U.S. Fish & Wildlife Service

Midway Seabird Protection Project

Draft Environmental Assessment

Sand Island, Midway Atoll, Papahānaumokuākea Marine National Monument


Front cover:

A male albatross bonds with his chick Kūkini, a Hawaiian word for messenger. The mother - an albatross named Wisdom who is the world's oldest known wild bird - is off foraging at sea. In her lifetime, Wisdom has raised over 35 chicks.

Credit: Kiah Walker/USFWS Volunteer

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Papahānaumokuākea Marine National Monument

Prepared for:
U.S. Fish and Wildlife Service

Cooperating Agency
USDA APHIS Wildlife Services
National Wildlife Research Center

Prepared by:
Hamer Environmental L.P. and Planning Solutions, Inc.

March 2018

EXECUTIVE SUMMARY

Midway Atoll National Wildlife Refuge (MANWR) lies in the North Pacific Ocean approximately equidistant between North America and Asia. The refuge is also designated the Battle of Midway National Memorial and is within the Papahānaumokuākea Marine National Monument. The fringing coral reef, shallow lagoons, and 3 low-lying islands (Sand, Eastern, and Spit Islands), are the breeding grounds for millions of seabirds, the wintering grounds for thousands of shorebirds, and a refuge for critically endangered species like the Hawaiian monk seal (*Monachus schauinslandi*) and Laysan duck (*Anas laysanensis*). Over 70% of the total global population of Laysan albatross (*Phoebastria immutabilis*) breeds at the refuge; with the majority of the Midway population nesting on the 1,128-acre Sand Island.

This Environmental Assessment (EA) documents an action proposed by the United States Fish and Wildlife Service (USFWS), Papahānaumokuākea Marine National Monument (PMNM) and presents the anticipated environmental effects of both the Proposed Action and a No Action alternative. The Proposed Action is to eradicate house mice (*Mus musculus*) from Sand Island by delivering a lethal dose of rodenticide to every rodent in a manner that minimizes harm to island residents and the ecosystem while still maintaining a high probability of success, and to maintain the island in rodent-free status in perpetuity. The toxicant to be employed as part of the Proposed Action would be Brodifacoum-25D Conservation, a pelleted rodenticide bait intended for conservation purposes for the control or eradication of invasive rodents on islands or vessels. Implementation of the proposed action is currently being considered for Summer, 2019.

This action was identified in the Papahānaumokuākea Monument Management Plan (PMMP), completed in December 2008, as Strategy AS-4 with a goal of developing an eradication plan within 5 years. The need for the action was reinforced when, in 2015, mice were confirmed to be feeding on the backs and necks of adult albatross nesting on Sand Island, leading to nest abandonment and mortality of adults, eggs and chicks. The Proposed Action was identified in the PMMP for many reasons, among them the fact that worldwide invasive species are a leading cause of island species extinctions including mammal, bird, reptile, and invertebrates. Forty to sixty % of all recorded bird and reptile extinctions are attributed to invasive rodents.

The USFWS is proposing the Action to protect seabirds and their habitats on MANWR’s Sand Island. The other islands of MANWR, Eastern and Spit, are not included because mice are not currently present on them. The USFWS is planning and would conduct the Action with technical support from Island Conservation (IC) and the Midway Restoration Partnership Group, which is a multidisciplinary stakeholder body including representatives from USFWS, Island Conservation, American Bird Conservancy, U.S. Department of Agriculture (USDA) Animal and Plant Health Inspection Service (APHIS) National Wildlife Research Center (NWRC), the National Oceanographic and Atmospheric Agency (NOAA), U.S. Geological Survey (USGS), and the State of Hawaiʻi Office of Hawaiian Affairs.

Removing mice would improve the MANWR’s ability to restore the natural island ecosystem, benefitting native coastal plants and insects. The proposed action would improve seabird nesting habitat and could aid in the recovery of rare seabirds such as the short-tailed albatross

(*Phoebastria albatrus*), Bulwer's petrel (*Bulweria bulwerii*), and Tristram's storm-petrel (*Oceanodroma tristrami*).

The proposed action involves the aerial broadcast of bait pellets containing rodenticide into all potential mouse territories on Sand Island along with supplemental hand broadcasting of bait in sensitive areas (e.g., narrow shorelines) and placing bait stations in commensal areas. The USFWS also considered other alternatives and methods to eradicate mice on Sand Island but these were dismissed from analysis since they failed to meet the purpose and need of the project. Mouse eradication would occur in the summer dry season to maximize the probability of success by targeting mice when their food resources are lowest and their abundance is declining.

Conducting the operation during this period would also minimize the risk of rain washing rodenticide pellets into the ocean and is also a period of low winds, which makes bait application easier to control. It is also the time of year when relatively few wintering shorebirds, which may be susceptible to primary and secondary poisoning, are present; relatively few seabirds are also present at this time because the majority have completed breeding and have left the island. The lower numbers of seabirds present on MANWR at this time of year also reduces, but does not eliminate, the potential for collisions between operational aircraft and seabirds.

The endangered Laysan duck, a year-round resident species, would be present at this time. Also, several species of water and land birds may be present during implementation. Protective measures would be implemented to avoid and minimize impacts to them. This EA evaluates the likelihood and magnitude of these incidental bird mortalities, and decribes the avoidance and minimization measures that will be implemented to reduce bird mortalities. This EA will also be used for consultation under Section 7 of the Endangered Species Act and for consulting with NOAA related to Essential Fish Habitat.

The USFWS is responsible for the final decision on the Action along with the plans for implementation and monitoring. The USFWS anticipates that the Proposed Action would have a less than significant adverse impact on the environment when it is conducted as outlined in this EA, including the implementation of the avoidance, minimization, and mitigation policies and actions.

Project:	Midway Seabird Protection Project
Agency:	U.S. Fish and Wildlife Service Papahānaumokuākea Marine National Monument 300 Ala Moana Boulevard, Room 5-231 Honolulu, Hawai‘i 96850 Submit Comments to: Midway_Comments@fws.gov
Cooperating Agencies:	USDA APHIS NWRC
Affected Location:	Sand Island, MANWR, Northwestern Hawaiian Islands
Proposed Action:	Eradication of invasive mice on Sand Island, MANWR via rodenticide.
Island & Project Area:	1,128 acres (456.5 hectares)
Required Permits & Approvals:	• National Environmental Policy Act (NEPA) Environmental Assessment • Section 7, Endangered Species Act (ESA) • Section 106, National Historic Preservation Act (NHPA) • Essential Fish Habitat • Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) Supplemental Label • National Pollutant Discharge Elimination System (NPDES) Permit • Marine National Monument Permit
Anticipated Determination:	No Significant Impacts
Parties Consulted:	See Chapter 7.0
Consultants:	Hamer Environmental Planning Solutions, Inc.

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ACRONYMS AND ABBREVIATIONS

Acronym	Phrase
a.i.	Active Ingredient
ARFF	Aircraft Rescue and Fire Fighting
ARMCO	1942 Battle of Midway structure (hut)
ASAP	Alien Species Action Plan
AST	Above-ground Storage Tank
BASH	Bird Aircraft Strike Hazard
BMP	Best Management Practices
BOQ	Bachelor Officer Quarters
CAMU	Corrective Action Management Unit
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
COPC	Chemicals of Potential Concern
CR	Critically Endangered
D	Dose
dB	Decibels
DNL	Day-Night Average - Noise Level
EA	Environmental Assessment
EC50	Half Maximal Effective Concentration (of a toxicant; measured in ppm)
EIS	Environmental Impact Statement
EPNdB	Effective Perceived Noise Level (in decibels)
EO	Executive Order
ESA	Endangered Species Act of 1973
ETOPS	Extended Twin-Engine Operations
FAA	Federal Aviation Association
FIRFA	Federal Insecticide, Fungicide and Rodenticide Act
FOD	Foreign Object Debris
FONSI	Finding of No Significant Impact
GIS	Geographic Information System
GPS	Global Positioning Satellite
HDLNR	Hawai‘i Department of Land and Natural Resources
IUCN	International Union for Conservation of Nature
L	Lethal
LD_{50}	Lethal Dosage of a toxin to 50 % of laboratory tested animals; measured in mg (D)/kg of animal body weight
LOAEL	Lowest Observable Adverse Effect Level
LUC	Land Use Controls
MANWR	Midway Atoll National Wildlife Refuge/Battle of Midway National Memorial
MBTA	Migratory Bird Treaty Act
MG	Million Gallon
MMPA	Marine Mammal Protection Act
MSL	Mean Sea Level

Acronym	**Phrase**
NAF	Naval Air Facilities
NEPA	National Environmental Policy Act
NGO	Non-governmental Organization
NHPA	National Historic Preservation Act
NISA	National Invasive Species Act
NISC	National Invasive Species Council
NOAEL	No Observable Adverse Effect Level
NT	Near Threatened
NWHI	Northwestern Hawaiian Islands
NWR	National Wildlife Refuge
NWRC	National Wildlife Research Center/Complex
NWRS	National Wildlife Refuge System
OBWLF	Old Bulky Waste Landfill
OSHA	Occupational Safety and Health Administration
PCB	Polychlorinated Biphenyl
pH	Potential of Hydrogen
PMDY	Henderson Field Airport International Air Transport Assoc. Airport Code
PMMP	Papahānaumokuākea Monument Management Plan
PMNM	Papahānaumokuākea Marine National Monument
PPE	Personal Protection Equipment
ppm	Parts Per Million
RCRA	Resource Conservation and Recovery Act
SARA	Superfund Amendments and Reauthorization Act
SMP	Structure Management Plan
TACA	Toxic Substances Control Act
USC	United States Code of Laws
USDA	U.S. Department of Agriculture
USEPA	United States Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
UST	Underground Storage Tank

