2008

Rat Island Habitat Restoration Project: Operational Report

U.S. Fish and Wildlife Service

Alaska Maritime National Wildlife Refuge

July 31, 2009

Suggested citation: Buckelew, S., G. Howald, S. MacLean, V. Byrd, L. Daniel, S. Ebbert, and W. Meeks. 2009. Rat Island Habitat Restoration Project: Operational Report. Report to USFWS. Island Conservation, Santa Cruz, CA.

ACKNOWLEDGEMENTS

This report was prepared by Island Conservation for the U.S. Fish and Wildlife Service Alaska Maritime National Wildlife Refuge (AMNWR). The Rat Island Habitat Restoration Project was conducted in partnership by AMNWR, The Nature Conservancy, and Island Conservation.

We appreciate the time and effort taken by individuals to review and comment on drafts of this report, including: Vernon Byrd, Laurie Daniel, Steve Ebbert, Will Meeks of AMNWR; Steve MacLean of TNC; and Gregg Howald, Jacob Sheppard, and Jen Curl of Island Conservation.

We would like to express our deepest appreciation to project staff for their diligent work, support, and contributions. Without their involvement this project would not have been possible. Individuals from state and federal offices should also be commended for their support, especially during assessments of the project operations. Last, we thank the Department of Conservation, New Zealand Island Eradication Advisory Group (IEAG) for providing invaluable insight into the project.

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EXECUTIVE SUMMARY

Introduced non-native species are a leading cause of extinctions in island communities worldwide. Increasingly, land managers are removing introduced species to aid in the restoration of native ecosystems. Rats are responsible for 40-60% of all recorded bird and reptile extinctions worldwide since 1600 (King 1985). Given their widespread successful colonization on islands and the resulting impact to native species, introduced rats are identified as key species for eradication.

The Aleutians, including many of the islands in Alaska Maritime National Wildlife Refuge (AMNWR), provide habitat for 26 species of seabirds breeding in densities of up to 10 million. Norway rats (*Rattus norvegicus*) have been introduced to at least 10 islands in the Aleutian archipelago, and are known to have direct impacts to native species on these islands (Bailey 1993; Major and Jones 2005; Kurle et al. 2008). The Alaska Maritime National Wildlife Refuge partnered with The Nature Conservancy and Island Conservation during September-October 2008 to restore seabird breeding habitat on Rat Island, located in the Aleutian Islands, by eradicating introduced Norway rats.

To our knowledge, the Rat Island Habitat Restoration Project is one of the most remote and logistically complex rodent eradications attempted worldwide. The distance of the island to Anchorage (2,400 km [1,500 miles]), notoriously poor weather conditions, and lack of permanent infrastructure added considerable risks to successfully completing the project. However, meticulous planning and a period of excellent weather allowed the aerial broadcast of rodenticide bait to be completed in an unexpectedly short time period, and in accordance with all state and federal regulatory requirements.

Pilots for the baiting operations were contracted from New Zealand specifically for their expertise and experience in aerial eradication operations. The skill of the pilots together with favorable weather allowed for the high standard of performance achieved during this baiting operation. Light winds and clear skies enabled the pilots to focus completely on the precise application of bait, particularly around sensitive areas such as freshwater exclusion buffers, the coastal zones, and the areas near the Steller sea lion rookery and haul site. Bait was dispersed evenly and entirely across the island during two applications, without any deviations or shut-downs experienced due to poor weather. A deflector placed on the bait bucket was effective in ensuring no pellets entered the marine water, and teams of individuals applied bait by hand within aerial exclusion buffers to prevent direct application to freshwater. No major technical or logistical difficulties were experienced over the course of aerial baiting operations.

The Rat Island project was planned so as to minimize disturbance to marine mammals. Indeed, there was no discernable impact to marine mammal habitat. We expected that particularly Steller sea lions would be displaced from beaches where they were hauled out by noise from the helicopter, and "takes" of sea lions were authorized by the National Marine Fisheries Service under the Incidental Harassment Authorization (IHA) and monitored by biologists. Based on monitoring during all overflight operations, responses of animals to project operations fell within the range of normal behavior and incidental take under Level B harassment. Overall, the number of animals whose behavior was altered as a result of project operations was considerably lower than the number of takes authorized under the IHA. Few sea otters or harbor seals were encountered, but behavior changes of those seen were within expected responses (e.g., leaving beaches or changing directions while swimming).

Pre-eradication biological monitoring was conducted on Rat Island and nearby islands in 2007 and 2008 to collect baseline population indices, which, along with pre-existing data, will be compared to surveys conducted 1, 2, and 5 years post-eradication to assess ecosystem recovery. While the eradication was timed to avoid overlap with the critical breeding period of non-target species, individuals were still present on the island during the project window. No discernable impacts to bird species were detected by incidental observation during and immediately following the bait broadcast. Although no specific surveys were conducted, no birds were observed dead or

displayed behavioral symptoms of anti-coagulant poisoning. The final outcome of the project and any potential population-level changes associated with the rat-removal efforts will be assessed over the following 1-5 years. Surveys will be conducted on nearby islands in the Rat Islands group, as a reference for regional change in avian populations.

Over the course of baiting operations, rats were captured and examined to evaluate bait consumption, and beaches were searched for rat carcasses. Twenty-three rats were collected, all except one displayed symptoms of anti-coagulant poisoning (internal bleeding) or had bait pellets in the stomach or intestines. The efficacy of the eradication will be assessed during two years (2009, 2010) of careful monitoring. Ultimately, the project will be assessed by the ecosystem changes and improvement of native habitat. Finally, biosecurity measures will be undertaken by future visitors and vessels going to Rat Island, to reduce the likelihood of reinvasion.

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1. INTRODUCTION

Introduced non-native species are one of the top drivers of extinctions in island communities worldwide. Native island species are particularly susceptible to risks by introduced mammalian predators as they often lack evolved behavioral responses to predators, or have restricted habitats or population sizes (Moors and Atkinson 1985; World Conservation Monitoring Center 1992). Increasingly, the removal of non-native predators is being used as a tool to prevent the loss of island biodiversity and restore native ecosystems to their original state. Introduced rodents are among the most detrimental mammals to native island species (Moors and Atkinson 1985). Rats alone have been responsible for 40-60% of all recorded bird and reptile extinctions worldwide since 1600 (King 1985). Given their widespread successful colonization on islands and their resulting impact on native species, introduced rats are identified as key species for eradication.

The Aleutian Islands, most of which are part of Alaska Maritime National Wildlife Refuge (AMNWR or Refuge, hereafter), provide habitat for 26 breeding species of seabirds totaling more than 10 million birds (Byrd et al. 2005) that nest across more than 200 named islands (see Gibson and Byrd 2008) and hundreds of unnamed islets in the archipelago. The region is of global significance to seabirds. Islands in the Refuge, however, have not been spared from the devastating impacts of non-native species. Populations of ground nesting birds and other native island species have been depleted or, in some cases, entirely extirpated through predation by introduced species (Bailey 1993). Thus, the restoration of island ecosystems through the removal of invasive predators has been a long-standing priority of the Refuge (Ebbert and Byrd 2002).

For the past 50 years, island ecosystems throughout the Refuge have been partially restored by removing introduced foxes (*Alopex lagopus*), resulting in dramatic population increases for 15-20 bird species (Gibson and Byrd 2008) and the delisting of the endemic Aleutian cackling goose (*Branta hutchinsii leucopareia)*, formerly on the brink of extinction (Byrd 1989). Natural biodiversity, however, continues to be threatened by Norway rats (*Rattus norvegicus*) introduced to at least 10 large islands in the Aleutian Island archipelago. The diversity and numbers of breeding birds are conspicuously low on islands with an established population of introduced rats. On Kiska Island in the Aleutians, rats prey on least (*Aethia pusilla*) and crested auklets (*A. cristatella*), and food caches from rats near these auklet colonies have been found to contain auklet carcasses (Major and Jones 2005). This phenomenon is consistent with worldwide observations of the direct impacts of introduced rats to bird populations.

Removal of introduced rats from islands can allow for the recovery of impacted species, including seabirds (Towns et al. 2006). Worldwide more than 300 islands have been successfully cleared of rats, using an application of rodenticide bait to every potential rat territory on an island (Howald et al. 2007). Bait was typically delivered during the time of year when rats were relatively food deprived based on seasonal declines in food resources. Aerial broadcast of pelletized bait across an entire island in one or more applications is becoming the most common method of rodenticide delivery on large islands. Aerially broadcasting bait is operationally preferable to other eradication methods, such as bait stations, when the terrain is steep or rugged, the island is large in size, and/or regular foot traffic would cause ecosystem damage through trampling of sensitive areas.

The Alaska Maritime National Wildlife Refuge has collaborated with Island Conservation and The Nature Conservancy to restore 2,900 ha (7,100 acres) of seabird breeding habitat on Rat Island and an offshore islet by removing introduced rats (Figure 1). Norway rats are thought to have been introduced to the island in the 1780's when a Japanese ship went aground (Black 1983). Over the past two centuries, rats have caused serious ecological damage by depleting breeding seabird and landbird populations, and altering island plant and intertidal communities. Rat Island was considered to be an ideal candidate for an initial rat eradication in the Aleutians since it is among the smallest of rat-infested islands (>10 ha in size), and has a low risk of reinvasion, due to being both remote and void of human habitation.

Here we report on the campaign to restore native habitat on Rat Island by eradicating rats during September-October 2008. The specifics of the project, including details pertaining to treatment area and aerial broadcast operations, are provided. The efficacy of the eradication will be determined via careful monitoring in 2009 and 2010. The expected success of this project should significantly improve habitat for native wildlife, particularly burrow nesting seabirds which breed on rat-free islets offshore at Rat Island. This project is an important step towards restoring habitat on Rat Island, and potentially on other rat-infested islands of distinct ecological importance in the Aleutian archipelago

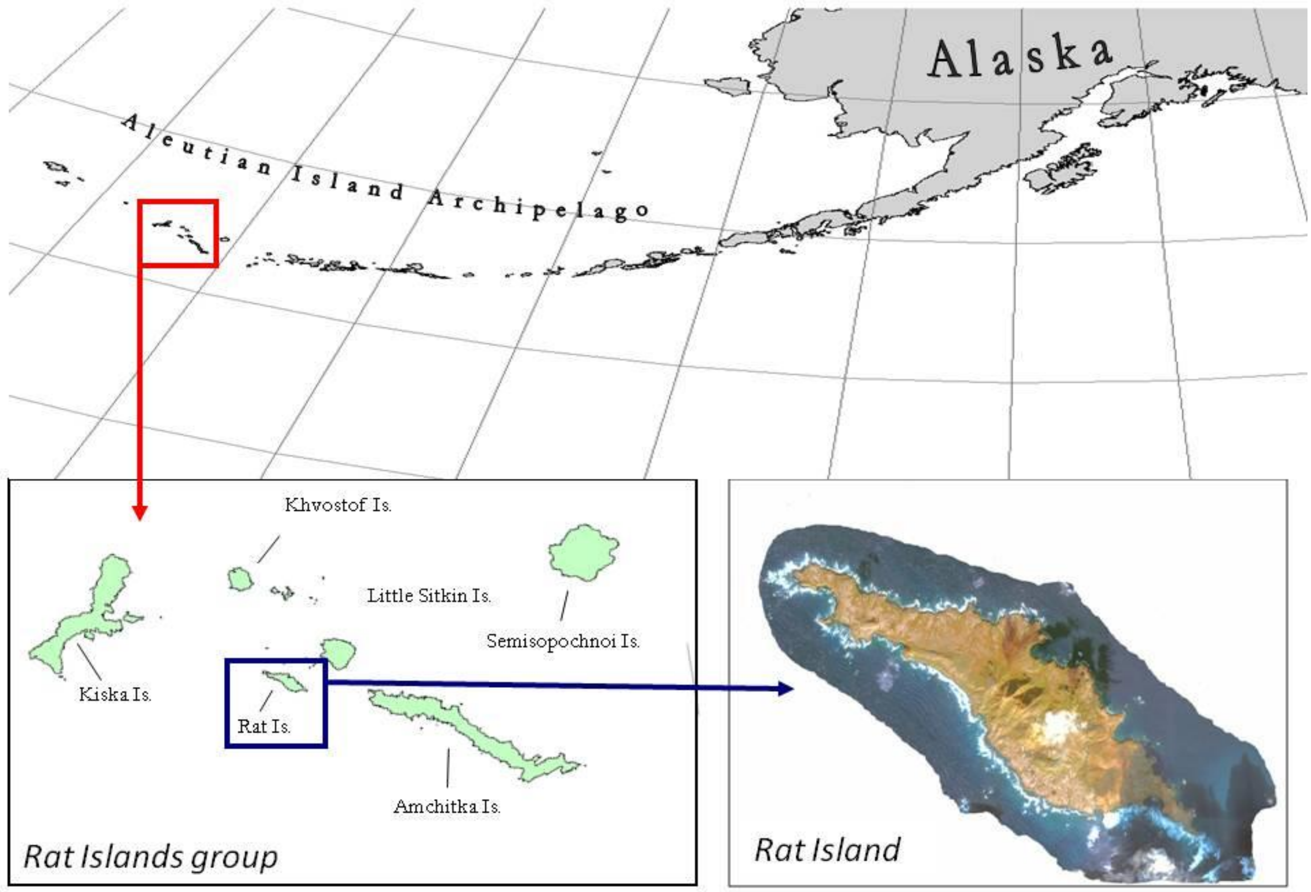

Figure 1. The location of Rat Island and the islet off Ayugadak Point in the Aleutians Island unit of the Alaska Maritime National Wildlife Refuge.

