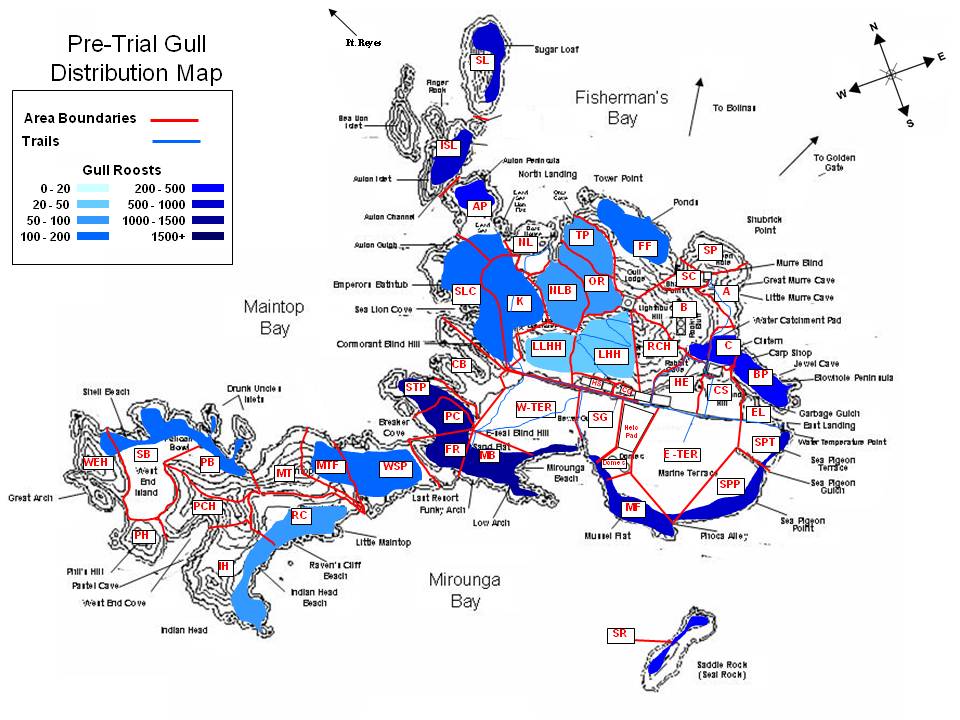
Hazing activity during Phase 2 of the trial significantly reduced gull numbers when compared to the 10 day period immediately preceding hazing activity (*t*=10.8225, *p*<0.01, *df*=17; Fig 6). During the ten day period of island-wide hazing, the average size of the gull population was only 327 as opposed to 3,700 over the ten days prior. Gull numbers increased throughout this period in other years gulls were monitored.

The average number of gulls present on the island during the same ten day period was 4795 in 2010 and 9102 in 2011. This represents a 93% to 96% reduction in the number of gulls present when compared to previous years (Fig. 7) and is significantly different from both previous seasons (2010 *t*=6.1246, *p*<0.01, *df*=9; 2011 *t*=6.5316, *p*<0.01, *df*=9).

The daily hazing success rate was estimated by comparing the daily maximum gull counts to the daily minimum count for each day of hazing activity (December 1 - 14; Fig 7). The number of gulls hazed off the islands was calculated from the difference between these two figures. The daily hazing success rate for Phase 2 (full-island hazing effort) and Phase 3 (hazing from SEFI only) of the trial was between 92% and 100% and averaged 98%. In other words, hazing efforts were 98% effective at keeping gulls off the island and away from areas that would potentially be baited during an eradication effort.

Fig. 7. The maximum number of gulls present on the South Farallon Islands at any given time (based on 1/2 hourly gull counts) and the estimated number that were successfully hazed during a gull hazing trial completed in December 2012. Percentages represent the daily hazing effectiveness. Hazing efforts were reduced on December 14 due to departure of staff.

Gull numbers remained low during Phase 3 when hazing was undertaken solely by ground based personnel on SEFI (Fig. 6.) and hazing efficacy appeared to remain high, even though the majority of WE was only hazed at dawn and dusk using lasers from the Lighthouse. Islets where gulls were allowed to roost included Sea Lion Islet, Saddle Rock and Sugarloaf (Fig. 8.) and these birds did not appear to attract other gulls. During Phase 3, gulls were completely kept off of Blowhole Peninsula and greatly reduced in both numbers and extent in other areas around the island. Remaining gulls were generally restricted to smaller flocks, farther out in intertidal areas (Fig. 8).