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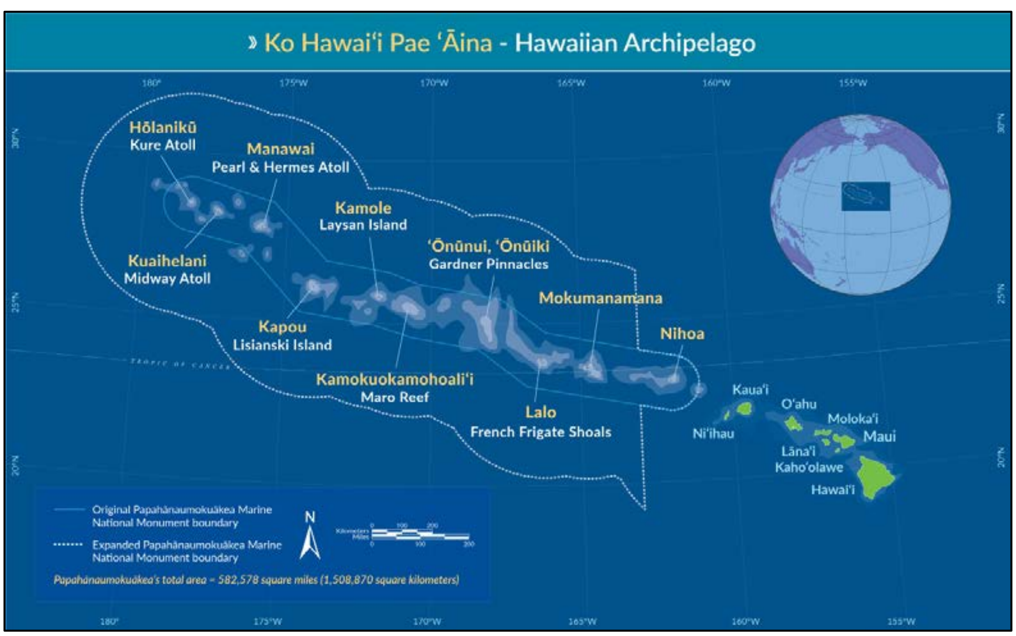
CHAPTER 1: PURPOSE AND NEED

1.1 INTRODUCTION

This Environmental Assessment (EA) evaluates the potential environmental effects of one action alternative and the No Action Alternative for mouse eradication on Sand Island, Midway Atoll National Wildlife Refuge (MANWR). The MANWR is located within the Papahānaumokuākea Marine National Monument (PMNM), located in the Northwestern Hawaiian Islands (NWHI) (see Figure 1.1, Figure 1.2, and Figure 1.3). Over 3 million birds, encompassing 25 different species, can be found on MANWR's 3 islands and all of them are susceptible to predation by mice. MANWR is home to the largest albatross colony in the world and is the most important and successful breeding ground for black-footed albatross (*Phoebastria nigripes*) and Laysan albatross (*Phoebastria immutabilis*). The NWHI are, respectively, home to approximately 97.5 and 99.7% of the total worldwide population of these 2 species, and both of these species are considered "near threatened" (NT) by the International Union for Conservation of Nature (IUCN). MANWR alone is globally significant, supporting 36% of all Black-footed albatross and 73% of all Laysan albatross. Sand Island alone has approximately 360,000 pairs of Laysan albatross and 15,084 pairs of black-footed albatross. As of 2004, MANWR also now hosts a translocated population of Laysan ducks (*Anas laysanensis*), which are considered "critically endangered" (CR) by the IUCN and is listed as endangered under the Endangered Species Act of 1973 (ESA), as amended.

This draft EA will be used by U.S. Fish and Wildlife Service (USFWS) to solicit public input and determine whether implementation of the alternatives would have a significant impact on the environment. This EA is part of the USFWS decision-making process in accordance with the National Environmental Policy Act (NEPA), as amended and its implementing regulations.

Figure 1.1 Location Map

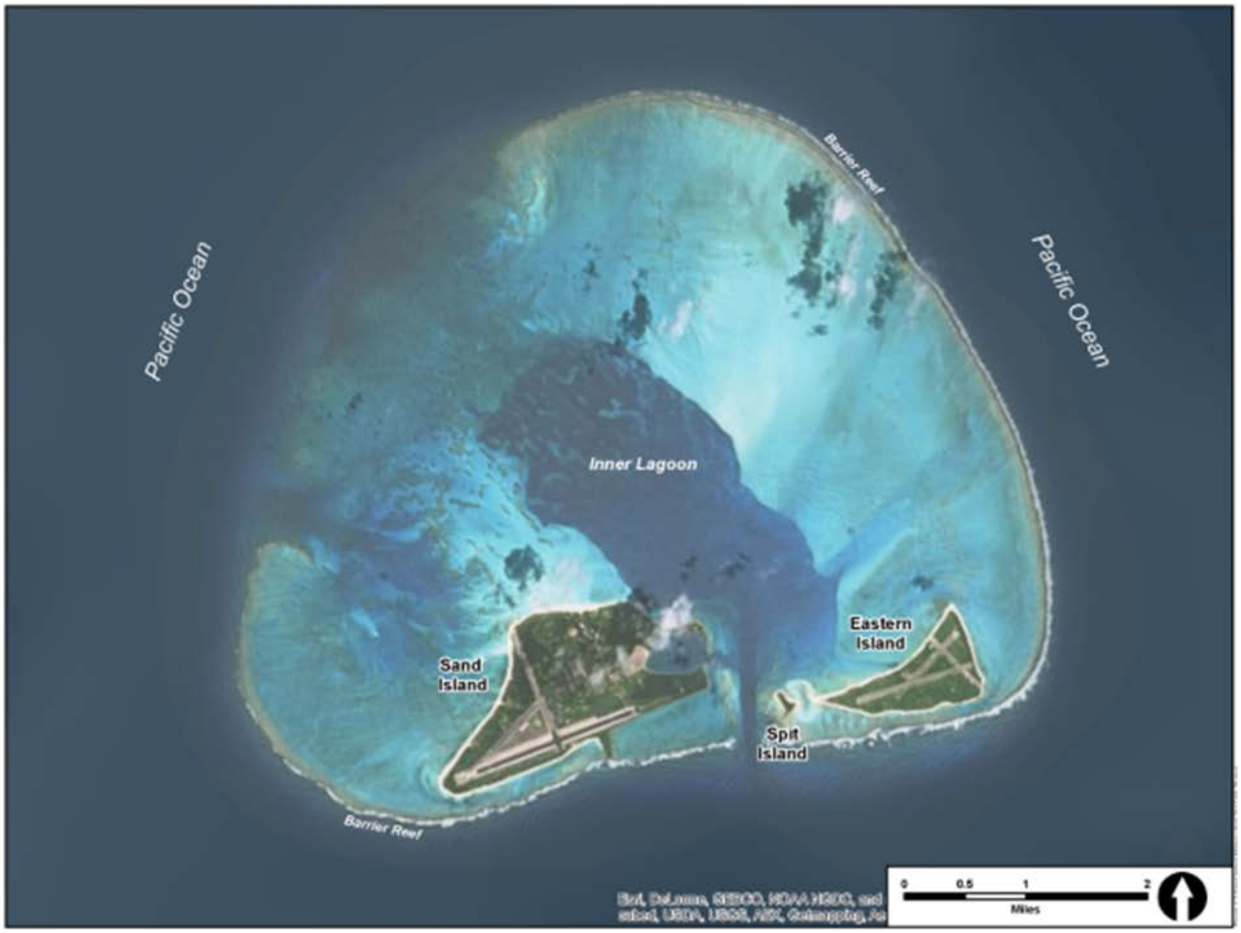


Source: https://www.papahanaumokuakea.gov/visit/ (2017)

1.2 PURPOSE OF THE ACTION

The purpose of the proposed action is to implement Strategy AS-4 from the PMMP and completely eradicate the invasive house mouse from Sand Island within the MANWR and to maintain its rodent-free status in perpetuity. To eradicate invasive mice, a lethal dose of rodenticide would be delivered to every rodent on the island in a manner that minimizes harm to island residents and the ecosystem while still maintaining a high probability of successful eradication.

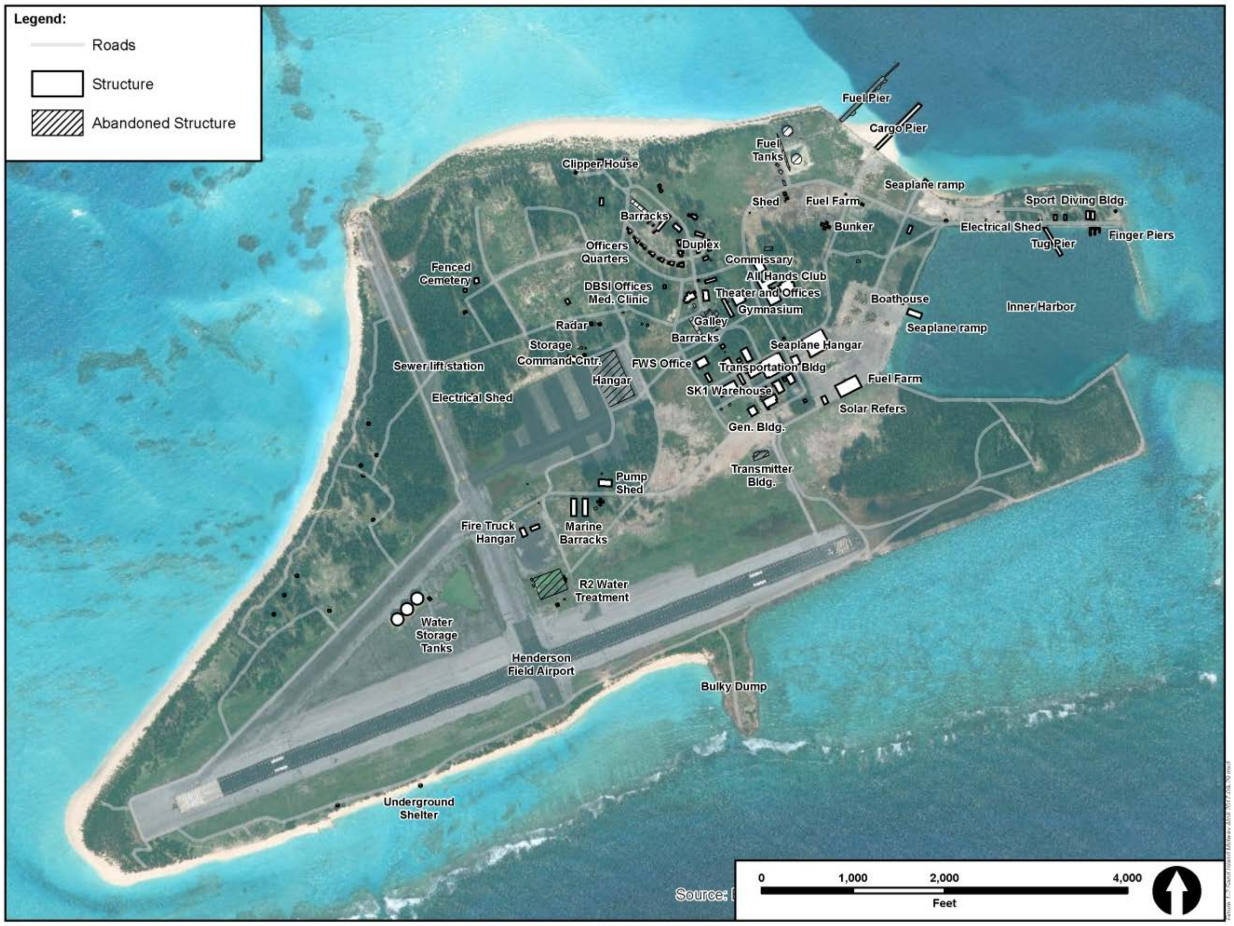
Figure 1.2 Midway Atoll National Wildlife Refuge (MANWR)



Source: Planning Solutions, Inc. (2017)

Within 1 year of project implementation, non-native mice will be eradicated (population = 0) from Sand Island on Midway Atoll National Wildlife Refuge for the benefit and protection of nesting albatross species (e.g., Laysan, short-tailed, and black-footed), other nesting seabirds (e.g., Bonin Petrel), and their habitats.