2. TREATMENT AREA

2.1 Physical description

Rat Island is located within the AMNWR in the central Aleutian Islands of Alaska. Rat Island is 2,900 ha (7,100 acres) in size and is located at 51° 80' North, 178° 30' East, approximately 2,400 km (1,500 miles) southwest of Anchorage, Alaska. The island is volcanic in origin, with the majority of the coastline composed of steep, vegetated, 50 m (160 ft) high cliffs and slopes. The interior of the island slopes up to form rolling plateaus rising to a small range of mountains with a peak elevation of 400 m (1,100 ft). Along the coastline and directly offshore are numerous (>30) offshore rock stacks. There are several offshore islets, the largest of which is located <1 km (approximately 0.5 mi.) off Ayugadak Point on the southeast end of Rat Island and is approximately 4 ha (10 acres) in size. This islet off Ayugadak Point supports a rookery and haul site of the federally endangered Steller sea lion (*Eumatopias jubatus*).

Rat Island is managed by the U.S. Fish and Wildlife Service (FWS), and designated as part of the Alaska Maritime National Wildlife Refuge. FWS is a bureau within the Department of the Interior, with a specific mission to work with others, to conserve, protect and enhance fish, wildlife, plants and their habitats for the continuing benefit of the American people. FWS manages more than 520 National Wildlife Refuges within North America. Additionally on Rat Island there are lands that have been claimed by the Aleut Corporation under the Alaska Native Land Claims Settlement Act (ANSCA) and are eligible for conveyance.

2.1.1 Soil type and characteristics

The predominant soil type in the Rat Island region has volcanic origin (andisol), and composed mostly of agglomerate and ash (Maakestad and Ranft 2005). However, years of vegetative organic matter have added a nutritive richness to the soil under grassland areas, in which case the soil profile has constituents of nutritive mollisol (young, underdeveloped soils). Higher elevations on Rat Island often show bare rock and basaltic rubble. The high slopes on Rat Island support well-drained volcanic-ash soils, while the middle and low slopes support a thick vegetated mat on top of well-drained loamy soil. Valley bottom soils are well to poorly drained loams with local areas of poorly drained peat.

2.1.2 Freshwater bodies

The freshwater bodies on Rat Island can be broken roughly into two categories, streams and lakes. The "stream" category consists of all moving water bodies on the island, whether or not they are continuous or run all the way to the ocean. The "lake" category consists of all standing bodies of fresh water on the island, regardless of depth. On Rat Island, the lakes occur almost entirely in clusters, scattered primarily across the rolling upland plateau (Figure 2; Buckelew et al. 2007b). The largest lakes are <200 m (<656 ft) across. The majority of lakes do not have associated wet meadows, and those that do have only very

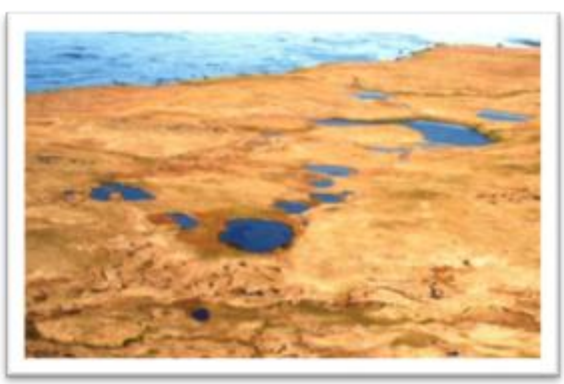

Figure 2. Standing bodies of freshwater occurring as lakes clusters on Rat Island.

narrow bands of meadow habitat. The two largest streams on Rat Island flow into Gunner's Cove, on the northern side of the island. The streams are on average less than 2 m (6.6 ft) wide. Numerous runoff drainages are intermittent, being active during spring melt and heavy rains, but most do not contain water throughout the year.

2.1.3 Climate

The Aleutian climate is marine-influenced and is characterized by generally overcast skies and frequent, often-severe, storm events driven by low-pressure systems and high winds (Rodionov et al. 2005). The average air temperature is cool with summer temperatures averaging 9° C (48° F) and winter temperatures averaging 1° C (34° F). Although temperatures seldom reach below -12° C (10°F) the effect of wind chill can be severe. Precipitation events occur frequently throughout the year with snow, often slushy, falling during the colder months. Snow accumulations are highly variable among years, but blowing snow causing "white-out" conditions occurs periodically from November through February and sometimes into March. Daily wind speeds average around 13 knots with frequent gusty winds occurring year-round, but most particularly during the fall and early winter seasons. Mist and low clouds are common around the localized higher peaks during the day, with sea fog often blanketing the island and large regions between islands (retrieved from NOAA National Buoy Data Center, UAF Geophysical Institute).

2.1.4 Cultural and historic resources

Rat Island is uninhabited and there is no infrastructure on the island other than occasional and temporary field camps installed during the summer time. There are four sites which have been certified by the Bureau of Indian Affairs (BIA) as cemetery and historical sites eligible for conveyance to The Aleut Corporation under section 14(h)(1) of ANCSA. These areas have been selected by The Aleut Corporation under that entitlement, but have not yet been conveyed.

2.2 Biological description

2.2.1 Terrestrial vegetation

Terrestrial plant communities in the Aleutians are classified as "maritime tundra" (Amundsen 1977) or "oceanic boreal heath" (Talbot et al. 1999). Aleutian vegetation lacks trees, instead being characterized by <2 m tall plant communities dominated by grasses, forbs, and dwarf shrubs. Rat Island is dominated by short grasses (e.g., *Calamagrostis nutkaensis*), sedges (e.g., *Carex macrochaeta, C. pluriflora*), dwarf shrubs (e.g., *Empetrum nigrum*) and non-vascular plants (e.g., *Cladina spp., Cladonia spp.*). Tall-plant communities, which are fairly extensive on islands in the Aleutians dense with breeding birds (e.g., Byrd 1984; Croll et al. 2005), are uncommon on Rat Island (Byrd 1989).

2.2.2 Animal species

Non-native species: Arctic fox were stocked on Rat Island, but were removed in 1984 allowing for the initial phase of native habitat restoration (Hanson and Goos 1984). Norway rats are the only remaining non-native mammal on the island, and their presence has long been a significant obstacle to full native habitat restoration.

Birds: Rat Island is inhabited by a diversity of birds, including waterfowl, birds of prey, shorebirds, seabirds, and landbirds. Only two species listed as threatened or endangered under the US Endangered Species Act (ESA) (Short-tailed albatross (*Phoebastria albatrus*) and Steller eider (*Polysticta stelleri)*) occur in the central Aleutian Islands, but neither has been recorded at Rat Island. Due to the likely impact of rats, there appears to be an absence of burrow-nesting seabirds and crevice-nesting species are rare on Rat Island. Also scarce is the Giant song sparrow (*Melospiza melodia maxima*), endemic to the central and western Aleutian Islands (Gibson and Byrd 2008). Appendix 2 provides a complete list of species known to occur on Rat Island and its nearshore waters from incidental observation made primarily during short visits in summer (June-August). Few prior observations have been made in fall (September-October), therefore we predicted what to expect at the time of the eradication operation based on observations from elsewhere in the central Aleutians (Gibson and Byrd 2008), which indicated that by late September and October breeding would be finished and the majority of migrants also would have finished passing through the region.

Marine mammals: Three species of marine mammals inhabit Rat Island and the nearshore waters: harbor seals (*Phoca vitulina*), sea otters (*Enhydra lutris kenyoni*), and Steller sea lion. Harbor seals are known to haul-out primarily on offshore rocks. Sea otters principally inhabit nearhsore kelp beds within 2 km (1.2 mi) of land, and may occasionally haul-out on offshore rocks or beaches on the island. There is a persistent haul-out site for Steller sea lions at Krysi Point, on the western tip of Rat Island, and a rookery and haul site on the islet 1 km (0.6 mi) offshore Ayugadak Point, on the eastern tip of the island.

Steller sea lions, harbor seals, and sea otters are protected by the Marine Mammal Protection Act (MMPA). The sea otter is further listed as threatened throughout southwest Alaska, including the Aleutians, and the Steller sea lion is listed as endangered under the Endangered Species Act in the western part of its range, including the Aleutian Islands.

Other aquatic species: The coastline surrounding Rat Island is characterized by rocky intertidal benches giving way to rocky coves and sandy beaches. The intertidal zones are abundant with marine invertebrates (mussels, sea stars, sea anemones, herbivorous snails, limpets, barnacles, and tunicates) have a relative abundance of fleshy algae. Stickleback fish (*Gasterosteus aculeatus*) are known to inhabit the island's freshwater bodies. There is evidence that anadromous fish, namely Dolly varden (*Salvelinus malma*), inhabit a small number of coastal streams on the island.

3. Regulatory Compliance

Full authorization for Rat Island Habitat Restoration Project activities was given by federal and state agencies in the form of permits or formal statements of consent, under appropriate Federal laws, regulations, guidelines, and Presidential Executive Orders pertaining to the project action. The project and regulatory framework is fully described in the Environmental Assessment and subsequent Finding of No Significant Impact, both on the Alaska Maritime National Wildlife Refuge website at: http://alaskamaritime.fws.gov/news_room.htm.

4. Methods

Following is a time table summarizing major operational activities for the Rat Island Habitat Restoration Project:

	Sept																			Oct											
Project activity	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	1	2	3	4	5	6	7	8	9	10	11	12
Vessel load	X	X	X	X	X	X	X																								
Travel to Rat Is								X	X	X	X	X	X	X	X																
Initial vessel offload															X	X	X														
1st bait broadcast																		X	X												
Manual broadcast																				X	X										
2nd bait broadcast																					X		X	X							
Project demobilization																									X						
Travel to Homer																									X	X	X	X	X	X	X

4.1 Aerial bait broadcast

Two independent applications of rodenticide-laden bait pellets were broadcast over the entire island (2,800 ha [6,916 acre] planar area; 2,900 ha [7,163 acre] surface area) from spreader buckets slung beneath Bell 206 Long Ranger helicopters (Pathfinder Aviation, Inc. based in Homer, Alaska). To prevent bait broadcast into marine and fresh water habitats, alternate techniques resulting in precise bait placement were made in these environments (Sec. 4.4 Alternate Baiting Areas).

Eradication success, in part, entails providing every individual rat on an island sufficient access to a lethal quantity of rodenticide. Therefore, bait application occurred by flying low-altitude parallel swaths over the entire land area and adjacent vegetated islets, with caution taken to prevent bait spread into marine and fresh water. To prevent uneven coverage or gaps in application subsequent flight swaths overlapped the previous swaths by 50%.

Helicopter instruments guided the application to promote even bait coverage across the island. Specifically, onboard differential global positioning systems (TracMap Ag Aviation GPS unit, TracMap NZ Ltd, Mosgiel, New Zealand) with differential correction by C-NAV SF-2110 StarFire receivers (NavCom Technology, Torrance, CA) were used to guide pilots along flight lines (Figure 3). This information was monitored by GIS specialists for application uniformity, and potential gaps or unanticipated overlaps in application coverage (Figure 4). Using this technology, adjustments to application rates and baiting strategy could be made as necessary to ensure the target application rate was achieved.

Figure 3. Onboard TracMap GPS used by helicopter pilots to monitor and guide aerial bait broadcast.

4.1.1 Bait

The bait used in the operation was a cereal grain compressed into 2 g (0.1 ounce) pellets, containing the rodenticide brodifacoum at a concentration of 0.0025% (Brodifacoum-25W Conservation, registered by the U.S. Department of Agriculture National Wildlife Research Center (NWRC), Fort Collins, CO and manufactured by Bell Laboratories, Madison, WI) (Figure 5). The rodenticide is registered for use with the Environmental Protection Agency (EPA) in compliance with the Federal Insecticide, Fungicide and Rodenticide Act for conservation-use purposes (EPA Registration # 56228-36), and additionally approved by the Alaska Department of Environmental Conservation (ADEC) Pesticide Control Program for use in the state.

Figure 4. GIS specialist monitoring bait application flight lines on Rat Island.

Through the Department of Agriculture Pocatello, ID Supply Depot, 46 metric tons (51 tons) of Brodifacoum-25W Conservation bait was acquired from Bell Labs for conservation use on Rat Island. Quality certification analysis was provided by Bell Labs as proof of optimum bait quality standard. Samples were collected from every batch produced (2 ton batch size) and analyzed for brodifacoum concentration and moisture content. Moisture content was used as a proxy for deterioration or mold growth (Table 1). Bait samples were also collected from each batch processed and sent to the NWRC for additional quality screening. Batch samples were analyzed at NWRC directly following manufacture and again 45 days post- manufacture for quality persistence testing.

Results of the analyses suggested that the bait was manufactured to specifications. In terms of moisture, while there has been little research to determine moisture thresholds for mold growth, anecdotal evidence from Bell Labs suggests that moisture content between 10- 11.9% is sufficient to maintain bait palatability and shelf life up to 7 months. The moisture content at manufacture and two weeks post-manufacture was within the acceptable range. Seven weeks post-manufacture, moisture content had decreased, suggesting that no moisture had accumulated in the baits.

Figure 5. Brodifacoum 25W Conservation bait pellet applied on Rat Island, with crowberry (*Empetrum nigrum*) shown for scale.

Table 1. Results of quality analysis for Brodifacoum-25W Conservation bait.

Analysis date	Analyst	Brodifacoum conc. (ppm)	Moisture content (%)
7/3/2008	Bell Laboratories	28.0 ± 1.8	11.4 ± 0.3
7/17/2008	National Wildlife Research Center	24.1 ± 2.2	11.8 ± 0.7
8/28/2008	National Wildlife Research Center	-	10.8 ± 1.1

4.1.2 Bait storage

To account for potentially prolonged periods of adverse weather on Rat Island, the project was planned to continue for up to 45 days, if needed, to complete the baiting operations. Bait storage over 45 days was a concern since there is no permanent infrastructure on the island for protection against the weather. Therefore, bait was stored in ADEC-approved bait storage vehicles. Bait quality storage vehicles (henceforth referred to as BSVs) are a sealable, external-quality wooden container mounted on a frame.

Figure 6. Signs posted for pesticide storage inside BSVs, and reference of bait manufacture batch.