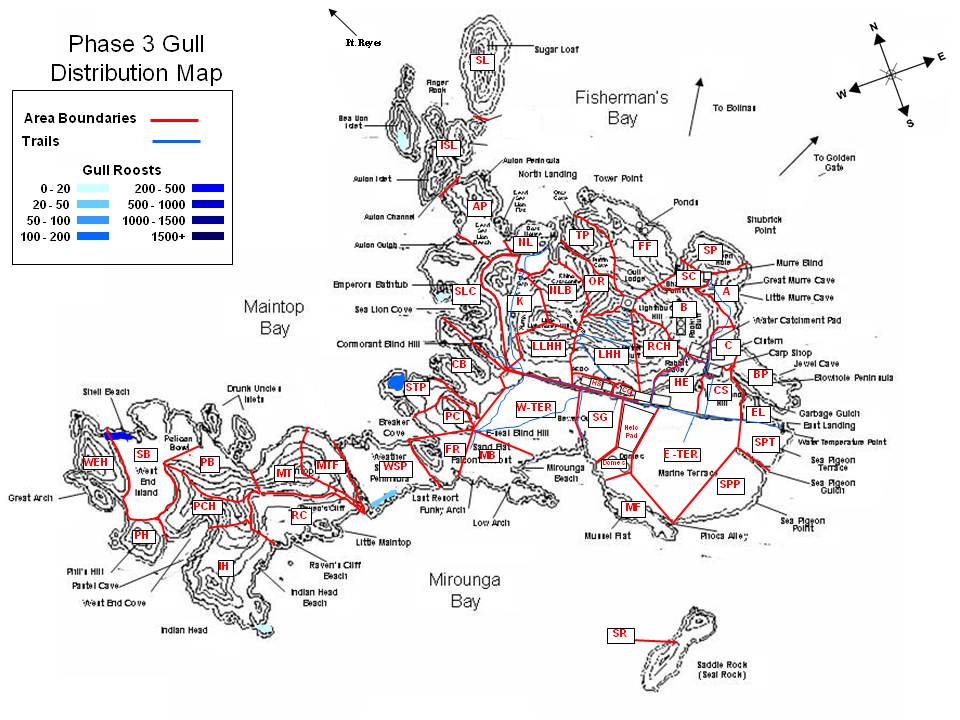
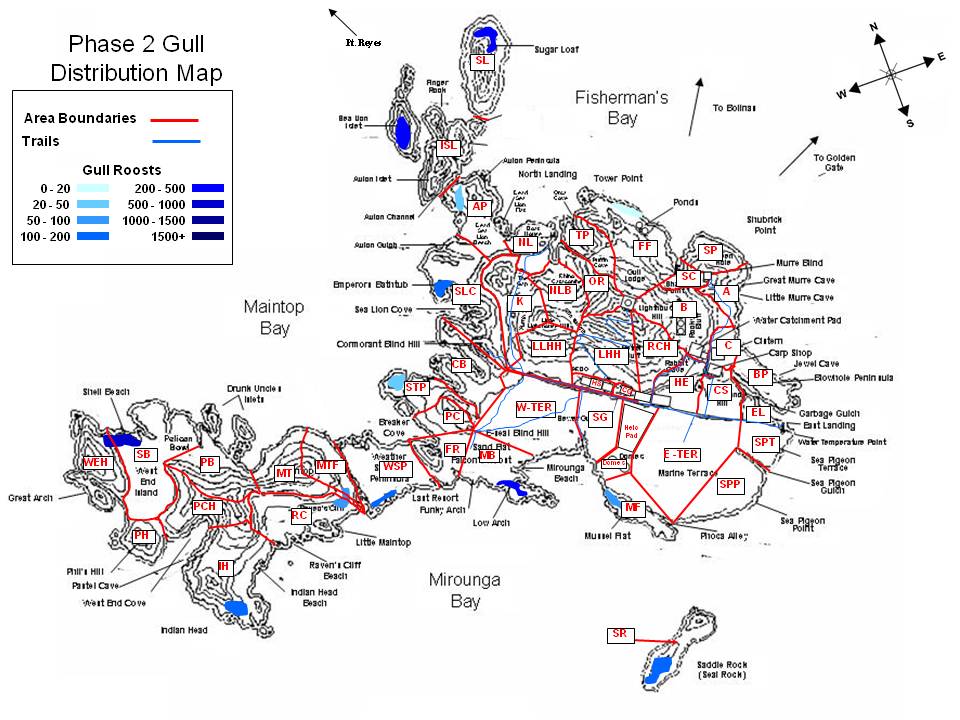