Figure 1.3 Sand Island, MANWR



Source: Planning Solutions, Inc. (2017)

1.3 NEED FOR THE ACTION

1.3.1 EFFECTS OF INTRODUCED INVASIVE SPECIES ON ISLANDS

Worldwide, invasive species are causing negative ecological and economic impacts. The impacts from invasive predatory mammals, including mice and rats, are one of the leading causes of species extinction on islands (Blackburn et al. 2004; Duncan and Blackburn 2007). The extinction of many island species of mammal, bird, reptile, and invertebrate have been attributed to the impact of invasive rodents (Andrews 1909, Atkinson 1985, Daniel and Williams 1984, Hutton et al. 1984, Tomich 1986), with estimates of between 40-60% of all recorded bird and reptile extinctions globally being directly attributable to invasive rodents (Atkinson 1985).

1.3.2 EFFECTS OF INTRODUCED MICE ON MANWR

Invasive house mice and black rats (*Rattus rattus*) became established on MANWR's Sand Island more than 75 years ago during military occupancy. Black rats were eradicated in 1996 and house mice are now the sole rodent and invasive mammal present in the NWHI.[1] Mouse predation of albatross on Sand Island was first identified in 2015 and the area where mouse predation occurs and the number of birds bitten has been observed to increase with each successive year. Mice were confirmed as the ultimate cause of death for bitten Laysan albatross during the 2015/2016 breeding season on MANWR with 42 dead adults and 70 nests abandoned in a 4 ac. (1.6 ha) area. Time lapse photography recorded mice repeatedly crawling onto and biting the head, neck, and backs of adult birds (see Figure 1.4 and Figure 1.5). Necropsy and histopathology results from recovered carcasses indicate bacterial infection from wounds as the cause of death (USGS, National Wildlife Health Center, Honolulu). This same phenomenon was again present in the 2016/2017 breeding season with a 6-fold increase in the number of affected albatross to 242 dead adults, 1,218 bitten birds, and 994 abandoned nests and site locations from 3 to 50 distinct areas, as well as an expansion of total affected area from 4 acres to 27 acres (11 ha) (USFWS, Unpublished b). Mouse attacks declined in 2017/2018, however, the reason for the decline is not known. A combination of environmental conditions, the cyclical nature of mouse populations, and active management to reduce attacks are thought to have played a role.

Beyond the predation of seabirds, rodents have deleterious effects on entire island ecosystems. Briefly summarized, they:

- Are a disease vector.
- Feed opportunistically on plants and alter the floral communities of island ecosystems (Campbell and Atkinson 2002). Their feeding competes with native species and in some cases degrades the quality of nesting habitat for birds that depend on the vegetation (Wegmann 2009, Young et al. 2010).
- Prey upon terrestrial invertebrates and reptiles, affecting the abundance and age structure of intertidal invertebrates directly (Navarrete and Castilla 1993).
- Have been demonstrated to lower total soil carbon, nitrogen, phosphorous, mineral nitrogen, marine-derived nitrogen, and pH relative to rodent-free islands (Fukami et al. 2006).
- Affect invertebrate and marine algal abundance, changing intertidal community structure from an algae-dominated system in rodent free areas to an invertebrate dominated system in rodent-invaded areas (Kurle et al. 2008).

[1] The 1996 eradication effort was geared solely towards black rats and was not intended to eliminate house mice.

Figure 1.4 Adult Laysan albatross on Sand Island showing effects of predatory mice

Source: USFWS (2016)

Figure 1.5 Mouse biting the head of Adult Laysan albatross on Sand Island

Source: USFWS (2016)

A comparison of rodent-infested and rodent-free islands, and pre- and post-rodent eradication projects have shown that rodents depressed the population size and recruitment of birds (Campbell 1991, Jouventin et al. 2003, Thibault 1995), reptiles (Bullock 1986, Cree et al. 1995, Towns 1991, Whitaker 1973), plants (Pye et al. 1999), and terrestrial invertebrates (Bremner et al. 1984, Campbell et al. 1984). In an analysis by Brooke et al. (2017), drawing on data of eradication of non-native mammals on islands from around the world, they examined the population growth rates (lambda) of 181 seabird populations of 69 seabird species following successful mammal eradication projects. Rate of growth (lambda) is the ratio of population size at the end of one interval to population size at the end of the previous interval. When lambda = 1.0 the population density is stable while values >1.0 indicate increasing populations. After successful eradication, the median population growth rate (lambda) was 1.119 and seabird populations with positive growth rates greatly outnumbered those in decline. Their study confirmed that invasive mammal eradication is usually followed by growth of seabird populations.

Predation of vulnerable populations of native seabirds is a real and ongoing threat on Sand Island and demands an immediate and effective response. Eradication of the house mouse from MANWR would also facilitate the protection and restoration of multiple native species and habitats present in the refuge.

1.3.3 MANWR ECOSYSTEM MANAGEMENT AND CONSERVATION PLANS

1.3.3.1 Papahānaumokuākea Monument Management Plan (PMMP)

The PMMP, completed in December 2008, was the result of an extensive public review process and identified 6 priority management needs, with supporting action plans and corresponding desired outcomes, for the PMNM. The 6 priorities were (PMMP, ES-3 to ES-5):

1. *Understanding and Interpreting the Northwestern Hawaiian Islands;*
2. *Conserving Wildlife and Habitats;*
3. *Reducing Threats to Monument Resources;*
4. *Managing Human Uses;*
5. *Coordinating Conservation and Management Activities; and*
6. *Achieving Effective Monument Operations.*

As evidenced by these priorities, protecting the land and waters of the NWHI from the impacts of alien species is critical to achieving the Monument's primary goal of resource protection. A specific component of Priority 3 was the development of an *Alien Species Action Plan* (ASAP). The ASAP advanced a series of strategies to address and mitigate the ongoing effects of invasive alien species on the PMNM. Specifically, the ASAP identified the eradication of the house mouse on Sand Island, MANWR as Strategy AS-4 (see Table 1.1).

Table 1.1 Strategy AS-4 of the PMMP

Strategy AS-4: Eradicate the house mouse population on Sand Island, Midway Atoll, within 15 years.
After the eradication of the black rat (Rattus rattus) at Midway Atoll and the Polynesian rat (Rattus exulans) at Kure Atoll, the house mouse (Mus musculus) on Sand Island, Midway, remains the only invasive mammal left in the NWHI. Mice can cause high mortality in seabirds as large as albatrosses (Wanless et al. 2007). In addition, Midway now hosts a translocated population of endangered Laysan ducks that are likely to be negatively affected by the high mouse populations. Mice are also a threat to native plants and terrestrial invertebrates.
Activity AS-4.1: Produce a house mouse eradication plan within 5 years and procure appropriate permits for chosen eradication techniques.
The eradication of introduced rodents from islands is routine, and the successful removal of black rats at Midway Atoll in recent years has provided a model for mouse eradication. Mice present additional challenges, however, as they have much smaller home range sizes and different foraging and reproductive ecology. A careful planning effort that emphasizes the minimization of effects to nontarget organisms at the site and the other biological differences that may affect the operation is necessary.
Activity AS-4.2: Implement and complete house mouse eradication.
All of Sand Island 1,128 acres (456 ha) will be treated with rodenticide, with active management to prevent nontarget impacts to native wildlife. Surveys of the affected ecosystem components before and after the operation will provide a valuable demonstration of the effects of introduced mice on biological communities.
Source: Alien Species Action Plan, *Papahānaumokuākea Monument Management Plan* (USFWS, December 2008)

One reason the PMMP-ASAP identified Strategy AS-4 was Wanless et al.'s (2007) observations that mice can and will predate seabirds once their competitors are removed. During the preparation of the PMMP, Wanless et al. (2007) observed mice depredating on Tristan albatross (*Diomedea dabbenena*) and Atlantic petrels (*Pterodroma incerta*) on Gough Island in the South Atlantic Ocean. Based on their experience on Gough Island, they suggested that once mice are released from the ecological effects of other predators and competitors (e.g., on Sand Island, MANWR where rats have been removed and mice are the sole alien mammal), the mice may begin to predate seabird chicks. Since completion of the PMMP in 2008, Wanless et al.'s predictions have been shown to be accurate on Sand Island, MANWR where mice are now the sole alien mammal.

1.3.3.2 Conservation Action Plan for Black-footed albatross and Laysan albatross

In a multi-agency report on conservation action plans for the black-footed albatross and Laysan albatross (Naughton et al. 2007), the authors state that one of the primary threats to these 2 species is predation by introduced mammals. The authors recommended a conservation action to eradicate house mice from MANWR to protect these 2 species of seabirds.

1.3.3.3 U.S. Fish and Wildlife Service Regional Seabird Conservation Plan

In addition, the USFWS Regional Seabird Conservation Plan (USFWS 2005) identified the eradication or control of introduced predators and other invasive species that have a negative impact on seabirds as one of the top priorities for seabird conservation. They specifically recommend eradicating introduced predators in the Pacific Islands where the Laysan and black-footed albatross breed or have historically bred.

1.4 REGULATORY REQUIREMENTS

The proposed action of eradicating invasive mice on Sand Island, MANWR by the USFWS, Papahānaumokuākea Marine National Monument, constitutes a Federal action, which makes it subject to review under the National Environmental Protection Act (NEPA) and other applicable statutes, regulations, and EOs. USFWS is required to integrate and consider the potential environmental effects that its actions may have on the human and natural environment prior to taking action. It accomplishes this by evaluating the environmental consequences of proposals to ensure that environmental values are given appropriate consideration in agency decision-making along with economic and technical factors within the agency's mission.