BSVs were manufactured from five-sheet external grade plywood and were approximately 0.96 m^3 (33.5 ft^3). BSVs were mounted on a custom-built wooden pallet for ease of transportation, and to prevent them from sinking into the vegetation while stored on the island. BSVs each contained sixteen 23 kg (50 lb) sacks of rodenticide bait. The total weight of loaded BSVs (including materials) was 448 kg (985 lb). BSVs were designed to be lifted independently by helicopter from the ship (on which they were transported) to the shore (where they were stored) using straps or a sling device (Figures 7-9).

Figure 7. Bait stored in BSVs at the bait loading zone.

Bait stored in 50 lb bags was loaded into BSVs at the manufacturer's warehouse. Bait bags were sealed inside the BSVs by screwing each lid shut. BSVs were then loaded into freight containers at the warehouse for shipment from Wisconsin to Homer, Alaska, where they were stored for 30 days prior to departure for Rat Island. The BSVs were not opened and the bait not accessed until application on the island. A warning notice was posted on the outside of each individual BSV per regulation (Figure 6).

Figure 8. Helicopter slingloading BSV from aft deck of the M/V *Reliance.*

Figure 9. Field team members offloading BSVs at bait loading zone.

4.2 Spreader Buckets

Three stainless-steel fertilizer spreader buckets, manufactured by Helicopters Otago, Mosgiel, New Zealand, were brought to Rat Island (Figure 10). The spreader buckets each weigh 128 kg (282 lb) with capacity of carrying 330 kg (725 lb) of bait, which is equivalent to fourteen 50 lb bags of bait. These agricultural spreader buckets broadcast bait by means of a pellet agitator coupled with a mechanized spinner. The gate to the spinner is activated using a pressurized air ram, and the application rate is regulated, in part, by adjusting the diameter of the gate opening.

Figure 10. Helicopter spreader buckets used for aerial broadcast of bait pellets.

Prior to departure for Rat Island, the buckets were calibrated and tested for general function on two different occasions. The buckets were first calibrated at Aspen Helicopters, Oxnard, CA on January 3, 2008 after importation to the United States and no defects identified. Bait buckets were again calibrated on August 7 and 8, 2008 with Pathfinder Aviation in Homer, Alaska. Pilots performing the calibration were the same pilots conducting the bait application on the island. Equipment was calibrated to achieve the target application rate for Rat Island using a non-toxic replica of the Brodifacoum-25W Conservation bait. Again, no defects or failure of the equipment occurred.

To prevent bait application into marine and freshwater a directional deflector was placed on the bucket to restrict bait broadcast to the landward side of the bucket. The deflector equipment was calibrated on September 10 and 12, 2008 at the Homer, Alaska airport by one of the same pilots performing the bait application on Rat Island. Slight modifications to the positioning of the deflector were made to optimize the precision of bait application.

During the bait application spreader buckets were manually loaded by ground teams. Prior to departure from Rat Island all ground teams were trained in basic aviation safety and external load operations by the Department of the Interior Aviation Management Directorate (AMD). Under the direction of AMD aviation safety officers, teams rehearsed the manual reload of spreader buckets with the same pilots responsible for aerial bait application on the island.

4.3 Aerial Treatment

4.3.1 Dates

The field team and helicopters arrived to Rat Island on September 26, 2008 (see Appendix 3 for list of field participants). After setting up camp and the helicopter loading zone the baiting operations for the Rat Island Habitat Restoration Project commenced on September 29. Bait was applied aerially in two concerted applications, which took 5 days to complete over a 7 day period (Table 2). Baiting was finalized on October 5, the field team and helicopters departed the island on October 6.

4.3.2 Methods

Figure11. Aerial application of bait pellets from a spreader bucket slung beneath a helicopter.

Forty-six metric tons (51 tons) of Brodifacoum-25W Conservation bait was broadcast from a helicopter over the entire land area on Rat Island (2,900 ha [7,100 acres]) in two applications at a nominal rate of 8.0 kg/ha (7.1 lb/acre) per application. Specifically, the application occurred by flying low-altitude (50 m [165 ft]) parallel swaths over the entire land area and adjacent vegetated islets, with the exception of marine and fresh water areas (Figure 11). A flight swath was defined by the uniform distance which bait was broadcast from the spreader bucket, in this case 70 m (230 ft). To reduce the potential for insufficient coverage or gaps in application, subsequent flight swaths overlapped the previous swaths by 50% (35 m [115 ft]) (Appendix 4).

The pilots conducting the aerial baiting operations on Rat Island were contracted from New Zealand specifically for their extensive expertise and demonstrated skill in eradication flying. Both pilots obtained an O-1 U.S. immigration visa based on "extraordinary ability" in their field. Combined, Peter Garden and Graeme Gale have over 45 years in eradication helicopter piloting, and have participated in numerous rodent eradication projects around the globe, in addition to routine pest control operations in New Zealand. The pilots had a combination of eradication-specific abilities and flight experience in adverse climatic conditions, which enabled a safe operation with precise bait application across the island. New Zealand pilots also trained local Pathfinder Aviation pilots in effort to develop capacity within the United States for eradication bucket and GPS work. Independent of the project operations, Pathfinder pilots received eradication training and instruction from the New Zealand pilots, both in New Zealand and during calibration flights in Alaska. During the aerial baiting operations, however, Pathfinder pilots worked as ground crew.

Figure 12. Spreader bucket being refilled by bait loading team.

To maintain quality control of baiting operations the island was partitioned into three baiting blocks (Figure 15). Block boundaries were divided by topographical features and were a size that could realistically be baited in a single day. Optimally, bait application would have occurred sequentially in an east-west direction across the island to keep the baiting front to a minimum, and reduce the likelihood of rats reinvading an area previously treated. However, accounting for the risk of not completing entire coverage across the island due to poor weather conditions, first priority for baiting was given to the mountainous block of the island. On any other aerial baiting day, the low elevation blocks (East and West blocks) were treated. Table

2 shows the schedule of baiting operations and Table 3 shows time estimates of bait application.

Figure 13. Two bait loaders reloading bait into spreader bucket, with two others collecting empty bait bags.

The first application commenced on September 29, 2008 and was completed on September 30, with the exception of treating the freshwater areas and Steller sea lion rookery off Ayugadak Point (refer to Sec 4.4 Alternative Baiting Areas). Treatment to fresh water areas began on October 1 and was completed on October 2. Treatment to the sea lion islet occurred on October 2.

The second application began 5 days after the initiation of the first application on the East and West blocks and the lower elevation of the Mountains block. The second application was initiated 3 days after the first application on the higher elevation areas of the Mountains block to take advantage of the clear skies and calm weather that were present. Weather was considered to be the single biggest risk of failure for the Rat Island Habitat Restoration Project. Therefore, all suitable weather and daylight hours were prioritized towards applying bait to the mountainous region to reduce the chance of failing to uniformly apply bait to the entire island in a 45 day period due to unsuitable flying conditions.

Both helicopters applied bait simultaneously in the same baiting block, with each pilot focusing on applying bait to assigned flight lines. Flight lines ran generally parallel to the coast, from west to east. The orientation of the flight lines during the second application was offset by approximately 10 degrees from the first application. While deviations to the baiting strategy were planned due to potential periods of prolonged bad weather, there was no need to alter the strategy as the baiting operations took place over 7 days of highly favorable weather.

Bait buckets were loaded manually by a four-person bait loading team. Two team members were responsible for tipping the 50-lb bags of bait into the bait hopper, while the other two were responsible for collecting and securing empty bait bags (Figures 12-14). All bait loaders were State of Alaska Department of Environmental Conservation (DEC) Certified Pesticide Applicators, and A-219 External Load certified under the Dept of the Interior AMD.

Figure 14. Bait loading platform for refilling of spreader bucket.

Table 2. Schedule of bait broadcast on Rat Island during the first and second applications and in areas of alternative baiting.

	Bait Block East	Mountains	West
First application	9/29/2008	9/29/2008	9/30/2008
Second application	10/4/2008	10/2/2008	10/5/2008

Alternative baiting areas	**Treatment type**	**Date**
Lake Systems 1,4,5,6, 9	hand broadcast	10/1/2008
Lake Systems 2,4,6,8,9,10	hand broadcast	10/2/2008
"Ayugadak" islet	aerial broadcast	10/2/2008

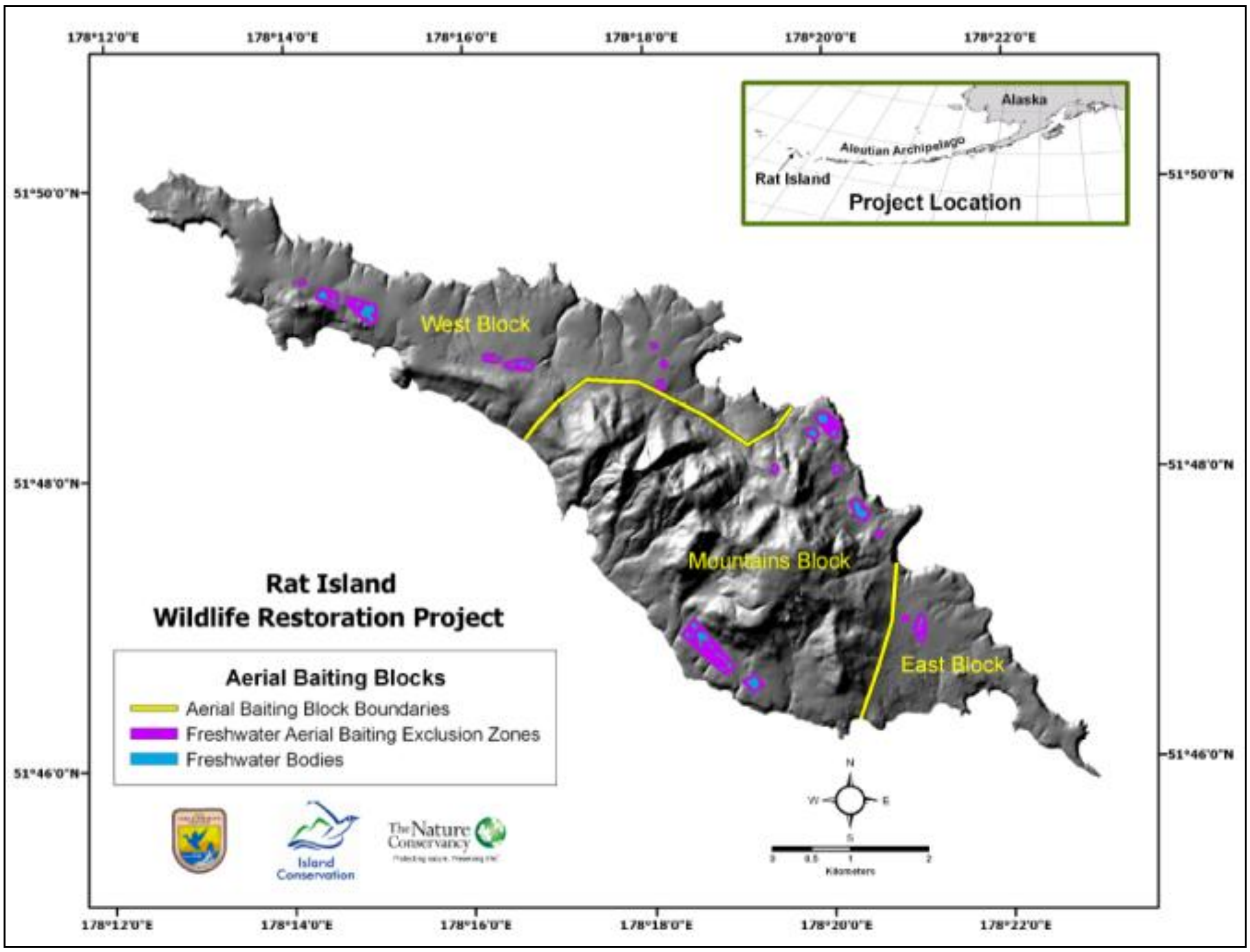

Figure 15. The three blocks used to partition aerial baiting operations on Rat Island.

Table 3. Time to complete first and second bait broadcasts across general island habitats (inland and coast).

Island habitat	Time to complete (HH:MM)	Metric tons/hour
First application		
Inland	18:47	0.8
Coast	6:35	0.5
Total	**25:04**	**0.7**
Second application		
Inland	17:04	1.1
Coast	6:32	0.5
Total	**23:36**	**0.9**
Grand total	**48:40**	**0.8**

4.3.2 Weather

Fall weather conditions in the Aleutian Islands are typically characterized by overcast skies with high winds caused by low-pressure systems cycling every 3-5 days. These low-pressure systems are generally followed by 3-5 days of light winds, with mist and low clouds common around the higher peaks. The low clouds and fog were of particular concern during the planning for operations on Rat Island since they can reduce pilot visibility and conditions for safe, effective flying. Therefore, in order to reduce the probability of eradication failure from incomplete application, the baiting plan prioritized treating the mountain tops on days when visibility and conditions were favorable.

Figure 16. Helicopter broadcasting bait over the mountain block on Rat Island.

The weather during the baiting operations, however, was different than anticipated and highly favorable overall. During transit to and from Rat Island low pressure systems brought strong winds, low clouds, and heavy seas. However, during baiting operations these low pressure systems were intermittent with 8 days of light winds and clear skies. On the third day following the first application on the mountain tops, weather conditions were calm with light winds and good visibility. Weather forecasts indicated a low pressure (storm) system building to the northwest of Rat Island, predicted to arrive at the island in 3-5 days. Therefore the second application occurred on the higher elevation areas of the Mountain block to maximize the good weather opportunity (Figure 16).

These favorable weather conditions with little to no winds benefited the baiting operation by allowing for precise and accurate bait application. Because weather conditions did not restrict bait application on any given day over the course of the project, the operations were completed ahead of schedule. A weather log from baiting operations on Rat Island is shown in Table 4.

Table 4. Log of daily weather conditions during bait application operations.