Fig. 8. Location of the main gull roosting sites prior to and during a gull hazing trial completed on the South Farallon Islands. Monitoring began on November 28, 2012.

Following the trial Western Gulls were slow to resume roosting on the South Farallon Islands and average weekly gull counts did not reach their pre-hazing trial level until approximately three weeks after hazing ceased (Fig. 6). In addition to overall reduced gull abundance, spatial changes in gull distribution were observed during the trial. In general, gulls were kept off of the marine terrace and other upland territorial areas throughout the trial period. The highest concentrations of gulls at the initiation of hazing activities (Phase 2) were on WE (primarily Shell Beach, Indian Head and Maintop), the Islets, Mussel Flat and Mirounga Beach. There were also large concentrations on Blowhole, Aulon, Weather Service and Study Point Peninsulas (Fig. 8).

**Bait consumption by gulls**

Although gulls were observed consuming non-toxic rodent bait in previous trials, no gulls were detected eating bait during the hazing trial. Due to the continuous hazing activity, gulls were never observed in the baited area and did not have access to rodent bait.

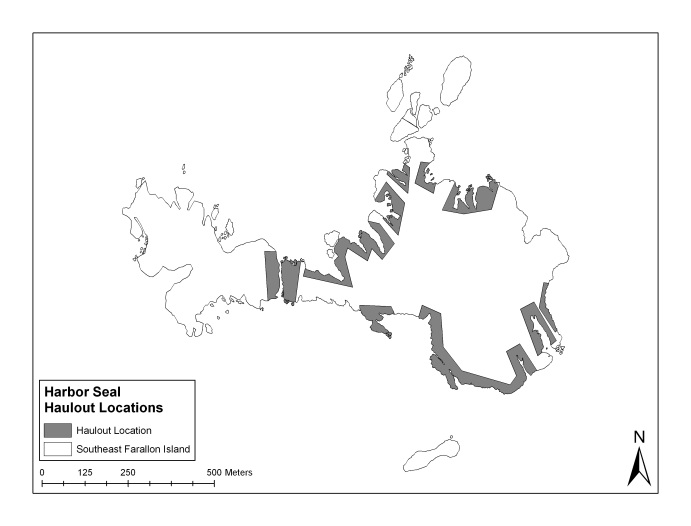
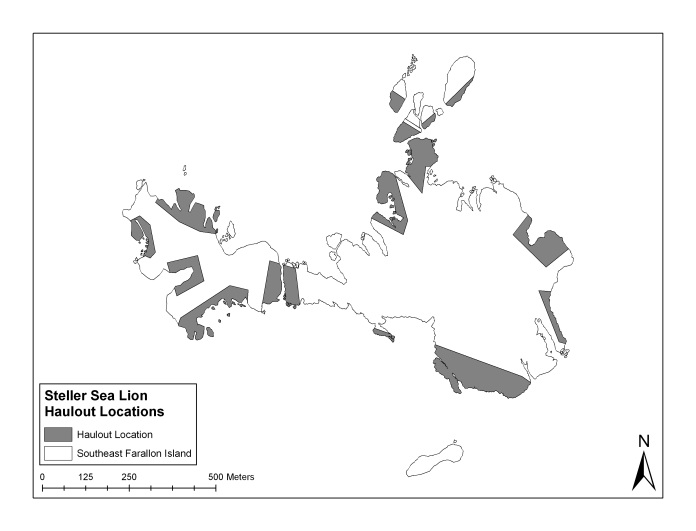
**Monitoring of impacts to non-target species**