This EA has been prepared in consultation with other agencies, private organizations, and the public. If, after circulating the report for public and agency comment, USFWS finds that the proposed project would not have a significant adverse effect on the quality of the environment, it would prepare a Finding of No Significant Impact (FONSI). Notification of the EA and FONSI will be available at:

https://www.papahanaumokuakea.gov

If at any point in the preparation of an EA, USFWS determines that the proposal would have a significant adverse effect on the quality of the environment, it would initiate preparation of an Environmental Impact Statement (EIS).

In addition to NEPA, other applicable laws and regulations include Section 7 of the Endangered Species Act (ESA) of 1973, Essential Fish Habitat under Magnuson-Stevens Conservation and Management Act and the Migratory Bird Treaty Act (MBTA) of 1918. Specific Federal laws that apply in addressing alien species and invasive species in the NWHI, in addition to the ESA, include the Lacey Act of 1900, as amended (18 USC 42, 16 USC 3371), and the National Invasive Species Act (NISA) of 1996. This EA is intended to address and satisfy many, but not all, of the above requirements. A full list of compliance needs for this project can be found in Chapter 8.

The Magnuson-Stevens Act mandates that Federal Agencies conduct an Essential Fish Habitat (EFH) consultation with NOAA Fisheries regarding any actions authorized, funded, or undertaken that may adversely affect EFH. This EA serves as a basis for EFH impact review and consultation for the proposed action to eradicate mice at MANWR.

The USFWS's resource managers are authorized, and mandated by law, to conserve and restore wildlife and habitats that are under the agency's jurisdiction. With a mission to work collaboratively with others to "conserve, protect, and enhance fish, wildlife, and plants and their habitats for the continuing benefit of the American people," it is the responsibility of USFWS to address any threats that introduced species pose to the habitat and native wildlife of MANWR. Eliminating invasive mice from MANWR's Sand Island is pertinent to the management strategy of USFWS for the refuge.

The proposed action would be carried out in compliance with various Federal laws, EOs, and legislative acts including:

- National Wildife Refuge System Improvement Act of 1997 (Public law 105-57);

- The Fish and Wildlife Act of 1956 (16 U.S.C. 742a-742j, not including 742 d-l, 70 Stat. 1119), as amended;
- National Environmental Policy Act of 1969 (NEPA);
- Endangered Species Act (ESA) of 1973 (16 U.S.C. 1531-1544, 87 Stat. 884);
- Migratory Bird Treaty Act of 1918 (MBTA)[2];
- EO 13186 Responsibilities of Federal Agencies to Protect Migratory Birds (66 FR 3853, Jan. 17, 2001);
- Marine Mammal Protection Act of 1972 (MMPA), as amended;
- Magnuson-Stevens Fishery Conservation and Management Act and Essential Fish Habitat;
- EO 13089 Coral Reef Protection (June 11, 1998);
- Water Pollution Control Act of 1948, as amended;
- EO 13112 Invasive Species as amended 12/08/2016 by E0 13751;
- National Historic Preservation Act of 1966 (NHPA);
- Federal Insecticide, Fungicide, and Rodenticide Act of 1947 (FIFRA); and
- Papahānaumokuākea Marine National Monument 50 CFR Part 404 – Permit Requirement.

1.5 PROJECT PARTICIPANTS

1.5.1 U.S. FISH AND WILDLIFE SERVICE (USFWS), - LEAD AGENCY

The U.S. Fish and Wildlife Service is a bureau of the U.S. Department of Interior that works with others to conserve, protect, and enhance fish, wildlife, and plants and their habitats for the continuing benefit of the American people. The National Wildlife Refuge System within the USFWS has primary jurisdiction and statutory authority for management of MANWR resources, thus it is the Lead agency for this Seabird Protection Project.

MANWR is part of the Papahānaumokuākea Marine National Monument, the largest contiguous fully protected conservation area under the U.S. flag, and one of the largest marine conservation areas in the world. It encompasses 582,578 square miles (mi^2) (1,508,870 square kilometers [km^2]) of the Pacific Ocean, an area larger than all the country's national parks combined. The Northwestern Hawaiian Islands Marine National Monument was established by Presidential Proclamation 8031 on June 15, 2006 under the authority of the Antiquities Act (16 U.S.C. §431-433). A year later, it was given its Hawaiian name, Papahānaumokuākea under Presidential

[2] The Department of the Interior Solicitor's Office issued a binding opinion (M-Opinion) on December 22, 2017 (Memorandum M-37050) which states that a permit is not required for incidental take of migratory birds. Therefore, an MBTA permit will not be sought. However, this document does analyze the effects to migratory birds and avoidance and minimization measures that will be implemented as part of the USFWS' responsibility to conserve the trust resource of migratory birds (See 1.4.5)

Proclamation 8112. The Monument was expanded by Presidential Proclamation 9478 on August 26, 2016. It was expressly created to protect an exceptional array of natural and cultural resources. The stated mission of PMNM is to carry out seamless integrated management of the monument to ensure ecological integrity and achieve strong, long-term protection and perpetuation of NWHI ecosystems, Native Hawaiian culture, and heritage resources for current and future generations.

1.5.2 U.S. DEPARTMENT OF AGRICULTURE, ANIMAL AND PLANT HEALTH INSPECTION SERVICE, WILDLIFE SERVICES (WS) AND THE NATIONAL WILDLIFE RESEARCH CENTER (NWRC) - COOPERATING AGENCY

The mission of USDA APHIS Wildlife Services (WS) is to provide Federal leadership and expertise to resolve wildlife conflicts to allow people and wildlife to coexist. WS conducts program delivery, research, and other activities through its Regional and State Offices, the NWRC and NWRC Field Stations, as well as through its National Programs. The NWRC is the federal institution devoted to resolving problems caused by the interaction of wild animals and society. The NWRC applies scientific expertise to the development of practical methods to resolve these problems and to maintain the quality of the environments shared with wildlife. NWRC has special expertise with respect to this proposed project and has agreed to be a Cooperating Agency.

NWRC actions in this project include:

- NWRC might be considered for the chemical analysis of pre- and post-application brodifacoum residues in rodents or non-target animals. NWRC's involvement would be limited to receiving samples from Midway project managers, conducting laboratory-based chemical analysis, and disposing of biological and chemical waste resulting from the analytical process in the NWRC waste management program.
- The NWRC Registration Unit will, with direction from the Midway project planners, conduct all activities associated with preparation of a specific label for the APHIS rodenticide product Brodificoum 25D Conservation (EPA Reg. No. 56228-37) used for the mouse eradication attempt, submission of the supplemental registration application to the Environmental Protection Agency and all communication required to obtain a registration approval.

1.5.3 MEMORANDUM OF UNDERSTANDING (MOU) BETWEEN ISLAND CONSERVATION, USDA (APHIS), AMERICAN BIRD CONSERVANCY AND THE USFWS

In April 2015, the USFWS entered into agreement with Island Conservation for the "purpose of furthering wildlife conservation and ecosystem management interests and responsibilities for the islands, atolls, and reefs under the jurisdiction of the United States." This partnership promotes an integrated and coordinated approach to protecting, restoring and managing native populations of plants and animals and island ecosystems impacted by invasive alien species including but not limited to rodents, ants, cats and plants. In 2016, 2 additional parties were added to this national level agreement, including APHIS and the American Bird Conservancy.

1.5.4 ISLAND CONSERVATION

Island Conservation (IC) is an active partner in this Seabird Protection Project under the MOU. IC is a non-profit organization with the mission "to prevent extinctions by removing invasive species from islands." Working in partnership with local communities, government management agencies, and conservation organizations, Island Conservation seeks to identify islands that have the greatest potential for preventing extinction of globally threatened species classified as Critically Endangered or Endangered (i.e., CR or EN) on the IUCN's Red List of Threatened Species. Island Conservation develops plans for, and implements the removal of, invasive alien species and conducts field research to document the environmental effects of this work in order to inform the planning and execution of future conservation projects.

Island Conservation seeks to prevent extinctions by focusing its efforts on islands where the concentration of biodiversity, and consequently the threat of species extinction, is greatest. Of the 245 recorded animal extinctions since 1500 AD, 80% were on islands. Of those, in cases where causes could be identified, non-native and invasive species were responsible for 54% of these extinctions. Eradicating the primary threat—introduced invasive vertebrates—is one of the most critical and effective means for preserving threatened populations of plants and animals and restoring island ecosystems. To date, Island Conservation has deployed teams to protect 994 populations of 389 species on 52 islands.

1.5.5 MIDWAY RESTORATION PARTNERSHIP

For the Midway project, and consistent with the National MOU, Island Conservation formed a partnership team with a variety of regulatory agencies and conservation organizations to provide individual input and project support in the planning phase of the mouse eradication. Participants in the Midway Restoration Partnership include the USFWS; USDA, APHIS WS and NWRC; NOAA; U.S. Geological Survey; Office of Hawaiian Affairs; and the American Bird Conservancy.

1.6 ORGANIZATION OF THE EA

The remainder of this document is organized as follows:

- Chapter 2 describes the proposed action and its alternatives in detail, including those alternatives that were initially considered but ultimately rejected from further evaluation.
- Chapter 3 provides information regarding the existing environment and identifies the kinds of environmental effects which each alternative is likely to have.
- Chapter 4 discusses the potential for cumulative effects.
- Chapter 5 lists the agencies, organizations, and individuals who prepared and contributed to this report.
- Chapter 6 provides the references for the information sources that were relied upon during preparation of this report.

- Chapter 7 describes the scoping process which was implemented during the planning process.
- Chapter 8 includes a statement of the project's consistency and compliance with relevant laws, EOs, agency policies and permits.
- Chapter 9 provides a glossary of terms.

CHAPTER 2: DESCRIPTION OF THE PROJECT AND ALTERNATIVES

This chapter provides detailed information about the Proposed Action and alternatives to the Proposed Action, including those alternatives that were initially considered but ultimately rejected from further evaluation because they did not meet the project objectives outlined in Section 1.2. It also describes the procedures that would be used in the implementation of the project, methods, estimated costs, and the anticipated schedule for project implementation.