Date	Time	Wind dir	Wind Sp (kt)	% Cloud cover	Precipitation	Notes
9/29/2008	900	W	25	57-75	0	start bait application
9/29/2008	1640	w	25	57-75	light rain showers	
9/29/2008	1755	W	25	57-75	0	
9/30/2008	930	SW	20	76-100	0	10+ mi horizontal visibility, no clouds on mts
9/30/2008	1200	W	15	76-100	light rain showers	10+ mi horizontal visibility, no clouds on mts
9/30/2008	2100	W	15	0-25	0	
10/1/2008	900	W	15	0-25	0	
10/1/2008	1200	W	<10	0-25	0	
10/1/2008	2100	W	15	76-100	light rain showers	
10/2/2008	900	W	<10	0-25	0	calm seas (no swell), 10+mi horizontal visibility
10/2/2008	1400	W	<10	50-75	0	
10/2/2008	1830	W	<10	50-75	0	
10/3/2008	945	W-NW	15	76-100	0	cumulus clouds, horizontal visibility 10+ mi, mts exposed
10/4/2008	900	N	15	0-25	0	no clouds on mts, horizontal visibility 10+ mi, snow on mt peaks at L Sitkin and Segula
10/4/2008	1200	N	15	0-25	0	
10/4/2008	1700	N	15	0-25	0	
10/5/2008	900	N	15	0-25	0	
10/5/2008	1200	N	15	0-25	0	
10/5/2008	1700	N	15	0-25	0	
10/6/2008	900	N	15	0-25	0	
10/6/2008	1200	N	15	0-25	0	
10/6/2008	1700	N	15	0-25	0	

4.4 Alternative Baiting Areas

4.4.1 Marine environment

The coastal areas of the island were treated with techniques to minimize the risk of bait entering the marine ecosystem and ensure sufficient bait was available in all potential rat territories. The coastal area of the island was divided into two aerial treatment sections: the external and internal perimeter (Figure 17). The external perimeter extended from the high tide line to 40 m inland, and the internal perimeter included the area 40-70 m from the high tide line.

The external perimeter was treated first with a directional deflector attached to the spreader bucket. The deflector restricted bait broadcast to approximately 120° to one side of the helicopter, the direction opposite the position of the pilot thereby allowing greater visibility and control to avoid bait entry to the water. The northeast, northwest, and south central areas of the island are characterized by steep coastal bluffs that rise to heights of approximately 50- 75 m (165 – 250 ft). The cliffs made it impossible to apply a sufficient quantity of bait to the higher elevations; therefore, a second pass with the deflector was made 35 m (115 ft) higher than the first pass to ensure that full coverage was achieved.

The internal perimeter was treated after the external perimeter and without the deflector on the bucket. The internal perimeter included two treatment passes, with the second pass occurring inland from and overlapping the previous flight line by 50%.

All vegetated islets within 1 km of Rat Island are considered potential rat habitat, and could provide refuge for rats if not treated with bait. In total, 43 vegetated islets surrounding Rat Island were treated aerially by helicopter using a deflector attached to the bucket. To prevent application to water, islets were treated with a trickle technique to achieve precise placement of bait and prevent bait application to the water. A trickle technique refers to a spreader bucket with the motor inactivated and the rotational spinner removed, which results in a highly restricted and low density bait broadcast. This technique was an effective way to prevent bait entry into the marine environment for these small islets.

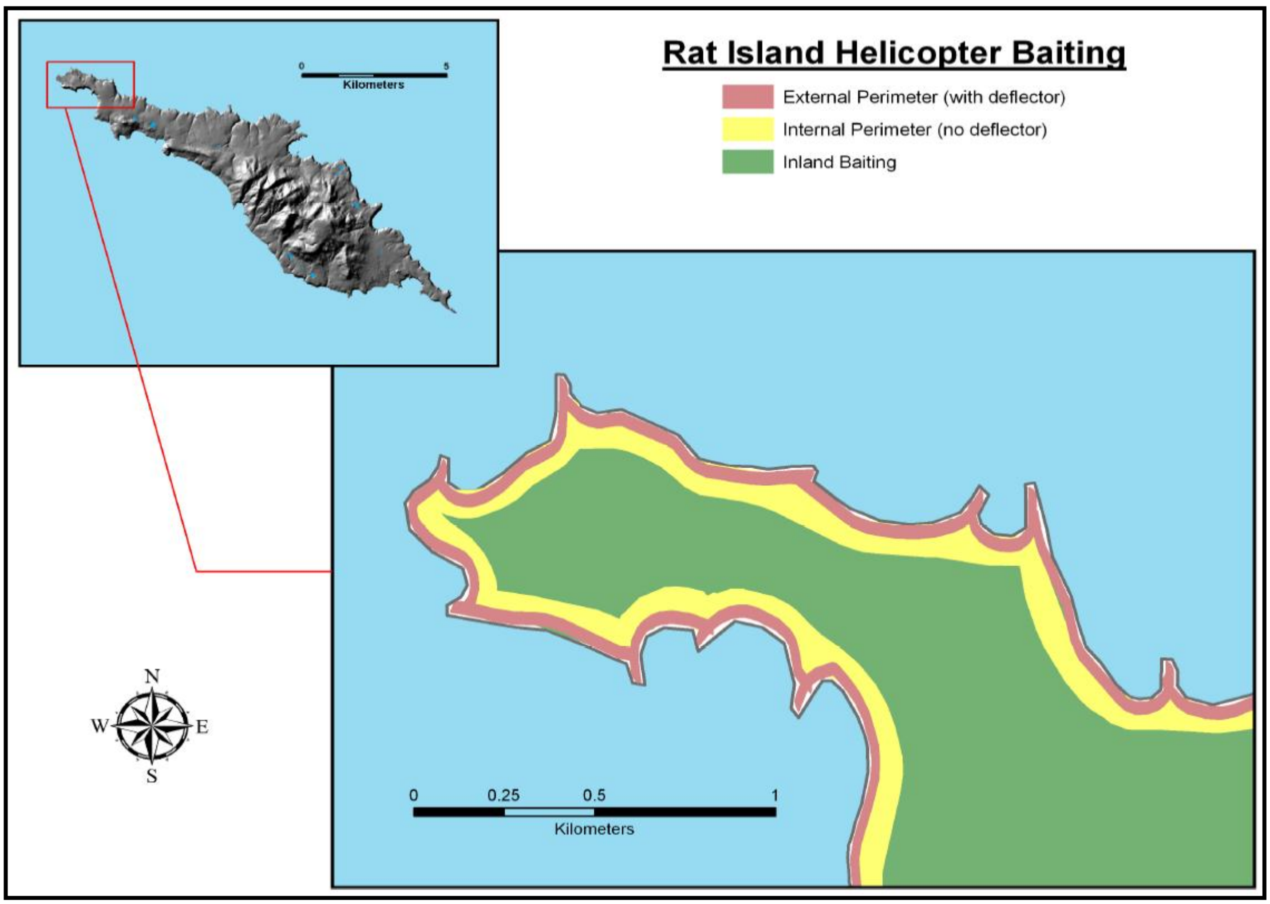

Figure 17. The external perimeter of Rat Island was treated with a deflector attached to the spreader bucket to avoid bait entry to marine water. The internal coastal perimeter and inland area were treated without a deflector attached to the bucket (map: J Vogel, U.S. Geological Survey, Flagstaff, AZ).

4.4.2 Freshwater environment

Figure 18. Team applying bait by hand within aerial exclusion zone on Rat Island.

The direct application of bait to freshwater bodies was prevented during aerial baiting operations by using alternate application techniques. Aerial application exclusion buffers, 45m from the edge of fresh water bodies, were established around each of the fourteen lake clusters on the island and marked on the helicopter GPS for inclusion into the flight paths across the island. Pilots ceased broadcasting bait by closing the gate on the bait bucket before they entered these exclusion areas to prevent direct application into fresh water. Areas around fresh water, however, are optimal rat habitat. Therefore it was imperative that the area inside buffers receive bait coverage. As a result, the interior of aerial exclusion zones were supplemented with bait broadcast systematically by hand. The external perimeter of buffers (e.g., 45 m from freshwater) were treated with a directional deflector, with bait applied outward from the lakes to ensure there were no gaps in bait coverage for areas immediately outside the exclusion buffer where pilots ceased baiting. In some cases where the distance between adjacent lakes was less than the deflector baiting swath, a trickle technique was used for precise bait placement.

Manual bait application within the freshwater aerial exclusion buffers occurred on October 1 and 2, following completion of the first aerial application to baiting blocks. This was conducted by four hand baiting teams, each consisting of four members and overseen by a ground baiting manager with a State of Alaska pesticide applicator certification and experience in hand baiting operations (Figure 18). Baiting teams were transported by helicopter outside of the exclusion buffers. The perimeters of each exclusion buffer were mapped on a handheld GPS unit for reference by the team. Within the aerial exclusion buffers, team members systematically applied bait in parallel transects spaced 10 m (33 ft) apart. The ground baiting manager directed movement and spacing of the bait applicators to ensure coverage within the buffer. Bait was applied by hand by each team member at 10 m (33 ft) intervals, extending in all four directions (i.e., front, back, right, left) to achieve coverage. Around the circumference of fresh water bodies bait was applied by hand up to the water's edge (Figure 19). To reduce the potential for gaps in coverage between the hand application and aerial application baiting boundaries all team members visually scanned the ground for pellets applied by helicopter to ensure the boundaries met and overlapped slightly. The area treated by hand was tracked by handheld GPS and layered together with the aerial application GPS flight paths to monitor coverage inside and around the buffer

Figure 19. A biologist inside an aerial exclusion buffer on Rat Island, manually applying bait outward from the water's edge.

boundary. To ensure treatment, gaps identified in the bait application were rebaited with a directional deflector or trickle technique, depending on the location of the gap (Appendix 5).

5. Environmental Effects

5.1 Target Species

Two days after bait application, snap traps were set along beaches around Gunner's Cove to capture rats and determine whether rats were consuming bait. Traps were set for a total of 43 trap nights. In total, 23 rats were either trapped or found dead along or within the vegetation line on beaches. All trapped rats were necropsied to assess anti-coagulant exposure. All rats except one either displayed symptoms of anti-coagulant poisoning (internal bleeding) or had bait pellets in the gut or intestines. For one rat the cause of death was unconfirmed. All rat carcasses collected were collected, frozen, and archived.

5.2 Non-target Species

5.2.1 Birds

As stated in the Finding of No Significant Impact for the Environmental Assessment for Rat Island, some individual birds were likely to be negatively impacted by the eradication operation. There are two primary pathways of exposure for birds –consuming bait or bait particles, or consuming other animals that consume the bait.

Based on eradication trial work conducted in the Aleutian Islands in 2006 (Buckelew et al. 2007b), birds most likely to suffer mortality were those with a grain-based diet, such as Giant song sparrows. Pre-eradication biological surveys however showed that song sparrows are rare on Rat Island, while common on rat-free islands in the Rat Islands group, which may be an artifact of persistent co-existence with rats (Buckelew et al. 2007b; Byrd et al. 2008). Song sparrows may have been present on the islet off Ayugadak Point during the eradication.

During the eradication, specific measures were taken to limit the direct ingestion of bait pellets by birds.

1. *Timing.* The operation was conducted during the fall season, after completion of bird breeding and seasonal migration.
2. *Exposure*. The target application rate was calculated during bait broadcast trials (Buckelew et al. 2007a) to make bait available to rats for up to four days, after which the majority of bait pellets would have been consumed thereby limiting the amount available for consumption by non-target species.
3. *Formulation*. Bait pellets were made of human food grade grains, which are attractive to granivorous birds. However, bait pellets were manufactured to a size too large to be wholly consumed by smaller birds, and too small to be attractive to larger birds (2 g [0.1 ounce]; 13mm [½ in.] diameter). Bait pellets were dyed blue, a color known to minimize attractiveness as a food item by song birds (Pank 1976). Bait was additionally formulated to withstand rain, maintain their structural integrity, and not readily crumble into smaller pieces which could be readily ingested by birds.

Other eradication projects have shown that some scavenging birds, such as eagles, may be at risk of brodifacoum exposure by feeding on other animals that have consumed bait pellets (secondary exposure) (Howald et al. 1999). On Rat Island, however, secondary exposure is expected to be limited because the majority of rats die beneath the ground in their burrows (Buckelew et al. 2007a), making them inaccessible to avian scavengers. Additionally, in the course of operations, any dead rat carcasses observed above ground following bait application were removed. Given the total size of the island, the area that was searched and cleared of carcasses was limited. We feel secondary exposure through consumption of other species was minimal, as densities of migratory birds were low following the summer breeding season and most rats die below ground.

Incidental observations of birds were made during aerial operations on Rat Island (September-October 2008) to document the general abundance of species encountered (Appendix 6). No observed impacts to birds were detected during or immediately following the first bait broadcast. Specifically, no birds on the island were encountered dead or displayed behavioral symptoms of anti-coagulant poisoning. Biological monitoring is planned on Rat Island 1, 2, and 5 years post-eradication to understand the final outcome of the project and to document any positive or negative population-level changes associated with the rat-removal. Additionally identical surveys conducted on other islands in the Rat Islands group prior to the eradication will be repeated for 1-5 years post-eradication as a reference of regional change in populations for comparison with potential changes observed on Rat Island (Byrd et al. 2008). Funds are currently being sought to extend biological monitoring for an additional 5-10 years to provide information regarding the prolonged recovery of native species.

Overall, while some individuals may be negatively impacted by the eradication, impacts are anticipated to be short-term and insignificant at a population level. Following rat removal there is expected to be a long-term and lasting benefit to birds, as a release from predation and significantly improved native habitat is expected to increase abundance and diversity of birds on the island.

5.2.2 Marine Mammals

The Rat Island Habitat Restoration Project, as planned and implemented, did not jeopardize any marine mammal species listed in the U.S. ESA, or the habitats on which they rely. Listed species at Rat Island include the endangered Steller sea lion and the threatened Northern sea otter, in addition to the MMPA-protected Pacific harbor seal. The islet located off Ayugadak Point at Rat Island is a Steller sea lion rookery, and is identified as critical habitat under the Endangered Species Act (Figure 20). Bait was delivered to Rat Island and the islet off Ayugadak Point using an adaptive, alternative-baiting strategy that was designed to limit helicopter disturbance to the rookery, and subject to review and approval by National Marine Fisheries Service.