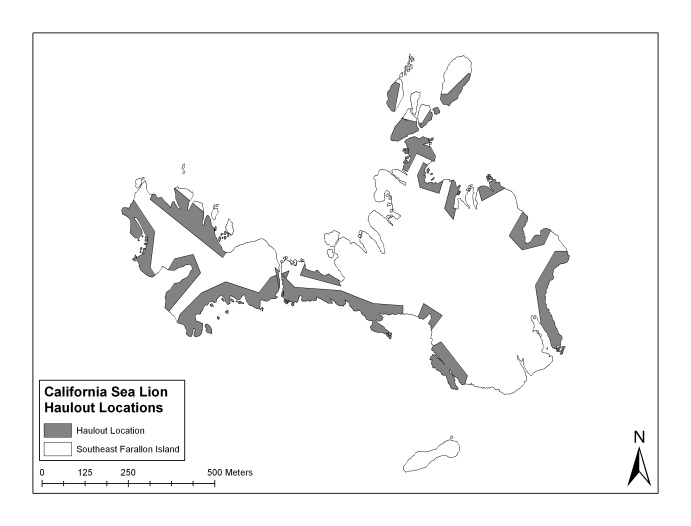
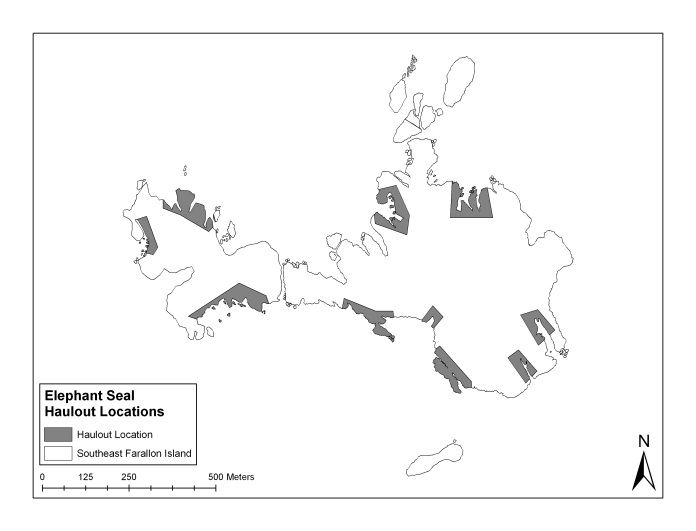
There was very little impact on non-target birds as a result of the hazing activity. The hazing trial was designed to be conducted during the time of year when the majority of seabirds are not present on the island. Overall numbers of non-target species were not determined as part of this trial. We simply noted the presence of and any disturbance to non-target species and made a general estimate of the number of birds affected. Common Murres only attended the colony on four days during the trial period and only small numbers of cormorants and pelicans were observed roosting on the island during the day. Of the 493 active hazing events during Phases 3 and 4 of the trial, only 37 caused disturbance to non-target birds (~7%). Of those, there were 22 which disturbed roosting cormorants, 10 events which disturbed Common Murre, six events which disturbed roosting Brown Pelican and six events which flushed shorebirds from intertidal roosts. For shorebirds, cormorants and pelicans the disturbance usually caused the birds to take flight and then return to their roosts. Murres on the other hand typically went to sea and did not return to roost on land again that day.

Similarly, the impact of gull hazing activities on overall pinniped abundance was minimal. Pre-trial counts for all species were statistically similar (two tailed tests - Northern Elephant Seal: *t* = 1.686, *p* = 0.106, *df* =22, Harbor Seal: *t* = 0.347, *p* = 0.732, *df*=22, California Sea Lion: *t* = 1.068, *p* = 0.297, *df*=22) or higher (Steller Sea Lion: *t*=3.751, *p*=0.001, *df*=22, Northern Fur Seal: *t* = 4.125 *p <* 0.001, *df*=22) to numbers observed during the same period in the previous five years (Figs 10 & 12). Fur seals in particular were present in greater numbers than the prior five year average owing to their recent and continuing rapid population growth.