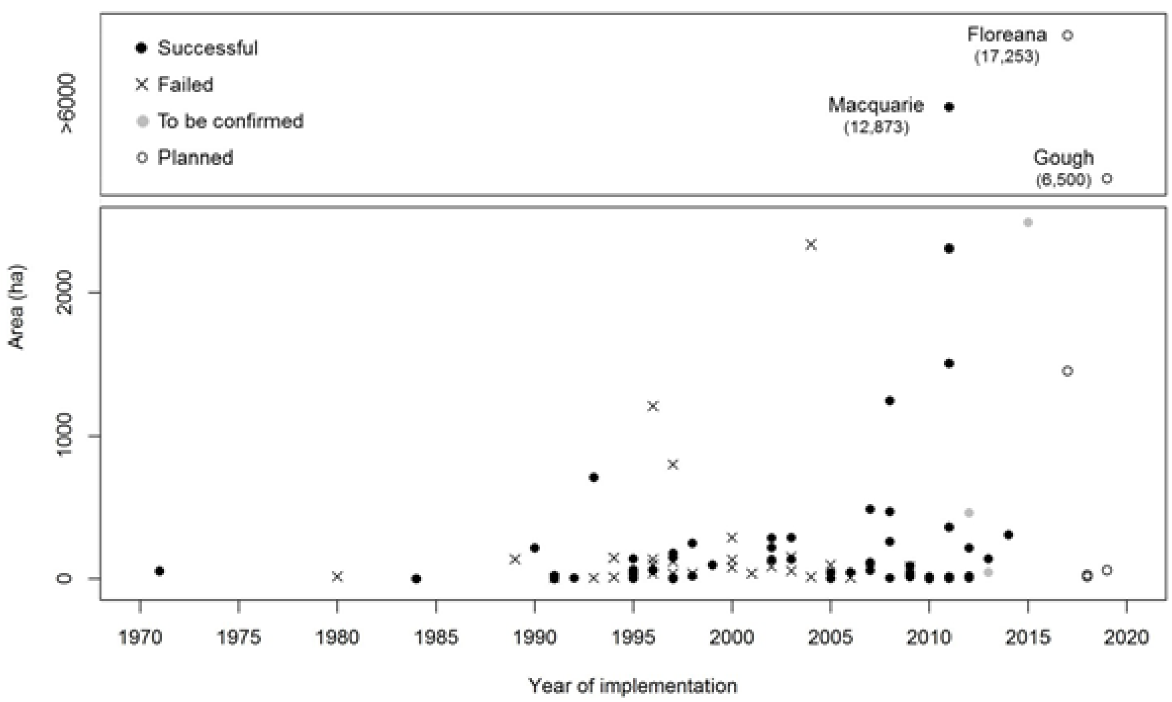
The information contained in this chapter draws from the *Feasibility Study: House Mouse Eradication on MANWR* (Island Conservation 2017), including the discussion of methods and potential alternatives. Sections 2.1 and 2.2 provide principles and considerations that all alternatives must address to fulfill the project's objectives. Section 2.3 presents the details of the proposed action; Section 2.4 outlines the No Action Alternative; and Section 2.5 discusses the alternatives that have been considered but rejected.

2.1 PRINCIPLES OF RODENT ERADICATION IN ISLAND ECOSYSTEMS

Rodent eradication has become a common tool for agencies charged with the maintenance and management of island ecosystems, and its use to protect and conserve threatened species and ecosystems has increased significantly over the past decade. By 2015, there were 944 documented attempts at rodent eradication—across 10 different rodent species—on 692 islands globally (Samaniego-Herrera 2016). In total, 87 (9.2%) of those attempts were specifically related to mouse eradication; these attempts were reported from 76 islands in 17 countries (Samaniego 2016). Most of these mouse eradication attempts were in the temperate region, with only 32 of the 87 (36%) of them being mouse eradication attempts on tropical islands.

Island size does not appear to be a limiting factor for successful eradication. Eradication attempts and successful eradication operations have been reported from small offshore islets to very large islands, including the largest known mouse eradication on Macquarie Island at approximately 31,810 acres (12,873 hectares). Mouse eradications are currently being planned or considered for very large islands such as Floreana Island in the Galapagos archipelago (~44,478 ac or 18,000 ha) and Marion Island in South Africa (~82,780 ac or ~33,500 ha) (Parkes 2014). Figure 2.1 below summarizes the outcomes of attempts globally at mouse eradication on islands over time and by island size.

Figure 2.1 Global Mouse Eradication Attempts on Islands Over Time and by Island Size



Source: DIISE 2016; Samaniego 2016 cited in Island Conservation (2017)

While no guarantee of success exists, as evidenced by Figure 2.1, mouse eradication from islands is achievable provided that basic principles of rodent eradication are applied. Attempted mouse eradication from all islands between 1975 and 2015 had an overall success rate of 71%. In comparison, success of rat eradication programs is approximately 87% (Russell and Holmes 2015). The reason(s) behind the lower success rate of mouse eradications is undetermined and has been the subject of several investigations (Samaniego 2016, Mackay 2011). Factors contributing to failure could include some, or a combination of, the following factors: (*i*) natural history differences between rats and mice could make it harder to target the complete population of mice, including their foraging behavior, travel distances, and home range sizes; (*ii*) the fact that mice have been a secondary target of multi-species eradication efforts; or (*iii*) ineffective eradication strategies or management approaches that failed to reach all mice, so that remnant mice remain and recolonize the island.

More recently, 6 of 10 mouse eradication projects on islands greater than 988 ac (400 ha) have been successful. All of these projects were conducted as multi-species eradications, typically known to be more challenging than single-species eradications, and were in temperate regions. Within the tropics, the largest mouse eradication attempt to-date has been on Mer Island (~1,134 ac or 459 ha) and is still being evaluated for success. Of the 3 largest mouse eradication attempts where a positive or negative outcome has been determined (i.e., success or failure), 2 were successful (Samaniego 2016).

Between 2005 and 2015, the success of mouse eradications increased to 93.3% of 31 attempted eradications. This increase in the success rate has been attributed to better international cooperation and knowledge sharing between eradication practitioners regarding lessons learned (Veitch et al. 2002, 2011), and the establishment of best practices principles for the eradication of rodents in temperate (Broome et al. 2014) and tropical ecosystems (Keitt et al. 2015). Today, successful rodent eradications on all but the smallest of islands (i.e., less than ~12 ac or 5 ha) rely on the use of rodenticides, and specifically, anticoagulant rodenticides (Database of Island Invasive Species Eradications [DIISE] 2016).

All successful eradications, regardless of species or location, are based on 3 fundamental principles (Cromarty et al. 2002):

1. Every individual of the target species must be put at risk with the proposed eradication technique(s).
2. The technique(s) employed must remove individuals from the target population at a rate greater than they can breed (i.e., their replacement rate).
3. Immigration of new specimens of the target species must be zero, or effectively managed to zero, by identifying and eliminating immigrant specimens.

These principles have been further developed with specific regard to rat and mouse eradications as summarized in Table 2.1 below (see Howald et al. 2007).

Table 2.1 Principles of Successful Rat and Mouse Eradications

No.	*Principle*
1	Deliver a highly palatable bait containing a toxic rodenticide into every potential rodent territory.
2	Ensure bait is available in enough quantity and for long enough that every mouse has access to a lethal dose.
3	Time the baiting operation to when the rodent population is most likely to consume the bait.
4	The short-term risks and impacts to nontarget wildlife, people, and the environment from disturbance and the rodenticide is minimized wherever possible. The benefits of eradication must outweigh the costs.
5	Biosecurity procedures must be able to sustain the eradication, with effective prevention, detection, and an effective response to any incursion.

Source: Howald et al. 2007 cited in Island Conservation (2017).

The principles outlined in Table 2.1 have been further refined into best practice guidelines for maximizing the probability of successful rodent eradications from temperate islands in New Zealand (Broome et al. 2014) and from tropical islands (Keitt et al. 2015).

2.2 MANWR TECHNICAL CONSIDERATIONS

Island Conservation, in its 2017 *Feasibility Report*, acknowledges that, “the feasibility of an eradication is a multi-dimensional analysis that considers technical, environmental, social, political, and legal factors.” These factors must all be considered, both individually and cumulatively, to determine if, and how, a successful mouse eradication can be achieved at Sand Island, MANWR.

2.2.1 CONSTRAINTS ON SUCCESSFUL ERADICATION

While all rodent eradications from large islands apply the same fundamental set of principles (see Table 2.1 above), the technical approach to each project must be tailored to the unique environmental context, including its wildlife communities, ecosystem function, and landscape features. Because of this, the first step in evaluating the best technical approach consists of identifying the local constraints acting on the operation and how they impact the overall probability of success, as well as the potential for concomitant adverse impacts to the local environment. These constraints have the potential to limit the likelihood of a successful eradication if they are not understood, minimized, mitigated, or eliminated.

The major constraints present on Sand Island, MANWR which must be considered in project design include the presence of manmade structures, underground utilities, native species that inhabit the island, and the resident community. These are discussed in the following sections.

2.2.1.1 Manmade Structures

The built environment on Sand Island is extensive, and is the result of a long history of human habitation and infrastructure development over more than a century. The structures on Sand Island vary in age, construction type, condition, and whether and how they are used. The entire built environment on Sand Island can be divided into one of 3 categories, summarized in Table 2.2 below.

Table 2.2 Manmade Structures on Sand Island, MANWR

Construction	*Category*	*Use*	*Description*
Vertical	Inhabited	Living Spaces	Buildings that provide housing and dining facilities, food storage, and food preparation areas.
		Work Spaces	Buildings that provide offices, utility buildings, covered storage, recreation facilities, covered garden, and nurseries.
	Abandoned	Condemned Spaces	Structures and spaces where human access is restricted or no longer permitted due to physical or other safety reasons.
Horizontal	In-use	Airfield	An active 7,897-foot (2,407 m) long and 151-foot (46 m) wide airfield, certified by the Federal Aviation Administration (FAA).[3] The runway and taxiway is maintained as an emergency landing site for extended twin-engine operations (ETOPS) flights across the Pacific Ocean.
Subterranean (both in use and abandon)		Utilities, Access Points Military Structures	High-voltage service boxes.
			Electrical conduit junction sites.
			Sewer system access points.
			Waterline junction sites and valves.
			Abandoned junction points for water, oil, and electrical services.
Source: Island Conservation (2017).			

All categories comprising the built environment on Sand Island present unique challenges to a successful eradication effort. These 3 categories of infrastructure each require specific strategies to ensure that rodenticide is applied to every potential mouse territory.

[3] In 2004, FAA issued a final rule that revised the Federal airport certification regulation [Title 14, Code of Federal Regulations (CFR), Part 139 (14 CFR Part 139)] and established certification requirements for airports serving scheduled air carrier operations in aircraft designed for more than 9 passenger seats but less than 31 passenger seats. In addition, this final rule amended a section of an air carrier operation regulation (14 CFR Part 121) so it would conform with changes to airport certification requirements. The revised Federal airport certification requirements went into effect on June 9, 2004.