Figure 20. The sea lion rookery on the islet located off Ayugadak Point.

The project was planned to minimize the potential for disturbance over sea lion haul-outs and rookeries. Biologists conducted marine mammal surveys upon arrival and departure to Rat island, as well as prior to, during, and following aerial baiting operations at both the islet off Ayugadak Point and Krysi Point (a persistent sea lion haul-out on the northwest point of Rat Island; Appendix 7) following guidelines set forth by the National Marine Fisheries Service under an Incidental Harassment Authorization. Observations were chiefly conducted from the M/V *Tiglax* (Refuge research vessel positioned at Rat Island from Oct 1-6, 2008, refer to Sec 7.4 Operations Staging). Incidental marine mammal observations were made by the field crew walking beaches, and/or traveling by skiff or helicopter.

Care was taken to reduce disturbance when making helicopter overflights of sea lion haul-outs or the rookery. In particular, when treating the islet near Ayugadak Point, the helicopter made an initial high-altitude (1,000 ft) approach to the islet, and gradually decreased altitude in slow circles dropping ~30 m (100 ft) every minute. A single pass was made over the islet to apply bait, after which the helicopter returned directly to Gunner's Cove on Rat Island. This gradual, deliberate approach allowed sea lions to become aware of the helicopter's presence, departing the beach into the water. No stampede of animals to the water occurred, which reduced the potential for injury.

During the course of operations no marked animals were seen and no unusual behavior of marine mammals was observed. Sea lions began to return to haul-out beaches 15 minutes after helicopter overflights, and one day after helicopter overflights sea lion numbers were nearly as high (Krysi Pt.) or higher (the islet off Ayugadak Point) than before the helicopter fly-over. Overall, the number of animals whose behavior was altered as a result of project operations was considerably lower than the number of takes authorized under the Incidental Harassment Authorization. All responses of animals to project operations were within the range of Level B harassment and primarily consisted of an alert head raise without moving, or limited, short-term displacement. A full report of marine mammal activities and response to aerial bait operations can be obtained from the Rat Island Habitat Restoration Project: MMPA Incidental Harassment Authorization Final Report (2008) (Appendix 8).

5.2.3 Other Species

Once the pellets have decomposed, brodifacoum will bind to the organic matter in soil and remain immobile until it is degraded. In this form the potential for consumption by other species is low, although some terrestrial invertebrates may consume residues within the soil. Brodifacoum is not known to affect invertebrates, and when consumed, has low persistence and accumulation in invertebrates (Howald et al. 2005). Also, because brodifacoum is insoluble in water and binds to organic matter in soil, it is not expected to be absorbed by plants nor cause other negative impacts to vegetation.

Fish are not abundant in lakes and streams on Rat Island. Alternate baiting strategies applied near marine and fresh water environments prevented direct application to water, therefore, there is negligible risk that fish will be affected by rodenticide exposure. Additionally, results from bait broadcast trials in the Aleutian Islands have demonstrated that fish do not ingest placebo bait pellets in marine environments (Buckelew et al. 2007a).

5.3 Soil and Water Quality

5.3.1 Soil

With the application rates carefully calculated the majority of bait pellets on Rat Island are expected to be consumed by rats, especially in areas of high rat density, thereby limiting the amount of bait remaining in the environment. Bait pellets remaining unconsumed in the environment will break down into CO_2 and H_20 with no known intermediate toxic metabolites. The amount of time required for breakdown depends on the composition of vegetation and soil, and also on local weather conditions. Individual pellets may persist for two to eight months in inland habitats on the island, or when frozen through the winter (Buckelew et al. 2007a).

5.3.2 Fresh and marine water

Baiting operations on Rat Island were planned and conducted using the most advanced technology available to prevent the direct application of pellets into fresh and marine environments. The use of the directional deflector, aerial exclusion buffers, and hand application around freshwater lakes prevented intentional entry of rodenticide to marine and freshwater bodies as confirmed by the GIS printout of helicopter flight paths over aerial exclusion buffers (Appendix 4).

Prior to and at 24- and 48- hours post bait application marine and freshwater samples were collected, and submitted to NWRC for brodifacoum residue analysis. Two marine water samples were collected from six random locations along the north central coastline of Rat Island during each sampling interval. Samples were collected by a M/V *Tiglax* crew member, whom had not handled bait during the eradication operation. Three replicate samples were collected from four lakes prior to the eradication in August 2007. At 24 hour post-application two replicate samples were collected from two lakes on the west end of Rat Island, and at 48 hours three replicate samples were collected from another two lakes within the same lake cluster. Samples were collected by a field team member prior to conducting hand baiting in the area. Sterilized gloves and a cotton suit were worn during collection. Water samples were collected into chemically-cleaned, glass laboratory jars, sealed, and maintained at ambient environmental temperatures in the field and in the refrigerator on return to the mainland. Samples were analyzed using developed methods to screen for possible matrix effects, interferences, and brodifacoum levels (T.M. Primus, unpublished Method 158A, 2007). The method used 120 mL of saltwater sample and 40 mL of freshwater sample, thus a portion of each water sample remained to double check any sample positive for brodifacoum. The mean method limit of detection (MLOD) was 0.022 ppb brodifacoum in marine water and 0.052 ppb in freshwater.

No brodifacoum was detected in any of the marine water samples collected (Table 5). Thus, the deflector mounted on the spreader bucket and trickle technique were effective in preventing pellet entry to the marine environment, while still allowing for precise bait placement along the coastline where rat densities are highest on the island.

Brodifacoum residue levels above MLOD were detected in two fresh water samples, from two lakes, following a second analysis to nullify a false positive (Table 6). Direct bait application to water was prevented using aerial exclusion buffers (refer to Appendix 4 for helicopter flight path), and no pellets in water seen or reported by observers in this area. Therefore the positive detection of brodifacoum in some fresh water lakes may have resulted from:

i) Sample contamination by collector.

- Freshwater samples, as much as possible, were collected following a standardized sampling protocol to reduce the likelihood of sample contamination. Sample collectors, however, also conducted hand application within aerial exclusion buffers following collection, therefore inadvertent entry of brodifacoum to freshwater lakes may have occurred during the time of collection (e.g. remnant brodifacoum on collector's hands or clothing).

  Using physical characteristic information collected from individual lakes on Rat Island (Buckelew et al 2007) the number of bait pellets required to achieve the observed residue levels was modeled (Table 7). This analysis assumed that all brodifacoum deposited in water was in solution, which represents a maximum and improbable case scenario since brodifacoum is non water soluble. The measured concentrations in water samples far exceeded what would be expected from direct pellet entry or fragments occurring in the freshwater environment. Using this model, a bait fragment 1% the size of a whole bait pellet (2 g) would results in a residue concentration > 20 times greater than those observed. Therefore, a minute bait particle from a hand or clothing could be sufficient to result in the observed concentration.

ii) Contiguous water mixing from lakes and streams.

- While the baiting operations were designed to prevent the direct entry of bait pellets to freshwater lakes, these same methods were not applied to freshwater streams. Therefore, the continuity of water between streams (where pellet entry may have occurred) and lakes (where pellet entry was prevented) could have resulted in brodifacoum run-off. However, the relatively low water flow in streams during the time of operations makes this scenario not likely.

iii) Drift of wind-blown particles from spreader bucket, directional deflector, or settlement in bait storage pails used for hand application.

- The strategy used to aerially apply bait across Rat Island utilized a series of aerial exclusion buffers to prevent the direct entry of pellets to freshwater lakes (refer to section 4.4.2). Buffers were set 45m (148 ft) from the outer edge of freshwater lake clusters, which was a distance 10m (33 ft) greater than the effective bucket swath width (defined as the uniform distance in which bait pellets are dispensed from the bucket). Bait application occurred by hand within aerial exclusion buffers, and a directional deflector was used to apply bait outward from the buffer boundary to ensure there were no gaps at the boundary edge.

  These combined methods were effective in preventing the direct application of bait pellets to freshwater lakes. However, results from freshwater samples indicate that inadvertent entry of brodifacoum to the water may have occurred during baiting operations. It is possible that drift of wind-blown brodifacoum particles occurred by teams of applicators manually applying bait within the buffers. The transport of bait from Madison, WI to Rat Island, Alaska created normal settlement and fragmentation of pellets, resulting in some pulverized powder within bait storage bags and pails.

Hand applicators wore specialized spreader bags during application, in which bait was poured into from 5-gallon pails inside aerial exclusion zones. It is possible that during the transfer of bait to spreader bags or during hand application some pulverized powder drifted by wind to the lake surface.

Wind-blown transfer of brodifacoum particles may have also occurred from the spreader bucket used outside the aerial exclusion buffer. The impact of bait dispensed from the bucket against the deflector and the air ram device used to close the bucket gate resulted in some breakage of pellets. It is likely that bait particles suspended in the air from normal function of the spreader bucket settled to the surface of some freshwater lakes.

While the deliberate application of bait pellets to freshwater environments was prevented during the operations on Rat Island, brodifacoum residues were detected above MLOD in some replicates of freshwater samples. It is unlikely that the unintentional entry of brodifacoum will cause impact to the freshwater systems. The high adsorption properties of brodifacoum combined with its very low water solubility make it highly likely that brodifacoum will remain immobile until it is degraded. In this form the potential for consumption by other species is low unless sediment layer is deliberately consumed or disturbed. Brodifacoum is not known to affect invertebrates at low concentrations. Fish are not abundant in lakes on Rat Island, and past studies indicate that fish do not ingest placebo bait pellets in marine environments (refer to section 5.2.3).

Given the outcome of freshwater sampling, adaptive management will be applied during the monitoring phase on Rat Island to evaluate brodifacoum degradation in this environment. Beginning in June 2009, residues samples will be collected from freshwater lakes and submitted to an approved laboratory for analysis. The outcome of this adaptive process aims to enhance the understanding and effectiveness of mitigation actions used during future eradication operations. Water sampling protocols will be improved in cooperation with an approved laboratory to eliminate the potential for sample contamination in the future. Additionally, improvements to bait application equipment may be pursued to reduce the potential for pellet breakage or fragmentation.

Table 5. Brodifacoum residues in marine water collected on Rat Island prior to, and at 24- and 48- hours post bait application (* MLOD= 0.022 ppb).

Collection location	Sample #	Collection Date	Time series	Brodifacoum conc (ppb)*
Gunner's cove	1	9/29/2008	pre-application	<MLOD
Gunner's cove	2	9/29/2008	pre-application	<MLOD
Gunner's cove	3	9/29/2008	pre-application	<MLOD
Gunner's cove	4	9/29/2008	pre-application	<MLOD
Gunner's cove	5	9/29/2008	pre-application	<MLOD
Gunner's cove	6	9/29/2008	pre-application	<MLOD
Gunner's cove	1	10/1/2008	24 hr post-application	<MLOD
Gunner's cove	2	10/1/2008	24 hr post-application	<MLOD
Gunner's cove	3	10/1/2008	24 hr post-application	<MLOD
Gunner's cove	4	10/1/2008	24 hr post-application	<MLOD
Gunner's cove	5	10/1/2008	24 hr post-application	<MLOD
Gunner's cove	6	10/1/2008	24 hr post-application	<MLOD
Gunner's cove	1-1	10/2/2008	48 hr post-application	<MLOD
Gunner's cove	1-2	10/2/2008	48 hr post-application	<MLOD
Gunner's cove	2-1	10/2/2008	48 hr post-application	<MLOD
Gunner's cove	2-2	10/2/2008	48 hr post-application	<MLOD
Gunner's cove	3-1	10/2/2008	48 hr post-application	<MLOD
Gunner's cove	3-2	10/2/2008	48 hr post-application	<MLOD
Gunner's cove	4-1	10/2/2008	48 hr post-application	<MLOD
Gunner's cove	4-2	10/2/2008	48 hr post-application	<MLOD
Gunner's cove	5-1	10/2/2008	48 hr post-application	<MLOD
Gunner's cove	5-2	10/2/2008	48 hr post-application	<MLOD
Gunner's cove	6-1	10/2/2008	48 hr post-application	<MLOD
Gunner's cove	6-2	10/2/2008	48 hr post-application	<MLOD

Table 6. Brodifacoum residues in fresh water collected on Rat Island prior to, and at 24- and 48- hours post bait application (* MLOD= 0.052 ppb).

Collection location	Sample #	Collection Date	Time series	Brodifacoum conc (ppb)*
Lake system 8	1-1	8/8/2007	pre-application	<MLOD
Lake system 8	1-2	8/8/2007	pre-application	<MLOD
Lake system 8	1-3	8/8/2007	pre-application	<MLOD
mean Lake system 8				**<MLOD**
Lake system 9	2-1	8/8/2007	pre-application	<MLOD
Lake system 9	2-2	8/8/2007	pre-application	<MLOD
Lake system 9	2-3	8/8/2007	pre-application	<MLOD
mean Lake system 9				**<MLOD**
Lake system 1	3-1	8/8/2007	pre-application	<MLOD
Lake system 1	3-2	8/8/2007	pre-application	<MLOD
Lake system 1	3-3	8/8/2007	pre-application	<MLOD
mean Lake system 1				**<MLOD**
Lake system 4	4-1	8/8/2007	pre-application	<MLOD
Lake system 4	4-2	8/8/2007	pre-application	<MLOD
Lake system 4	4-3	8/8/2007	pre-application	<MLOD
mean Lake system 4				**<MLOD**
Lake 4B West	1-1	10/1/2008	24 hr post-application	<MLOD
Lake 4B West	1-2	10/1/2008	24 hr post-application	<MLOD
mean Lake system 4B West				**<MLOD**
Lake 4B East	1-1	10/1/2008	24 hr post-application	<MLOD
Lake 4B East	1-2	10/1/2008	24 hr post-application	0.203
mean Lake system 4B East				**<MLOD**
Lake 4A	1-1	10/2/2008	48 hr post-application	0.199
Lake 4A	1-2	10/2/2008	48 hr post-application	<MLOD
Lake 4A	1-3	10/2/2008	48 hr post-application	<MLOD
mean Lake system 4A				**<MLOD**
Lake 4B West	2-1	10/2/2008	48 hr post-application	<MLOD
Lake 4B West	2-2	10/2/2008	48 hr post-application	<MLOD
Lake 4B West	2-3	10/2/2008	48 hr post-application	<MLOD
mean Lake system 4B West				**<MLOD**

Table 7. Analysis of theoretical pellet entry required to achieve brodifacoum concentrations in fresh water lakes on Rat Island.