Comparing one month of surveys pre and post *gull* hazing trial, three pinniped species showed no significant differences in numbers before and after the trial: Harbor Seals (*t* = 1.198, *p* = 0.270, *df*=7), Steller Sea Lions (*t* = 1.306, *p* = 0.233,*df*=7), and California Sea Lions (*t* = 1.096, *p* = 0.309, *df*=7) (Figs 11 & 12). The other two species showed significant declines: Northern Elephant Seals (*t* = 6.328, *p* < 0.001, *df*=7) and Northern Fur Seals (*t* = 3.721, *p* = 0.008, *df*=7) (Fig 11). However, these declines are consistent with regularly observed seasonal declines as juvenile elephant seals and most fur seals depart the island at this time. The post-trial numbers for both elephant and fur seals were not significantly different from their number during this period for the past five years (Northern Elephant Seals: *t* = 0.193, *p* = 0.849, *df*=24,Northern Fur Seal: *t* = 1.136, *p* = 0.267, *df*=24). Thus we conclude that there were no major impacts to pinniped abundance from the trial.

A map of pinniped haul-out areas on the Farallones Islands can be found below in Fig. 9. No major changes in the spatial distribution of pinnipeds were noted.





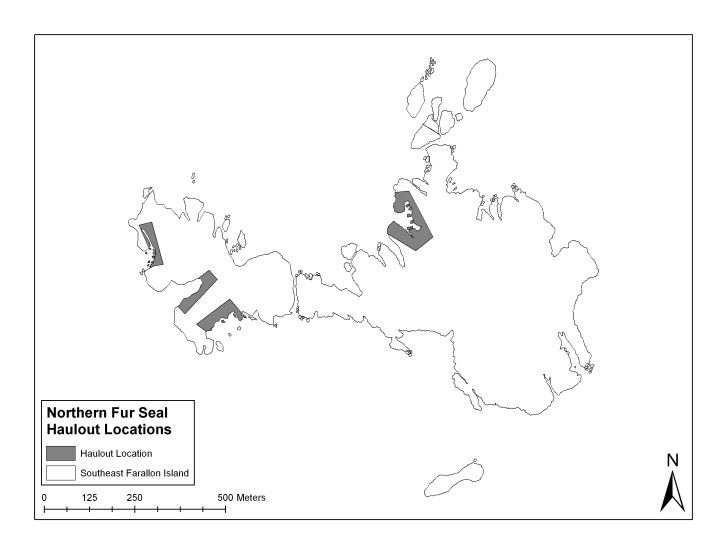


Fig. 9. Pinniped haul-out sites on the South Farallon Islands.



Fig. 10. Pretrial Farallon Pinniped numbers for November. Historic data (2007-2011) compared with pre-trial data from 2012. Mean monthly values with standard errors are plotted. Species shown are Northern Elephant Seal (Mir), Harbor Seal (Pho), Steller Sea Lion (Eum), and Northern Fur Seal (Cal)



Fig. 11. Post-trial Farallon Pinniped numbers for mid-December to mid-January. Historic data (2007-2011/2) compared with pre-trial data from 2012/2013. Mean monthly values with standard errors are plotted. Species shown are Northern Elephant Seal (Mir), Harbor Seal (Pho), Steller Sea Lion (Eum), and Northern Fur Seal (Cal)



Fig. 12. Pre and Post Trial Farallon California Sea Lion numbers. Historic data (2007-2011/2) compared with trial data from 2012/2013. Mean monthly values with standard errors are plotted.

Bioacoustic hazing methods showed little effects on pinniped behavior, with no responses of animals moving greater than >1m or flushing for elephant seals and harbor seals, and mean response for the other species for both behaviors at less than 3% of the time they were present in hazing target areas (Figs 13 and 14).



Fig. 13. Bioacoustic gull hazing tool effects on Farallon Pinnipeds in target areas (total n=103). Methods used include Bird Gard, Wailer, LRAD, and LRAD from Helicopter. Percentage of pinnipeds moved >1m and standard error shown, for treatments with animals present . Species are Northern Elephant Seal (Mir), Harbor Seal (Pho), Steller Sea Lion (Eum), California Sea Lion (Zal), and Northern Fur Seal (Cal)



Fig. 14. Bioacoustic gull hazing tool effects on Farallon Pinnipeds in target areas (total n=103). Methods used include Bird Gard, Wailer, LRAD, and LRAD from Helicopter. Percentage of pinnipeds flushed and standard error shown, for treatments with animals present . Species are Northern Elephant Seal (Mir), Harbor Seal (Pho), Steller Sea Lion (Eum), California Sea Lion (Zal), and Northern Fur Seal (Cal)

Pyrotechnic hazing methods elicited greater responses from marine mammals. However, Elephant seal and fur seal response was effectively nil. The localized nature and low numbers of fur seals in December prevented them from exposure to a lot of these techniques. California Sea Lions were the only species with over 10% mean response for movement >1m (Fig. 15). Harbor seal flushing rates were high, over 20% mean value (Fig. 16). This response was primarily driven by the loudest of the pyrotechnic devices, the CAPA rocket.