2.2.1.2 Native Species

The presence of wildlife on and around islands targeted for eradication efforts present an inherent challenge. In essence, the operation must be able to deliver bait to every mouse on the island while minimizing the availability of or the exposure to the rodenticide to other non-target species susceptible to it. In addition to the toxicological risks, the operation may also impose disturbances and habitat alterations that could have negative impacts on the ecosystem as a whole.

Although impacts to native species are only ecologically significant if they pose a population-level threat, in principle all risks to wildlife should be avoided, minimized, or mitigated whenever reasonably practicable. As noted in the discussion of principles of successful rodent eradication, the benefits of the effort must outweigh the environmental costs and mitigation strategies must be considered in the tradeoff framework (Broome et al. 2014).

MANWR is of great significance (see Section 3.3.6) to several terrestrial and marine species, including:

- The critically endangered, non-migratory resident Laysan duck.
- The endangered short-tailed albatross (*Phoebastria albatrus*).
- High-density breeding populations of Laysan albatross and black-footed albatross.
- Threatened green sea turtles (*Chelonia mydas*) use the beach for basking and nesting; endangered hawksbill sea turtles (*Eretmochelys imbricate*) may also be present in MANWR but have not been confirmed to bask or nest there.
- Endangered Hawaiian monk seals (*Neomonachus schauinslandi*) that use the beaches and fore-shore vegetation for resting and pupping.

2.2.1.3 Resident Community on Sand Island

Successful island-based rodent eradications have been, for the most part, conducted on remote, uninhabited islands free from permanent human settlements or development. Human settlements, inadvertently, provide food and shelter to rodents. This situation is referred to as “commensal” in that it is used by both humans and rodents; it is a relationship in which the rodents benefit from the presence of the humans while the humans can be largely unaffected by the presence of rodents. This commensal behavior can represent a significant risk to an eradication attempt, decreasing the probability of success. There is precedent to rodent eradications from human inhabited islands—a total of 94 documented cases—but these operations require supplemental treatment strategies such as targeted hand application of baitmechanical devices (e.g., traps) and modification of bait strategies (DIISE 2016). The infrastructure of Sand Island would be no exception.

Local communities are frequently key-stakeholders in island eradication projects and must be considered from the outset where an eradication effort takes place on an inhabited island. The year-round community on MANWR numbers roughly 57 people and includes: (*i*) USFWS staff and volunteers; (*ii*) base operations staff from Chugach Alaska Corp.; and (*iii*) transient contractors or researchers. The community would bear the direct or indirect negative impacts of invasive rodent infestations and stand to benefit from the outcomes of eradication and subsequent restoration efforts. Moreover, these local communities play a significant role in the eradication process and maintaining the rodent-free status of Sand Island, which frequently requires changes in behavior. In brief, their involvement is essential to the success of all effective eradication projects.

2.2.2 BAIT DISTRIBUTION APPROACHES

The only viable approach to completely remove the house mouse from Sand Island, MANWR is the use of rodenticide(s). Other tools and strategies used to control mice were considered but rejected because there is no evidence that they would have a reasonable probability of eradicating mice on MANWR. See Section 2.5 for a more detailed discussion of approaches which were considered but ultimately rejected from further evaluation.

Use of rodenticide requires the delivery of rodenticide-impregnated bait into every potential mouse territory. In order to accomplish this, there are 3 basic methods, and a fourth hybrid method: (*i*) bait stations; (*ii*) hand broadcast; (*iii*) aerial broadcast using a helicopter and bait-sowing bucket; and (*iv*) a combination of the above methods. Each of these methods is described in greater detail in the following subsections.

2.2.2.1 Bait Stations

Bait stations have been used in rodent eradication projects on islands ranging from very small to relatively large (DIISE 2016). Bait stations typically used in island eradications have been either commercially manufactured plastic bait boxes, or plastic pipes, or other similar material. Either design allows rodents to enter the stations freely to access bait placed within it, but prevent larger, non-target species from easily entering and feeding on the bait and greatly extend the longevity of the bait. The major advantage of bait stations is that the bait can be delivered to all mice while preventing most non-target species from gaining access to the station or the poisoned bait within.

For eradication purposes, bait stations are systematically placed on a grid pattern in all habitats across the entire island. Once placed, bait crews would arm and check stations regularly and re-arm each station over a period of months until bait take by rodents declines to zero. Bait stations were previously and successfully used at MANWR in the 1990s to eradicate *R. rattus*. In that effort, bait stations were spaced at ~164 ft. (50 m) intervals with live traps in between, ensuring that at least 2 stations were found in every potential rat home range. Due to smaller territory size when targeting mice, bait stations would need to be at smaller intervals.

2.2.2.2 Broadcast

In the 1990s, island managers began to explore more efficient techniques to undertake eradications more quickly and on larger islands, and adopted methods of broadcasting rodenticide impregnated bait using both hand broadcast and aerial broadcast (see additional discussion below). Bait, in the form of cylindrical or spherical pellets, is broadcast evenly across the landscape at a prescribed application rate calculated as kilograms per hectare or pounds per acre (i.e., kg/ha or lbs./ac.) so that all rodents have access to it for long enough to find the bait, overcome any neophobia, and consume a lethal dose.

A strategy which broadcasts bait across the island, whether by hand, helicopter, or both can achieve success in a significantly shorter timeframe than with bait stations as it exposes all target individuals at one time and avoids the risk of neophobia related to animals entering bait stations.

2.2.2.2.1 Hand Broadcast

Broadcast of bait by hand is the second most-documented approach to island rodent eradication efforts (DIISE 2016). Bait is typically distributed by a team of baiters who systematically walk on parallel transects, stopping at predetermined intervals to distribute pellets as evenly as possible in a quadrant or circle.[4] As the end of one transect is approached, the teams move over to the next transects and start anew, treating the entire area of the island in a “rolling front”.

For successful hand broadcast of bait, significant advance preparation is required to ensure efficient application and to minimize delays and errors in bait application. Complexity increases with the size of the land area and the topography of the island being treated. Transects through heavy vegetation would be opened using mechanical or hand tools to create a path to all baiting points in advance, and each broadcast point would be marked using flagging or pins, and recorded by global positioning system (GPS) technology. Bait must also be staged at various accessible locations across the island to minimize the time and effort needed for baiters to refresh their supplies as they progress across the treatment transects.

2.2.2.2.2 Aerial Broadcast

Aerial broadcast for rodent eradication projects involves using a commercial-grade bait bucket slung under a helicopter, guided by GPS to evenly distribute bait across the entire area of the island. The set rate at which the bait exits the bucket, the width of the treatment swath, and flight speed are calibrated to achieve a desired application rate. The pilot is guided by a computer connected to a GPS and guidance system to keep the helicopter on pre-programmed bait application flight lines. The bait flow from the bucket is controlled by the pilot at all times, opening and closing the bait bucket on demand to apply bait in desired areas and minimize bait application in other areas, such as the marine environment. The hopper can be fitted with a deflector to broadcast bait out to one side, allowing the helicopter to fly parallel to and along the shoreline with minimal unintentional bait applications. Bait application along the shoreline can be accomplished with minimal bait drift into the marine environment with the use of a deflector.

The infrastructure on MANWR, provides a highly suitable base from which to implement an aerial broadcast operation. This includes support equipment for loading bait and large operational areas for loading and refueling. The airfield services available there include: (*i*) equipment staging; (*ii*) aircraft storage; (*iii*) fuel supply; and (*iv*) necessary fire, medical, and support infrastructure.

[4] See: http://rce.pacificinvasivesinitiative.org

2.2.2.3 Summary

Table 2.3 below summarizes the relative advantages and disadvantages of the 3 methods of bait application discussed in the preceding sections.

Table 2.3 Summary of Technical Considerations

Method	*Advantages*	*Disadvantages*
Bait Stations	• Requires least total bait. • Controlled bait delivery. • Lower mobilization of bait into ecosystem. • Easier removal of residual bait when effort concluded. • Lower risk of primary exposure to non-target species. • Limits requirement for specialized skills.	• Rodents are often neophobic and take time to enter bait stations. • Difficult to ensure all rodents have access to bait. • Labor intensive and significan set up time. • Presents logistical challenges and safety risks related to managing a large team conducting repetitive and demanding physical labor and accessing all parts of the island. • Relatively slow, with total eradication requiring a period of between several months to several years. • Non-target species are exposed to secondary risks for a prolonged period. • Requires a very large number of bait stations and access trails to bait stations with prolonged impact to vegetation. • Prolongs potential for direct impacts to ground-nesting seabirds and seabird burrows and repeated disturbance to monk seals and turtles.
Broadcast in general	• High likelihood that all rodents have access to bait. • Minimizes any neophobic behavior towards bait delivery devices • Shorter period of bait availabillity.	• Requires more bait. • Bait is readily available to non-target species.
Hand Broadcast specific	• Allows greater control over bait application. • Limits requirement for specialized skills.	• Labor intensive. • Presents logistical challenges and safety risks related to managing a large team conducting repetitive and demanding physical labor. • Requires transect paths along with access to all areas with dense vegetation and fragile areas. It is not possible to bait entire island in a single day. Precision needed is not achievable. • Potential for direct impact to ground-nesting seabirds and seabird burrows and repeated disturbance to monk seals and turtles.
Aerial Broadcast specific	• Fastest method for applying bait to a large area. • Relies on a smaller team of workers. • No need to clear trails.	• Requires specialized skills and equipment. • Depending on the label, may or may not be restricted over inhabited areas. • Distribution is limited to exposed areas and does not allow distribution of bait within buildings, under structures or underground. • May result in some unintentional bait entering the ocean.

Source: Island Conservation (2017)

2.2.3 RODENTICIDE AND BAIT CONSIDERATIONS

Several factors must be considered in the selection of a bait product and associated toxicant for rodent eradication. Under ideal conditions, the bait product would have demonstrated 100% efficacy under both laboratory and field trials on the target island. In addition, it would have been successfully used to eradicate the target species (i.e., house mice) on other islands. It would also have low risk to non-target species. From an eradication perspective, the rodenticide used on Sand Island, MANWR must:

- Contain an active ingredient that is known to be highly toxic to mice;
- Be palatable and demonstrated to cause little or no aversion in mice;
- Be deliverable to every potential mouse territory on the island;
- Be legally registered for use in compliance with the Federal Insecticide, Fungicide and Rodenticide Act (FIRFA);
- Kill mice with a single application to avoid bait shyness; and
- Be of low attractiveness to non-target species.