Lake	Lake area (m^2)	Average depth (cm)	Lake volume (L)	Measured brodifacoum (mg/kg)- sample	Measured brodifacoum (mg)- lake	Measured brodifacoum (mg/kg)- indiv pellet
4A	421	10	42,100	0.00019	8	0.05075
4B East	21,440	30	6,432,000	0.00019	1222	0.05075
4B West (2)	8,511	20	1,702,200	0.00005	85	0.05075
4B West (3)	8,511	20	1,702,200	0.00005	89	0.05075

Lake	Theoretical pellets in lake to achieve residue level	Target application rate (kg/ha)	Theoretical pellets in lake at target application rate (kg/ha)	% difference
4A	158	6	124	27
4B East	24,080	6	6,337	280
4B West (2)	1,677	6	2,515	-33
4B West (3)	1,744	6	2,515	-31

5.4 Cultural and Historic Resources

Four sites on Rat Island have been certified by the Bureau of Indian Affairs as cemetery and historical sites and are eligible for conveyance to The Aleut Corporation under section 14(h)(1) of the Alaska Native Claims Settlement Act. These sites were treated with rodenticide, under appropriate permission, as these areas are likely to harbor rats. Other than aircraft overflights, these areas were not visited or otherwise manipulated in any manner that would compromise their cultural or historical values.

5.5 Human Health

When working with rodenticide bait in a planned and controlled operation the risks to human health are very low. To promote safe use of pesticides to protect human and environmental health, all bait application activities (aerial broadcast, hand broadcast, and bait bucket filling) were supervised by a State of Alaska certified pesticide applicator, and all individuals that handled rodenticide bait were additionally certified. Helicopter pilots were certified with an aircraft-specific pesticide applicator license, and the contract company (Pathfinder Aviation) held an Agricultural Aircraft Operator certification under the Federal Aviation Administration (FAA).

Figure 22. Notification posted in Gunner's Cove on Rat Island following label guidelines.

Personal Protective Equipment (PPE) issued to all personnel that handled bait in the field met or exceeded all requirements described on the EPA pesticide label (Figure 21). All personnel that loaded bait into buckets wore hard hats, ear protection, safety goggles, dust masks or respirators, protective gloves, and Nomex® coveralls or fire-retardant rain gear. The risk of rodenticide entering the camp area was reduced by storing bait-exposed gear outside the living area, and by providing hot showers and washing facilities in the field. To further reduce the risk of ingestion, water for cooking, cleaning, and direct consumption was taken from Homer and stored in sealed barrels on the island.

Figure 21. Bait loader wearing PPE for refilling of spreader buckets on Rat Island.

Rat Island is an uninhabited island that lacks both permanent infrastructure and frequent human visitation, other than a team of biologists (3-4) that occasionally reside on the island in summer months to conduct research. Signs were posted at the main boat landing site in Gunner's Cove to warn visitors that brodifacoum was present on the island, and to describe the appearance of the pellets and project purpose (Figure 22). The signs will remain in place until spring 2009, long after the bait is expected to remain on the island.

6. EFFICACY

6.1 Eradication Efficacy

The efficacy of the operation will be assessed over the next two years (2009, 2010), which is the international standard for determining rodent eradication outcome. Two years gives enough time for rats to repopulate the island to detectable levels, should some have survived the eradication. Only after two years of monitoring with no detected rat activity will Rat Island be declared rat-free. Ultimately, the success of the eradication will be determined by beneficial ecosystem changes; following rat removal there is expected to be significantly improved native habitat and long-term lasting benefit to birds.

During June 2009 and 2010 a team of researchers will visit Rat Island to determine the efficacy of the eradication. Detailed monitoring protocols can be obtained in Appendix 9. If no sign of rats are detected after two years, then the island will be declared rat-free in 2010. However, if questions remain (e.g., scat or tracks observed but no rat directly trapped) about the success of the operation then an additional year of monitoring will occur in 2011.

In June 2008, tissue samples from 30 Norway rats were collected on Rat Island. Samples were collected, labeled, and frozen for archival purposes at academic and museum locations. If rats are found on the island at any time following the eradication, genetic analyses may allow researchers to determine whether the eradication was unsuccessful or reinvasion of the island occurred.

6. 2 Biological Monitoring

Figure 23. Biologist performs point count surveys to document abundance of landbirds on Rat Island.

Eradication of introduced rats may allow for the recovery of many native island species. The recovery of plant, invertebrate, reptile, seabird, and song bird populations has been documented on islands around the world following eradication (Towns et al. 2006). Based on this evidence, it is anticipated that successful rat removal will result in improved habitat quality and recovery of native species on Rat Island.

Pre-eradication biological monitoring was conducted on Rat Island and nearby islands in 2007 and 2008 to establish baseline population indices of native species (Figure 23-24). These surveys will be repeated on-island 1, 2 and 5 years following the eradication, and compared with other pre-existing data to assess ecosystem recovery. These surveys include monitoring for abundance of common avian species (seabirds, shorebirds, waterfowl, song birds, and birds of prey), marine mammals, vegetation, and intertidal flora and fauna. Surveys will also be repeated on nearby islands, all within the Rat Islands group, as a reference for regional changes in avian populations.

Figure 24. Biologist collects plant biomass sample to document vegetation structure on Rat Island prior to rat removal.

Given the remote location of the island, wildlife monitoring has occurred infrequently on Rat Island over the past several decades. Therefore to obtain the most robust information possible, biological surveys followed standardized USFWS protocols in order to facilitate replication over time and comparisons with other island ecosystems. A team of biologists will visit Rat Island and other islands in the Rat Islands group during June 2009, and again over the succeeding 1-4 years, to continue monitoring for long-term population changes to native species following the removal of rats.

6.3 Biosecurity

Once the success of the eradication and the potential for ecosystem recovery has been established, it is important to ensure that the island maintains its rodent-free status. The biosecurity plan for Rat Island couples island-specific protocols with statewide programs to prevent the reinvasion of rats to the island.

Before vessels visit Rat Island, all equipment, food, and supplies going to the island should be checked and packed in a quarantine facility on Adak Island. The facility will be armed with bait stations and snap traps to reduce the likelihood of stowaway rodents being transported to the island. Transport and storage of equipment to the island will be carried out on a certified rodent-free vessel, also equipped with traps in the event that rats board the vessel at port.

The Aleutian Islands, including Rat Island, remain at risk of rat invasion from shipwreck, as one of the world's largest trade shipping routes passes through the archipelago. Approximately 3,000 ships transport goods between Asia and North America annually, with an average of two ships running aground each year. Although state-wide shipboard prevention regulations (see below) reduce the likelihood of ships introducing rats to rat-free islands, a single biosecurity failure could negate all eradication efforts on Rat Island, or place other seabird islands at risk.

The Nature Conservancy and the Alaska Region of the FWS, including Alaska Maritime National Wildlife Refuge, are partners in the Alaska Rodent Action Team (AKRAT) established to prevent the spread of introduced rodents throughout Alaska. Recent state regulations make it illegal for any ship, aircraft, or other vessel to harbor rats, and mandate that any vehicle or facility harboring rodents maintain active eradication or response plans. The AKRAT group has distributed over 400 "rat prevention kits" to vessel owners throughout Alaska and the Pacific Northwest to reduce the number of vessels in Alaskan waters that are rat-infested and prevent the potential for rat introductions.

7. LOGISTICS

Given the remote location and lack of human habitation on Rat Island, a considerable amount of effort was dedicated to logistical planning and preparation for the eradication. Information regarding the logistics supporting the eradication operation is provided in the below section. Sequentially, these events occurred leading up to (June-July 2008) or immediately following (September 2008) the aerial bait broadcast. Information specific to the bait application operations has been provided in the previous sections.

7. 1 Pre-operations staging

Bait was manufactured at Bell Laboratories 26 June- July 3, 2008, during a period of low relative humidity. Following manufacture, bait bags were packed and sealed into BSVs, and loaded into connex boxes (e.g. general purpose dry cargo shipping containers) for shipment from Madison, WI to Homer, AK (Table 5). Bait was sealed into the BSVs, and subsequently into connex boxes to ensure security for the duration of transport and storage.

The bait arrived to Homer on August 4, 2008 and was securely stored at an outdoor storage facility. The connex boxes were opened to check for any potential damage (water leakage, BSV tipping, etc), and then remained sealed for approximately 30 days until transported to Rat Island. No bait was damaged during the transport or storage periods.

A large amount of equipment and supplies were necessary to support a field team of 17 living on Rat Island for up to 45 days. All equipment was purchased and/or shipped to Homer for packing and storage at a garage facility. Equipment requisition took approximately 7 weeks to complete (excluding spreader buckets and helicopter GPS units)

Table 5. Methods of transport and duration for bait shipment from Bell Labs to Homer, AK.

From	To	Transport method	Dates	# days
Bell Labs, WI	Madison rail depot, WI	truck	7/10/2008	1
Madison rail depot, WI	Seattle, WA	rail	7/11 to7/22/2008	12
Seattle, WA	Anchorage, AK	barge	7/25 to 8/4/2008	10
Anchorage, AK	Homer, AK	truck	8/14/2008	1

7. 2 Vessel loading

The M/V *Reliance* (a 160 ft. former fishing vessel) was chartered from Sitka, AK to transport all equipment, supplies, and personnel (excluding pilots and helicopters) to Rat Island. Vessel loading began on Friday, September 12, 2008 with six connex boxes (three 20' and three 40' in length) loaded onto the aft deck using a portside tonnage crane at the North Star Terminal in Homer, AK (Figure 25). The loading of the vessel continued the following week, with 5,000 gallons of fuel (stored in sealed 55 gallon drums), timber, food, inflatable zodiacs, outboard engines, and drinking water loaded to the ship. Initially, loading was not expected to take more than three days to complete, however, strong winds damaged the vessel's docking lines during loading. As a result, further loading was delayed by two days and then completed on Friday, September 19, after which the vessel immediately departed for Rat Island.

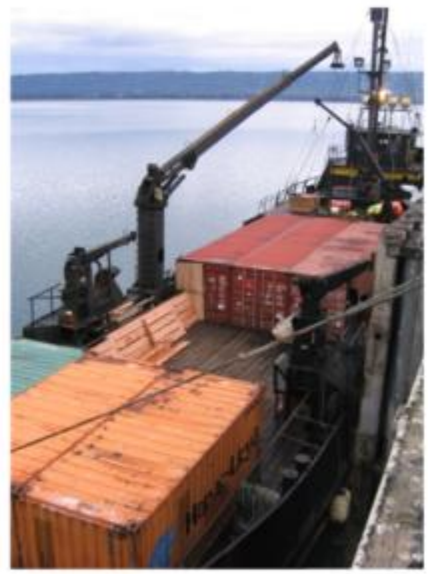

Figure 25. The M/V *Reliance* loaded with BSVs stored inside connex boxes ; Homer, AK.

7. 3 Helicopter transport

Two Bell 206L helicopters were chartered from Pathfinder Aviation in Homer, Alaska to conduct the aerial baiting operations on Rat Island. The helicopters flew the 2,100 km (1,300 miles) from Homer to Rat Island, island hopping with frequent refueling stops at airports or remote caches staged along the Aleutian chain (Table 6). During the transport flight, each helicopter had two pilots onboard, plus a helicopter mechanic was a third passenger on one (Figure 26). The transport flight navigated over islands along the Aleutian archipelago as much as possible, however, overwater flights (Figure 27) were required in a few places with a maximum open water distance of approximately 145 km (90 mi). Before departure, the chartered Pathfinder helicopters were certified by the federal Aviation Management Directorate and fitted with onboard safety, communication, flight following, and emergency equipment necessary for the journey.

The helicopters departed Homer on September 21, 2008 and stopped overnight at Dutch Harbor on Unalaska Island in the eastern Aleutians. They departed Dutch Harbor the following day and arrived at Adak Island to await the arrival of the transport vessel M/V *Reliance*. Inclement weather conditions were experienced during this second leg of the flight, approximately 160 km (100 mi) were under conditions of low visibility (fog clear to the sea surface) and winds in excess of 40 kt. Weather forecasting ability was essential to the safety of helicopters throughout the project, especially during the long transport flight to and from Rat Island. herefore, regional weather fax information was received by the M/V *Reliance* and M/V *Tiglax* (refer to Sec 7.4 Operations Staging) and discussed with pilots, either directly or by satellite phone, twice daily.

Table 6. Locations of helicopter refueling during transport flight from Homer to Rat Island.

Location	Fuel type	Coordinates	Location	Fuel type	Coordinates
King Salmon	Airport	N58°40’10 W156°37’49	Seguam Island*	fuel cache	N52°22’42 W172°24’21
Cold Bay	Airport	N55°13’33 W162°43’26	Atka Island	fuel cache	N52°11’57 W174°12’40
Port Moeller	fuel cache	N55°59’03 W160°34’20	Adak Island	airport	N51°52’27 W176°38’21
Dutch Harbor	airport	N53°52’52 W166°31’59	Ulak Island *	fuel cache	N51°34’45 E179°03’03
Chuginadik Island	fuel cache	N52°51’30 W170°00’08	Rat Island	fuel cache	N51°47’56 E178°18’32

*- fuel cache added as an emergency depot

Figure 26. Pilots departing Homer, Alaska in survival flight suits for Rat Island. From left to right: Merlin Handley, George Mason (mechanic), Mike Fell, Peter Garden (NZ), and Graeme Gale (NZ).