Fig. 15. Pyrotechnic gull hazing tool effects on Farallon Pinnipeds in target areas (total n=91). Methods used include screamers, bangers, and CAPA rockets. Percentage of pinnipeds moved > 1m and standard error shown, for treatments with animals present. Species are Northern Elephant Seal (Mir), Harbor Seal (Pho), Steller Sea Lion (Eum), California Sea Lion (Zal), and Northern Fur Seal (Cal)



Fig. 16. Pyrotechnic gull hazing tool effects on Farallon Pinnipeds in target areas (total n=91). Methods used include screamers, bangers, and CAPA rockets. Percentage of pinnipeds flushed and standard error shown for treatments with animals present. Species are Northern Elephant Seal (Mir), Harbor Seal (Pho), Steller Sea Lion (Eum), California Sea Lion (Zal), and Northern Fur Seal (Cal)

**DISCUSSION**

The hazing trial tested many different techniques and tools and at the same time demonstrated that it is possible to keep the majority of Western Gulls off the South Farallon Islands for an extended period of time. The trial also successfully prevented gulls accessing areas where rodent bait was available. Results from the trial provide a high degree of confidence that a well planned and executed hazing operation implemented during and after the application of rodent bait for mouse eradication could reduce gull mortality to minimal levels and well below levels that might affect current population trends.

Gull numbers were effectively reduced from an average of approximately 3,700 present on the island prior to the trial to none present for the majority of each day by the end of the hazing period. Individual gulls often moved from one roost location to another on the island and coordinated efforts were required to prevent birds from returning to roost after they had been initially hazed. Gull numbers on and around the island were greatest during the morning and evening periods when they would be observed flying in from the sea to roost and a near-constant effort was required to keep all birds off the islands.

In all we tested 19 different hazing tools and multiple combinations of these tools throughout the trial period. In general, tools that involved both sound and motion were more effective than stationary tools, with the exception of effigies. The least useful tools tested were mylar, balloons and kites. These were difficult to use in the high wind conditions prevalent, often broke down, and seemed to have little impact on gulls. Zons were effective at flushing gulls at relatively close ranges, but their use was hindered by the need to protect them from moisture and, when placed close to tidal flats, the need to minimize disturbance to pinnipeds. The most effective hazing methods were effigies, lasers, pyrotechnics, amplified biosonics and LRAD, helicopters and a combination of these same tools. Effigies were particularly effective at dissuading birds from roosting but were only effective over a relatively small area. Lasers were highly effective over long line-of-sight distances at dawn and dusk, before it became too bright to use them. They were successful at clearing roosting gulls and also discouraging them from landing. Lasers also had the added benefit of causing no disturbance to pinnipeds and less disturbance to other bird species. Biosonic devices which play predator and distress calls were successful in clearing large areas with relatively little effort and often little to no impact on pinnipeds. The biosonic devices could also be automated to produce a call at random varying intervals to keep an area gull free for extended periods.

The LRAD (Long Range Acoustic Device) offered the ability to directionally project sounds toward distant gull roosts while preventing disturbance to pinnipeds. This device was particularly effective when played from the helicopter attempting to haze difficult to access roost sites on offshore islets and other remote locations. Pyrotechnics were also effective at hazing birds in difficult to reach areas or driving off birds that had already been flushed into the air using another tool. The effectiveness of pyrotechnics depended greatly on the type of pyrotechnic chosen and the target distance. Screamers and CAPA (which cover a greater distance) typically had a greater effect than bangers or cracker shells. Pyrotechnics do have the drawback of causing a greater amount of pinniped disturbance, particularly to Harbor Seals.