Presently there are 10 different rodenticides approved for use and available on the market in the United States. However, only 3 anticoagulant rodenticide products are currently registered for conservation use and therefore available for the eradication of rodents from island ecosystems; they are characterized in Table 2.4 below.

Table 2.4 Rodenticides Approved for Conservation Use in the United States

Name	*Description*
Diphacinone D50	A 0.07 to 0.17 ounces (oz) (2-5 g) pelleted bait product containing 50 parts per million (ppm) diphacinone, adopted for use primarily in Hawaiʻi for main island conservation, landscape control, and eradication from offshore islets. It is made by Hacco, Inc. and Ditrac 50D by Bell Labs
Brodifacoum-25D	A 0.03 to 0.07 oz (1-2 g) pelleted bait product containing 25 ppm brodifacoum, designed for use on islands with Mediterranean climates. It is produced by Bell Labratories, Inc.
Brodifacoum-25W	A 0.07 oz (2 g) pelleted bait containing 25 ppm brodifacoum, designed for use on islands with wet to very wet climates. It is produced by Bell Laboratories, Inc.
Source: Island Conservation (2017)	

The major advantage of anticoagulant rodenticides is the delayed onset of symptoms, usually requiring between 2 and 3 days to take effect. They are not known to cause aversion, referred to as "bait shyness," as per acute toxicants which rodents may learn to associate with their sublethal effects, and rodents would continue to feed on the bait even after symptoms develop (Parkes et al. 2011). Some rodents are even known to continue to feed on bait during the latent period, the time between ingestion of a lethal dose and mortality (Howald et al. 2005, Buckelew et al. 2005).

First generation anticoagulant rodenticides, such as diphacinone (see Table 2.4), are multi-feed rodenticides and rodents need to consume bait over a sustained period of days to achieve mortality, which may vary from 3 to 12 days of ingestion for a lethal dose. Diphacinone has been successfully used to eradicate rats from islands, typically delivered by bait stations with relatively few instances of broadcast being the delivery method (DIISE 2016). It has been used in efforts to eradicate house mice on islands twice, with one instance being a reported success and one a failure (Samaniego 2016).

Second generation anticoagulant rodenticides, such as brodifacoum, can be toxic after a single exposure or feeding event to sensitive rodents (Kaukeinen 1993). In some laboratory trials of brodifacoum, 100% mortality of rats and mice have been reported after a 3-day choice test (Pitt et al. 2011). Globally, a total of 87 house mouse eradication attempts have been carried out, and all but the 2 mentioned above using diphacinone, utilized brodifacoum.

2.3 PREFERRED ALTERNATIVE: MOUSE ERADICATION WITH RODENTICIDE VIA MULTIPLE DISTRIBUTION METHODS

The Preferred Alternative consists broadly of:

- The use of Brodifacoum-25D rodenticide with supplemental trapping.
- Multiple bait distribution methods – primarily aerial broadcast but also supplemental hand broadcast and bait stations (Section 2.3.1).
- Three bait applications spaced roughly 7-10 days apart (Section 2.3.2), projected to start in early July (Section 2.3.5).
- Implementing mitigation measures identified for selected species in Chapter 3.
- Implementing effectiveness monitoring to assure mitigation is carried out and determine if mitigation is producing the desired results.
- Employing long-term biosecurity protocols to prevent the reinvasion of the island by mice and rats. See Appendix A for a summary of long-term biosecurity protocols developed for MANWR.

Implementation of the proposed action is currently being considered for July/August 2019.

2.3.1 BAIT AND ITS DISTRIBUTION METHODS

The toxicant to be employed as part of the Preferred Alternative would be Brodifacoum-25D Conservation, a pelleted rodenticide bait intended for conservation purposes for the control or eradication of invasive rodents on islands or vessels. Island Conservation's *Feasibility Report* (2017) specifically recommends the use of a bait containing brodifacoum and notes that use of a less robust alternative rodenticide could compromise the success of the eradication effort. The rodenticide bait used for Sand Island would be dyed a green color to reduce the likelihood of birds picking up the bait.

The Preferred Alternative consists of the use of brodificoum to eradicate all mice on Sand Island, MANWR via 1 primary method and 2 supplemental distribution methods. The 3 methods (Island Conservation 2017) are discussed in the following 3 subsections.

2.3.1.1 <u>Primary Distribution Method – Aerial Broadcast</u>

Aerial broadcast (Section 2.2.2.2.2) of a pelleted bait containing rodenticide across the entire emergent land area, except:

- The portion of the airfield within the Foreign Object Debris (FOD) management area, which is delineated by large, conspicuous painted aircraft control lines on the tarmac.
- Portions of the coastal fringe where metal retaining structures combine with eroding sand to create undercut areas, rock piles, and piers.
- Within a buffer zone around the fresh water ponds that cannot be covered by tarps or cannot be protected by other means.
- Indoor residential/commensal areas; aerially baiting over all buildings will occur if the supplemental label allows.

Bait would be applied using bait stations or by hand broadcast and along the narrow sea wall on the harbor entrance. Aerial broadcast would also likely occur over rock piles on the island. These piles are rock staged for shore stabilization. Aerial broadcast is the most widely-used method of delivery of pelletized bait on islands, and is effective in delivering bait into every potential open above ground mouse territory. The helicopter broadcasting the rodenticide would fly at speeds ranging from 29-58 mph (46 - 93 km/hr.) and at an average expected altitude of approximately 164 ft. (50 m) above the ground. The bait hopper would be on a long-line 20-30 ft. (6 - 9 m) slung below the helicopter. Therefore, the bait hopper would be approximately 134 to 144 ft. (41 – 44 m) above the ground during the rodenticide drop. Except for landings and take-offs at the runway, the helicopter would fly at an average altitude of 164 ft. (50 m) and the bucket would be >134 ft. (>41 m) above the ground most of the time. The height of the helicopter would likely be higher when over forested areas or buildings. These numbers are an estimate and may change as needed to complete the baiting operation safely and effectively. The helicopter pilot would be certified for aerial bait application and in compliance with FAA safety requirements.

Three bait drops are planned on Sand Island using 2 helicopters to maximize the chance of completing each drop in a single day. It is expected each drop would take a total of 20 flight hours or 60 total flight hours for the entire operation; total flight time could be longer. Check flights and boundary flights will also add to the total flight time.

Bait would be delivered in shipping containers from the point of manufacture in the Mainland U.S. The rodenticide bait would be stored in locked shipping containers. The shipping containers would protect the bait from exposure to the elements and would allow a controllable area to access bait during aerial broadcast operations.

Bait would be packaged in either 50 lbs. (23 kg) bags, or in large (up to 700 lbs. or 318 kg) bags, and loaded into large cardboard boxes on skids. The shipping containers would remain locked, and staged in a large storage building adjacent to the airport runway on Sand Island and opened periodically for inspection prior to the eradication, and during the baiting operation. Bait would be loaded either manually by hand from bags into the hopper, or directly from bulk bags.

2.3.1.2 *Secondary Distribution Method – Supplemental Hand Broadcast*

Supplemental hand broadcast of pelleted bait and the use of bait stations (Section 2.2.2.1) with rodenticide would be used in the following areas:

- The locations listed above where aerial broadcast would not be conducted.
- Key shoreline habitats (e.g., across causeways too narrow for aerial broadcast and along seawalls or armored shorelines).
- In commensal environments such as within aboveground and underground structures.

Within the commensal environment, where people are typically not present, hand broadcast may be employed, along with the following supplemental bait station methods for distributing bait inside occupied structures:

- Hand placement of loose bait trays, with an open top to expose bait.
- Bait bolas, where the bait is held within rodent accessible material that can be hung in place to keep out of water.
- Enclosed bait stations (either tubes or bait boxes with lids).

Each structure, in use, abandoned, or condemned and above ground or below ground, would be individually identified and assigned a unique mouse removal strategy, known as a *Structure Management Plan* (SMP); all SMPs would outline a structure-specific mixture of secondary distribution methods (hand broadcast and/or bait stations) plus the possible use of traps. The following factors would be considered and recorded when developing each individual SMP:

- Structure category and use;
- Numerical identification;
- GPS coordinates and GIS map; and
- Details regarding how it is to be treated throughout the implementation period including detailed maps of bait application and placement.

When available, photographs of the structure and a floor plan showing treatment options may be included.

2.3.2 NUMBER AND RATE OF BAIT APPLICATIONS

Bait must be delivered at an application rate that ensures bait is made available to all mice on the island for long enough that each individual mouse would be exposed to, and consume a lethal dose of the toxicant. The application rate needs to account for other species that compete with mice to gain access to the bait. Some competitor species, like invertebrates such as crabs and insects, can consume a significant amount of the bait but are not affected by the rodenticide (Island Conservation 2017). Other avian competitor species, such as the myna, cattle egret, canary and Laysan duck, could also consume bait and would be negatively affected by the exposure. Bait application rates are set to ensure that adequate amounts of bait are available for long enough, regardless of the number of species or individuals that consume it. Based on other eradication efforts, a minimum of 4 nights bait availability may be necessary (Keitt et al. 2015).

Three bait drops are planned on Sand Island using 2 helicopters to maximize the chance of completing each drop in a single day. These drops would be spaced 7-10 days apart. Overall, the expected target application rate on Sand Island would be 65 lbs./ac. (73kg/hectare) with further refinement based on ongoing field trials with non-toxic bait. This approach would ensure that bait is available for a minimum of 4 nights each drop, and it would intercept any new generations of mice that may have been missed during or emerge after earlier bait applications. All applications would be made in compliance with the EPA bait label.

The bait would be applied according to a helicopter flight plan that would take into account the need to: (*i*) apply bait relatively evenly and to prevent any gaps in coverage; (*ii*) accommodate island topography; (*iii*) minimize bait spread into the marine environment; (*iv*) minimize disturbance to native wildlife and; (*v*) ensure human safety.

The onboard computer linked to the GPS would serve as the primary method of monitoring where bait has been applied to the island. Data from the onboard computer would be downloaded from the computer and evaluated on a laptop computer to assess where bait has been applied and total area treated, in order to calculate the approximate actual bait application rate.