Figure 27. Bell 206L helicopter during transport flight from Homer to Rat Island.

7. 4 Operations Staging

The helicopters and the M/V *Reliance* (with field team onboard) arrived at Rat Island on September 26, 2008. Prior to landing on the island, a vessel-based count of marine mammals was made at the islet off Ayugadak Point and at Krysi Point (Appendix 7). Following counts, favorable weather conditions allowed for the initial offload of equipment from the ship to shore. The *Reliance* held anchor in Gunner's Cove while both helicopters began to slingload equipment from the aft deck of the ship both to the camp location (approximately ½ mile inland from the coast) and the bait loading site (located on the western side of Gunner's Cove) (Figure 28). Helicopter flight paths were kept narrow and discrete between the staging zone locations to minimize disturbance to pinnipeds. During this initial offload, the majority of camp gear, camp fuel, and a portion (20) of the BSVs and helicopter fuel were transported ashore. Two Weatherport shelters were erected in camp and secure tie-downs were established for helicopters.

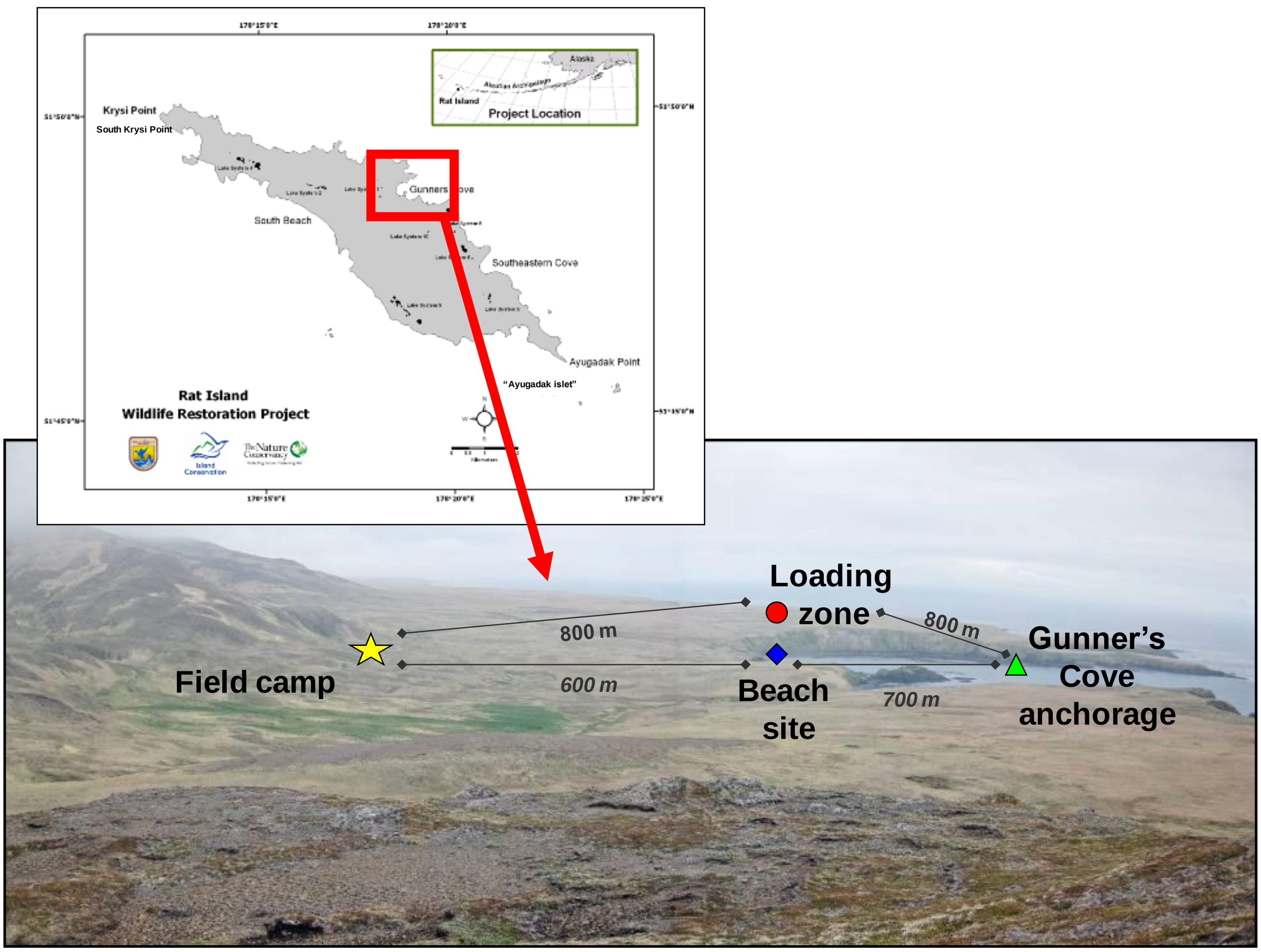

Figure 28. Location detail showing distances of helicopter flight paths from the ship anchorage to the staging zones.

Figure 29. The temporary field camp installed on Rat Island for the aerial baiting operations.

On September 27, 2008, a southeast gale developed with winds 35-45 knots, rain, and 2-3 m (6-9 ft) ocean swells. The field team was unable to safely arrive ashore, therefore remained on the vessel until conditions improved later in the day. Equipment offloading resumed mid-afternoon, with the remainder of camp equipment and additional 40 BSVs transported ashore. On September 28, a south gale blew winds up to 35 knots on the island with low clouds obscuring visibility. The camp was installed on the island, and field team members moved from the ship to begin living onshore. In total, six Weatherports were erected on the island: two for pilot accommodations, one kitchen tent, one dining tent, one storage tent, and one smaller office tent (Figure 29). Field team members slept in individual fabric tents. Two outhouses and one shower facility were installed. Following EPA fuel storage regulations, fuel was stored in sealed drums and placed inside secondary storage berms made from high density polyethylene. Drinking water was brought to the island from Homer in drums. All food items, trash, and human waste were fully contained in the camp to reduce the likelihood of rats being attracted to food items other than bait.

On September 29, weather conditions lessened to 20 knots of winds from the west and excellent visibility. Bait application commenced on the Mountain and East island blocks. On September 30, baiting continued on the West island block and along the internal and external coastal perimeters. Following completion of the first bait application, the remaining 65 BSVs were offloaded from the M/V *Reliance* to the bait loading zone. The ship was then back-loaded with empty, disassembled BSVs and garbage for transport back to Homer. On October 1, the FWS research vessel M/V *Tiglax* arrived at Rat Island, and the *Reliance* then departed for Homer, Alaska. The *Tiglax* carried additional field crew to participate in the manual baiting operations around freshwater lakes. The *Tiglax* remained at Rat Island for the duration of the project, providing general support to the on-island field team.

Over the course of the project, spill and emergency response kits were maintained to respond to any bait spill, fuel spill, or helicopter incident that might have occurred. No fuel spill or helicopter incidents occurred that required clean-up or emergency response. Additionally, no bait spills occurred, beyond stray, individual bait pellets that were scattered at the base of the spreader bucket refilling site. As much as possible, bait loaders attempted to pick-up stray bait pellets and placed them back into the bait bags or the spreader buckets.

7. 5 Operations Demobilization

Following the completion of baiting operations on Rat Island all equipment was removed from the island and transported back to Homer by the M/V *Tiglax*. Beginning October 3, 2008, initial loads of empty, disassembled BSVs were transported from the island to the ship. Over the following three days, occasional loads of camp equipment and trash were opportunistically transported from the island to the ship (Figure 30). Once the baiting operations were complete on October 5, the entire camp was disassembled and all remaining camp equipment, empty fuel drums, and dismantled BSVs were transported off the island. All perishable and non-perishable garbage was placed into empty BSVs and transported off the island for disposal at the municipal waste facility in Homer. As much as possible, evidence from human occupation (besides vegetation compression from tents) was returned to its original state before departing the island.

Figure 30. The M/V *Tiglax* receiving a helicopter slingload of empty fuel drums in Gunner's Cove on Rat Island.

The meticulous planning of the operation, favorable weather conditions, and lack of accidents or spills, resulted in a small excess of bait (originally contingency in case of delay or spill) which was applied to the island in areas where bait concentration on the ground may have been reduced due to topography or terrain type (e.g., coastal cliffs). Therefore, no excess bait remained following the operation. Bait bags were disposed of at an approved waste facility, following EPA bait label specifications.

The helicopters departed Rat Island mid-afternoon on October 6 for the return flight to Homer. On October 8, the helicopters arrived safely in Homer without any major weather or mechanical delays. The M/V *Tiglax* also departed Rat Island on the afternoon of October 6, following completion of final marine mammal counts at the islet off Ayugadak Point and Krysi Point. The field team disembarked on Adak Island on October 7 and, after several days weather delay, returned by air to Homer on October 12. The *Tiglax* made the return journey in a southerly gale with high seas and winds in excess of 50 kt, and arrived safely in Homer on October 12. From October 14 to16, the field equipment was offloaded from the *Tiglax*, then cleaned and stored as necessary. A full team debriefing occurred with all field participants and partner agencies on October 17. Field team members departed Homer on October 18.

8. SUMMARY

The Rat Island Habitat Restoration Project was the first aerial rat eradication effort in Alaska and builds upon a long history of successful invasive predator removal from islands in the Refuge. Foxes were removed from Rat Island in 1984, paving the way for further island restoration actions. Removal of introduced Norway rats is the next step to furthering habitat restoration for native species on the island.

With the completion of the aerial bait broadcast in October 2008, the island will be visited yearly over the next 5 years to determine the outcome of the eradication and assess the response of island species to rat removal. The expected success of this project should significantly improve habitat for native wildlife, particularly burrow nesting seabirds which breed on islets offshore of Rat Island and elsewhere in the Rat Island group. This project is an important step towards restoring habitat on Rat Island and, potentially, on other rat-invaded islands of distinct ecological importance within the Aleutian archipelago.

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Appendix 1.

Framework of regulatory compliance with federal and state laws for the Rat Island Habitat Restoration Project.

Authorization	Regulatory compliance	Authorization	Regulatory compliance
Environmental Assessment/FONSI	National Environmental Policy Act (NEPA)	Aerial Pesticide Applicator Certification	Alaska Dept Environmental Conservation
USFWS Section 7 consultation- Northern sea otter, Steller's eider	Endangered Species Act	Agricultural aircraft operations	FAA Federal Aviation Regulations 137
NMFS Section 7 consultation- Steller sea lion	Endangered Species Act	Collection Permit	Alaska Dept Fish and Game
NMFS Incidental Harassment Authorization - Steller sea lion, harbor seal	Marine Mammal Protection Act	Private land permission	Alaska Native Claims Settlement Act-14(h)(1)
EPA Pesticide Registration- Section 3	Federal Insecticide, Fungicide, and Rodenticide Act		
Alaska DEC Pesticide Registration	Alaska State Pesticide Law		
ACMP Consistency Determination	Alaska Coastal Zone Management Act		
Minimum Requirements Decision Guide	Wilderness Act		
Implementation Program review	Alaska National Interest Lands Conservation Act		
Pesticide Use Proposal	US Fish and Wildlife Service agency requirement		
Implementation Program review	National Historic Preservation Act		
Permit to Apply Pesticides	Alaska Dept Environmental Conservation- Statute and Administrative codes		
Authorization for use of poison	Alaska Board of Game		
Nuisance Wildlife Permit	Alaska Dept Fish and Game		

Appendix 2.

The status and relative abundance of birds observed on Rat Island and the islet off Ayugadak Point during summer months. Data from: Williams 2008; Gibson and Byrd 2007; Buckelew et al. 2007b.

Common Name	Scientific Name	Breeding status (Rat Is)	Breeding status (islet off Ayugadak)	Summer abundance (June - Aug)
Aleutian cackling goose	*Branta canadensis leucopareia*	confirmed breeding	non-breeding	uncommon
Northern pintail	*Anas acuta*	non-breeding	non-breeding	uncommon
Mallard	*Anas platyrhynchos*	non-breeding	non-breeding	uncommon
Green-winged teal	*Anas crecca*	probable breeding	non-breeding	rare
Common eider	*Somateria mollissima*	confirmed breeding	non-breeding	common
Harlequin duck	*Histrionicus histrionicus*	non-breeding	non-breeding	common; offshore
Black scoter	*Melanitta nigra*	non-breeding	non-breeding	abundant
Rock ptarmigan	*Lagopus muta*	confirmed breeding	non-breeding	fairly common
Northern fulmar	*Fulmarus glacialis*	non-breeding	non-breeding	rare; offshore
Fork-tailed storm petrel	*Oceanodroma furcata*	non-breeding	confirmed breeding	fairly common
Leach's storm petrel	*Oceanodroma leucorhoa*	non-breeding	probable breeding	uncommon
Sooty shearwater	*Puffinus griseus*	non-breeding	non-breeding	rare; offshore
Short-tailed shearwater	*Puffinus tenuirostris*	non-breeding	non-breeding	fairly common
Red-faced cormorant	*Phalacrocorax urile*	confirmed breeding	non-breeding	fairly common
Pelagic cormorant	*Phalacrocorax pelagicus*	confirmed breeding	non-breeding	abundant
Bald eagle	*Haliaeetus leucocephalus*	confirmed breeding	non-breeding	fairly common
Peregrine falcon	*Falco peregrinus*	confirmed breeding	probable breeding	uncommon
Black oystercatcher	*Haematopus bachmani*	confirmed breeding	non-breeding	fairly common
Wandering tattler	*Tringa incana*	non-breeding	non-breeding	rare
Rock sandpiper	*Calidris ptilocnemis*	confirmed breeding	non-breeding	fairly common
Red-necked phalarope	*Phalaropus lobatus*	non-breeding	non-breeding	rare
Glaucous-winged gull	*Larus glaucescens*	confirmed breeding	probable breeding	abundant
Parasitic jaeger	*Stercorarius parasiticus*	probable breeding	probable breeding	fairly common
Common murre	*Uria aalge*	non-breeding	non-breeding	rare; offshore
Thick-billed murre	*Uria lomvia*	non-breeding	non-breeding	rare; offshore
Pigeon guillemot	*Cepphus columba*	non-breeding	probable breeding	abundant; offshore
Ancient murrelet	*Synthliboramphus antiquus*	probable breeding	probable breeding	rare; offshore
Least auklet	*Aethia pusilla*	non-breeding	non-breeding	rare; offshore
Whiskered auklet	*Aethia pygmaea*	non-breeding	confirmed breeding	uncommon; offshore
Cassin's auklet	*Ptychoramphus aleuticus*	non-breeding	confirmed breeding	uncommon; offshore
Horned puffin	*Fratercula corniculata*	non-breeding	probable breeding	abundant; offshore
Tufted puffin	*Fratercula cirrhata*	non-breeding	confirmed breeding	common
Short-eared owl	*Asio flameus*	non-breeding	non-breeding	seasonal migrant
Common raven	*Corvus corax*	non-breeding	non-breeding	uncommon
Winter wren	*Troglodytes troglodytes*	confirmed breeding	confirmed breeding	abundant
Song sparrow	*Melospiza melodia*	probable breeding	confirmed breeding	rare
Lapland Longspur	*Calcarius lapponicus*	confirmed breeding	confirmed breeding	abundant
Snow Bunting	*Plectrophenax nivalis*	probable breeding	probable breeding	rare
Gray-crowned rosy-finch	*Leucosticte tephrocotis*	confirmed breeding	confirmed breeding	uncommon

Appendix 3.