The number of Western Gulls on the South Farallon Islands is variable, both seasonally and between years ([Ainley and Boekelheide 1990](#_ENREF_1)). Immediately prior to the trial, the gull population was intermediate in size relative to the same time of year in 2010 and 2011 and there were particularly low numbers present within breeding territories. The data suggest that there are significant inter-annual differences in the total number of gulls roosting on the island during the fall, but the 2012 population was well within the normal variation expected. Data from the previous two seasons also indicate that gull numbers typically increase between late November and early January as more birds return to roost on the island. It is clear from the count data that the hazing activity altered this pattern during 2012 and that overall gull numbers were significantly reduced during this period. Although we believe that the hazing methods tested here would continue to be effective even if the gull population was larger, it is likely that the effort required would be proportionately greater given a larger starting population.

By the end of the hazing trial, gulls were confined to just a few small isolated pockets in difficult to reach areas of the intertidal zone or on offshore islets. For mouse eradication rodent bait would not be applied to intertidal areas and wave washed rock stacks, thus the gulls roosting in many of these location would not be at risk. Gulls roosting in these areas did not appear to attract other gulls so allowing some roosting refugia may be an option during an eradication operation.

We did not have the opportunity to demonstrate the effect of hazing activities on territorial gulls because the trial began before gulls had established territories and no territories were established during the trial. However, hazing activity likely postponed the formation of territories and the same outcome is expected to occur if a hazing operation is implemented prior to and during a mouse eradication. Hazing activities associated with an eradication operation would likely commence in early November or earlier.

In general, the hazing trial caused minimal disturbance to non-target species. The timing of the trial (and the planned timing of the proposed eradication) ensured that all seabird populations were at their annual minimums. Other than gulls, the only bird species affected by the trial were Brandt’s Cormorants, Common Murres, Brown Pelicans, Black Oystercatcher and a handful of overwintering shorebirds. These species were sensitive to disturbance, and most hazing methods, effective on gulls, would also cause some disturbance to these species. As such, from a non-target disturbance perspective, it is desirable that any eradication of mice be conducted during the late fall/early winter.

The hazing trial also had a proportionately low impact on pinnipeds (seals and sea-lions) hauled out at the island. When disturbance was observed, the vast majority of them were animals alerting (i.e. rising up or looking around) and few resulted in animals abandoning their haul-out areas and flushing to the water. Responses of pinnipeds varied depending on the hazing tool employed and the species present. Generally speaking, pyrotechnics, helicopter activity and human approach were the most disruptive. Of the five species present on the island, Harbor Seals were the most sensitive to all hazing methods and the most likely to flush. Elephant seals, in contrast, exhibited almost no response to any of the hazing methods employed.

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**APPENDIX 1 Hazing Methods used in a 2012 Gull Hazing Trial on the South Farallon Islands.**