The names, roles, and affiliations of field crew on Rat Island and M/V *Tiglax* during the eradication operations.

Field crew

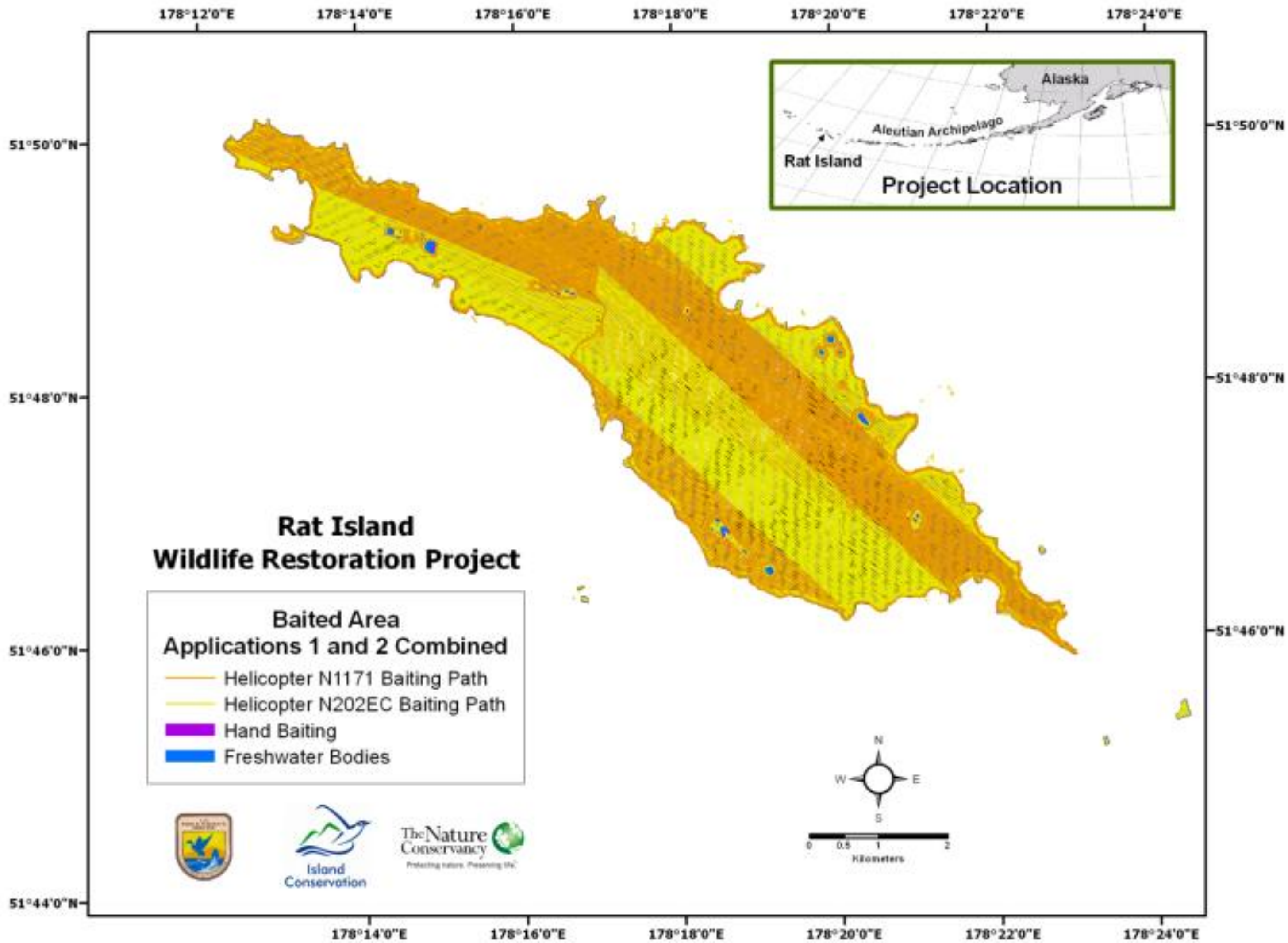
Name	Role	Affiliation
Stacey Buckelew	Project manager	Island Conservation
Jen Curl	Restoration specialist	Island Conservation
Noe Silva	Field crew	Island Conservation
Kirsty Swinnerton	Restoration specialist	Island Conservation
Steve Ebbert	Biologist	USFWS
Kent Sundseth	Aleutian Island Unit Manager; Safety Officer	USFWS
John Vogel	GIS specialist	USGS
Jonathan Giffard	GIS specialist	independent
Garrett Savery	Field crew	USDA
Pete McClelland	Eradication advisor	independent
Heather Inzalaco	Camp cook	independent
Iris Saxer	Camp manager; Medic	independent
Mike Fell	Chief pilot	Pathfinder Aviation
George Morgan	Mechanic	Pathfinder Aviation
Merlin Handley	Pilot	Pathfinder Aviation
Graeme Gale	Eradication pilot	Helicopters Otago
Peter Garden	Eradication pilot	independent

M/V Tiglax

Name	Role	Affiliation
Will Meeks	Deputy Refuge Manger	USFWS
Vernon Byrd	Supervisory Biologist	USFWS
Leslie Slater	Biologist	USFWS
Robb Kaler	Field crew	USFWS
Leah Kenney	Field crew	USFWS
Greg Thomson	Field crew	USFWS
William Pepper	Captain	USFWS
Dan Erickson	First mate	USFWS
John Faris	Deck hand	USFWS
Rueben Guetschow	Galley cook	USFWS
Eric Nelson	Engineer	USFWS
Andy Velsko	Deck hand	USFWS

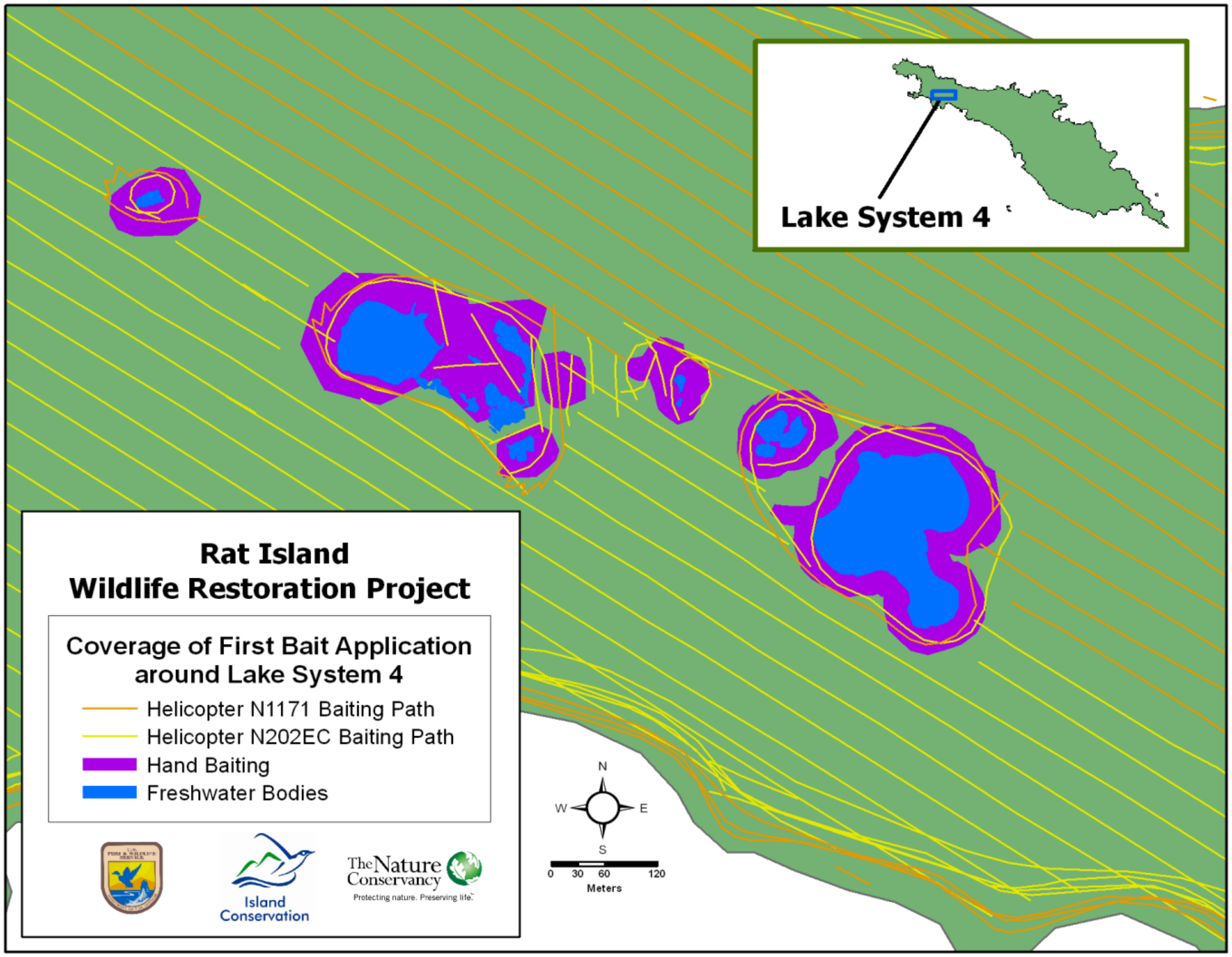
Appendix 4.

The areas treated with bait during the first and second application on Rat Island. Helicopter baiting flight paths are shown in yellow and orange (map: J Vogel, U.S. Geological Survey, Flagstaff, AZ).



Appendix 5.

A lake cluster on Rat Island detailed to show hand bait application and baiting path with deflector attached to spreader bucket or dribble technique. The purple-shaded area shows area inside the aerial exclusion buffers manually treated with bait. Bait application precision around the outer edges of exclusion buffers was achieved using a deflector attached to the bucket or dribble technique (map: J Vogel, U.S. Geological Survey, Flagstaff, AZ).



Appendix 6.

Incidental observations of birds present on Rat Island during baiting operations (Sept 29- Oct 5, 2008).

Common Name	Scientific Name	Observations in Sept-Oct
Aleutian cackling goose	*Branta canadensis leucopareia*	flock observed flying over Rat Is
Northern pintail	*Anas acuta*	single flock in Gunner's Cove
Mallard	*Anas platyrhynchos*	2 individuals seen on lakes
Green-winged teal	*Anas crecca*	flocks common on lakes
Common eider	*Somateria mollissima*	flocks common offshore
Harlequin duck	*Histrionicus histrionicus*	flocks common offshore
Rock ptarmigan	*Lagopus muta*	fairly common
Red-faced cormorant	*Phalacrocorax urile*	fairly common on offshore rocks
Pelagic cormorant	*Phalacrocorax pelagicus*	few observed on offshore rocks
Bald eagle	*Haliaeetus leucocephalus*	up to 6 adults and 1 immature observed
Peregrine falcon	*Falco peregrinus*	up to 3 observed
Black oystercatcher	*Haematopus bachmani*	fairly common
Rock sandpiper	*Calidris ptilocnemis*	1 individual observed
Glaucous-winged gull	*Larus glaucescens*	common on beaches and offshore rocks
Common murre	*Uria aalge*	up to 3 seen offhsore
Pigeon guillemot	*Cepphus columba*	fairly common offshore
Least auklet	*Aethia pusilla*	fairly common offshore
Whiskered auklet	*Aethia pygmaea*	fairly common offshore
Horned puffin	*Fratercula corniculata*	occasional observations offshore
Tufted puffin	*Fratercula cirrhata*	up to 2 birds observed offshore
Short-eared owl	*Asio flameus*	single bird observed
Common raven	*Corvus corax*	up to 4 invividuals observed
Winter wren	*Troglodytes troglodytes*	abundant along beaches
Song sparrow	*Melospiza melodia*	single bird observed
Lapland longspur	*Calcarius lapponicus*	occasionally observed
Snow bunting	*Plectrophenax nivalis*	single bird observed
Gray-crowned rosy-finch	*Leucosticte tephrocotis*	occasionally observed

Appendix 7.

Map showing key areas of alternative baiting strategy during the aerial baiting operations on Rat Island (map: J Vogel, U.S. Geological Survey, Flagstaff, AZ).

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