|  |  |  |
| --- | --- | --- |
| Description | Use | Location |
| *Human Movement* | | |
| Movement of people on foot across the island | Monitoring and setting up hazing equipment occasionally flushed gulls from roost sites | Various locations |
| *Effigies* | | |
| Effigies are models of animals or human forms (scarecrows) used with the intent of scaring birds. | Effigies consisting of dead Western Gulls (beach wrecked carcasses) were attached to 8ft poles by nylon fishing line. Approximately 15 effigies were used during Phase 3 of the trial. | Various locations at persistent gull roosts  (See Fig. 2) |
| *Mylar Tape* | | |
| Mylar is a reflective plastic ribbon colored on one side. It is often tied to poles or suspended from overhanging lines, where its motion in the wind creates a humming or crackling sound and it reflects sunlight. | Mylar tape was deployed at a few locations to discourage gulls from roosting. | Mussel Flat and Blowhole Peninsula (See Fig. 2) |
| *Kites* | | |
| Kites (traditional and inflatable) in the shape of predators or painted with predators can be used to deter birds. | Two types of kites were deployed, a standard kite (Kite) and a helium-filled balloon (balloon) (“eye in the sky”). Both kite designs aimed to mimic aerial predators to frighten and disperse birds. | These were flown or positioned as close to intertidal gull roost areas as possible, usually on the Marine Terrace or Aulon Peninsula. See Fig. 2. |
| *Lasers* | | |
| Lasers are concentrated light beams used in low lighting conditions to disperse or deter birds. | Three different lasers of varying power and intensity were used during the trial, a small 5mW green penlight, a red Avian Dissuader™ (Sea Technology, Inc., Albuquerque, NM), and a green Aries Phaser. Lasers were generally used in the early morning and the evening when light levels were low. Lasers were known to be less effective during daylight hours except at close range ([Pott and Grout 2012](#_ENREF_5)), so limited testing of this tool during the day was undertaken. On moonless nights, spotlights were sometimes used to estimate numbers of gulls prior to flushing them with a laser. | Lasers were used primarily from Lighthouse Hill and West End locations. See Fig. 2. |
| *Zon guns (Zons)* | | |
| Propane cannons, also called gas exploders, produce a loud, directional blast similar to that emitted by a 12-gauge shotgun. | Due to issues associated with moisture and sound levels, Zons were only occasionally used during the trial. Zons were triggered on command to flush gulls that were roosting or returning to roost areas. | Zons were established in three locations on the island See Fig. 2. |
| *Biosonics – Birdgard Units* | | |
| Biosonics, or bioacoustics, as a hazing method, involves using animal alarm or distress calls to alter the behavior of a target species. | Three different Birdgard biosonic units were tested, a small unit with four small speakers, a medium unit, and a larger Super Pro-Amp with amplified speakers on a tower. Each unit was pre-programmed with a combination of recorded gull distress calls and hawk, peregrine falcon, and eagle calls, and were triggered on command or randomly to flush gulls or deter them from returning. | Birdgard units were established at 19 locations.  See Fig. 2. |
| *Biosonics - Marine Wailer* | | |
| The Marine Wailer is designed to prevent birds from alighting on the water and typically used to discourage birds from landing on oil slicks. | The sound-emitting component of the Wailer was removed from its marine floats and played pre-recorded distress and predator calls. | The Wailer was positioned predominantly within the Marine Terrace area above Mussel Flat. (See Fig. 2) |
| *Biosonics - Long Range Acoustic Device* | | |
| A powerful but portable directional speaker which can be made to play pre-recorded sounds. | Predator and distress calls were played both from the ground and later from a helicopter, to flush gulls from roost sites and deter them from resettling. | Used at several locations across the island (see Fig. 2) and from the air. |
| *Pyrotechnics* | | |
| Pyrotechnics describe a wide variety of tools that can be used to haze birds. Pyrotechnics are primarily an auditory stimulus, creating a loud bang or report, but many charges also produce bright flashes, spiraling light, and smoke. | Pyrotechnics of varying types (Bangers, Screamers, Whistlers, Cracker Shells and Capa Rockets) were tested. Quieter or less disturbing charges were used first when near or close to pinnipeds, to minimize any unnecessary disturbance, to gauge the range of these devices and evaluate whether habituation by pinnipeds to their use was possible. Pyrotechnics were often used in conjunction with other hazing methods to disperse birds that were already in the air. | Various locations around the island |
| *Helicopter* | | |
| Helicopters present both an auditory and visual stimulus that can be used to flush roosting birds or dissuade them from landing. | A small Robinson 22 helicopter was used principally for monitoring the presence of gulls and pinnipeds on the islands, as well as to transport personnel and equipment to West End. It was also later used as a tool for hazing gulls in less accessible locations. |  |

|  |  |  |
| --- | --- | --- |
| **Method Combinations** | | |
| *Biosonics – Birdguard and Pyrotechnics* | | |
| Birdguard units were used in combination with pyrotechnics during Phase 3 of the trial. | |
| *Biosonics – LRAD and Pyrotechnics* | | |
|  | The LRAD unit was used in combination with pyrotechnics during Phase 3 of the trial. | |
| *Biosonics – LRAD and Helicopter* | | |
|  | The LRAD unit was used from the helicopter to haze gulls from less accessible locations during Phase 3 of the trial. | |
| *Laser and helicopter* | | |
|  | Lasers were used to flush roosting gulls from land. Helicopter hazing then followed to disperse gulls and dissuade them from landing again (Phase 3 only). | |
| *Pyrotechnics and helicopter* | | |
|  | Pyrotechnics were used to flush roosting gulls from land. Helicopter hazing then followed to disperse gulls and dissuade them from landing again (Phase 3 only). | |