A monitoring team would be staged on Sand Island to collect near-real time data during the bait application to ensure that the application rate stays within the legal and optimal application rates. In addition, a monitoring plan would be implemented to determine if: (*i*) eradication of mice is progressing as expected (mice mortality), and (*ii*) potential risks and expected impacts of the rodenticide in the environment and to non- native species are documented and in compliance with applicable permits and guidelines (e.g., NEPA permits and labels). At a minimum, sampling of marine water, fish, birds, and rodents would be made. To implement the monitoring plan, a field team would be present on Sand Island for approximately 6 weeks.

2.3.3 MECHANICAL TRAPPING

Mechanical traps including, but not restricted to, snap-traps and glue boards would be employed in conjunction with hand broadcast and/or bait stations in the commensal environment and other areas where bait is not aerially broadcast, as deemed appropriate per the terms of each structure's SMP (see Section 2.3.1). These traps would be used as an additional detection and removal method within structures to appropriately target mice. Traps would be activated and checked on the same schedule as bait stations within buildings, except live traps, which would be checked daily.

2.3.4 PRE-APPLICATION PREPARATIONS

The collection of water in the storage tanks would be maximized prior to the eradication effort. The water storage tanks, when filled to capacity, have the ability to provide water to the island for a 2-year period. Once the tanks are full, they would be disconnected from the water collection system and the intake-grates covered prior to bait application.

MANWR must remain an active residential community before, during, and after the Midway Seabird Protection Project. Certain activities, such as maintaining the airfield's operability, potential construction projects, biological monitoring, and maintenance of facilities and utilities would continue and the eradication effort must accommodate these activities. However, modifications to the day-to-day systems, processes, and infrastructure can, and in certain cases must, be made to minimize the risk of eradication failure. These may include:

- Procedural changes to food delivery, handling, storage, and disposal.
- Procedural changes to grow operations at the hydroponic gardens.
- Procedural changes to food preparation and consumption.
- Modifications to waste disposal and the on-island landfill.
- Development of a biosecurity plan which would prevent reintroduction of mice and rats. See Appendix A for a summary of the biosecurity plan developed for MANWR.

Food would be stored at all times in rodent proof containers. Some food comes in rodent proof containers (e.g. canned food), but food that may be more accessible (loose vegetables, bags of rice) would be put in containers that can be closed tight. Additional bait stations/traps may be deployed in areas where food is stored as well. At a minimum, each grow operation (e.g. tables, pots on ground) would be assessed and determined if it should be removed or modified to prevent mice from accessing food. Baits stations, bait trays, and/or traps would be placed in the shade house and modifications may be made to further prevent mice from accessing food. Any food growing operation would be closely monitored for signs of mouse activity and be responded to accordingly.

For food preparation and consumption, personnel would be trained in proper procedures, which would likely include emphasis on not leaving food out and immediate clean up. Garbage would be stored in sealed containers at all phases (in buildings, outside, when awaiting incineration), and the garbage collection schedule may likely be modified to include more frequent collections and complete incineration. Additional discussion of human health and safety factors are provided in Section 3.3.6.21.

2.3.5 APPLICATION SCHEDULE

In MANWR, the average period of lowest rainfall is from April through July, with increasing rainfall from late summer through winter. Reports from island biologists suggest that the condition of low vegetation such as grasses are deteriorated due to dry conditions and trampling by albatross chicks. Thus, the lowest availability of vegetation as a food source to mice, and likely low point in their annual population cycle, is probably between May and July. The low precipitation and low level of vegetation food sources make the summer a very attractive timeframe for an eradication effort employing bait broadcast.

The role that nesting albatross play in providing alternative food sources to mice (i.e., dead chicks and adults, and regurgitated food), and the influence it may have on the annual mouse population cycle is unclear, but it may be relevant. To date, there is no data available on the annual mouse population cycle, but for the purposes of this eradication effort it is assumed that the mice breed year-round, even though it is likely that the rate at which they breed fluctuates on an annual and intra-annual basis, depending on climate (Brown and Singleton 1999, Drost and Fellers 1991).

The presence of potential nontarget species on Midway is another consideration in selecting the rodenticide application period. There is no point in the year when non-target species are not present on Sand Island; however, the late summer timeframe is considered better than other times because relatively few potential non-target species are typically present (see Section 3.3.6).

Based on these considerations, the first rodenticide application would occur in early July. A second application would occur roughly 7-10 days later, and a third application conducted roughly 7-10 days after the second application.

If a significant storm event (i.e., tropical storm) is forecast to occur within 7 days after the application of the rodenticide, then the application would be postponed until the threat of the storm has past. Other dynamic elements, such as the presence of bird airstrike hazards (BASH), high winds, and other factors may also require adjustments in the project implementation schedule. This measure, like many other considerations detailed in this Chapter, is included to avoid and minimize potential adverse environmental effects and increase the potential for success.

2.3.6 MITIGATION ACTIONS AND EFFECTIVENESS MONITORING

Mitigation measures and actions identified for multiple species in Chapter 3 would be carried out and monitored for their effectiveness. Effectiveness monitoring tracks the success in achieving desired outcomes and evaluating environmental effects. Mitigation includes specific measures or practices that would reduce, avoid or eliminate the effect of the proposed action on non target species. In this EA, the identified mitigation measures are part of the proposed action (project) and necessary to support a FONSI. Examples of mitigation measures in Chapter 3 include: training ground-based staff to identify endangered plants and how to avoid stepping on burrows; capturing and moving vulnerable species to avoid rodenticide exposure; measures to minimize bait entering the marine environment; and measures to reduce impacts to sea turtles and monk seals. For detailed descriptions see the mitigation section for each species in Chapter 3.

2.3.7 POST-APPLICATION ACTIONS

Post-application actions include 3 critical tasks:

- Post-treatment efficacy monitoring and post reatment environmental effects and residue monitoring for rodenticide in the terrestrial, freshwater aquatic, and marine environments and for documenting mortality of non-target organisms.
- The remaining potable water would undergo additional filtration and no additional fresh water would be collected until a monitored degradation of residual bait pellets and rodenticide residue indicated that the potable water system was free of rodenticide. See Section 3.3.2 for a detailed discussion of water resources and management systems present on Sand Island, MANWR.
- Implementation of the long-term biosecurity plan to prevent the reintroduction of mice on Sand Island, MANWR (see Appendix A).

2.3.8 CONTINGENCY PLANNING

There is a chance that the project could fail to eradicate all mice after the main implementation phase. The follow-up actions should one or more mice be detected after the project is implemented will vary based on the time and circumstances of the detection. Additional baiting may occur in areas where mice are found if the circumstances dictate there is a reasonable chance of eliminating any remaining mice without additional adverse effects. Should the project fail entirely and a mouse population persists, the partners will undergo reviews to determine the main causes of failure, and to identify possible solutions to those failures to inform a new strategy for future eradication attempts. Mouse population control using cholecalciferol would continue proactively and reactively to reduce mouse attacks on albatross while a new eradication strategy is being developed.

2.4 ALTERNATIVE 2: NO ACTION

Analysis of the "No Action" Alternative, the alternative in which current conditions and trends are projected into the future in the absence of the proposed action, is required pursuant to NEPA [40 CFR 1502.14(d)]. In this case, under the No Action Alternative, Sand Island's mouse population would not be the subject of a targeted eradication project, but mouse control efforts started in 2016 would continue to protect nesting seabirds and human health and safety.

Mouse control on Sand Island currently consists of: (*i*) using traps and rodenticide bait stations in commensal areas such as food storage and preparation areas to maintain human health standards, as well as in areas near buildings, manmade structures, at the airport, and on shipping docks receiving conveyances; (*ii*) multi-catch live trapping; and (*iii*) rodenticide bait stations and hand broadcasting of AGRID$_3$ Pelleted Bait for seabird and listed candidate plant protection in areas where mouse predation of seabirds and mouse damage to listed or candidate plants is detected. The bait product AGRID$_{3,}$ (active ingredient 0.075% cholecalciferol; Bell Laboratories, Madison, WI; approved for restricted use at MANWR under a supplemental label for mouse control) is a non-anticoagulant. It disrupts calcium homeostasis by increasing calcium absorption from the small intestine and mobilization from the bones into the blood stream, as well as decreasing calcium excretion by the kidneys. The effectiveness of this product on rodents has been proven in limited hand-broadcast situations, and it is relatively safe to nontarget species if used according to label directions (Marshall 1984, Eason et al. 2000, DurShultz et al. in press, USFWS, Unpublished b).

Trapping includes: (*i*) multi-catch live traps; and (*ii*) mechanical traps (snap-traps and glue boards) used in the commensal environment as deemed appropriate per the terms of each structure's SMP (see Section 2.3.1).

Hand broadcasting previously involved 2 separate hand-broadcast applications of AGRID$_3$ pellets. Following label instructions, a 17.8 lbs./ac. (20 kg/ha) application rate was used over 27 ac (11 ha) where evidence of mouse attacks occurred in 2016. Future applications starting in November 2017 prior to the albatross's main egg laying season, would occur at the same rate and area and then would occur as needed if and where mouse attacks occur throughout the incubation period, up until the following February.

It should be noted that there were no observations of any non-target organism such as shorebirds or Laysan ducks interacting with $AGRID_3$ bait pellets in the field or being found sick or dead in the colony as a result of the baiting process in 2016/2017 (DurShultz et al, in press; USFWS, Unpublished b). Toxicity tests by Eason et al. (2000) found that the lethal dose for a mallard duck is 4.4 lbs. (2000 g) of 0.08% cholecalciferol. There is the potential for Laysan ducks to consume some bait, but it is unlikely they would consume lethal amounts. Further, to reach a lethal dose, a Laysan duck would need to ingest 3 times its body weight in pellets, which is unlikely to occur (DurShultz et al. in press). Both control measures (i.e., trapping and rodenticide treatment) are ongoing.

There are currently no other activities taking place at Sand Island, MANWR in terms of mouse management or control; however, other unrelated invasive species management and conservation operations at MANWR would continue per their respective agency plans. In addition, any other non-USFWS programs or projects would continue to be implemented under their respective authorities.

The No Action Alternative would be contrary to: (*i*) general principles of wildlife management; (*ii*) the PMMP's strategy AS-4; which calls for conservation actions to continue predator control and eradication of predators at Laysan and black-footed albatross nesting colonies; (*iii*) multi-agency conservation action plans for the black-footed and Laysan albatross (Naughton et al. 2007) that recommend eradicating house mice from MANWR to protect these 2 species of seabirds; and (i*v*) the USFWS Regional Seabird Conservation Plan (USFWS 2005) that identified the eradication or control of introduced predators and other invasive species that have a negative impact on seabirds as one of the top priorities for seabird conservation. The USFWS Regional Seabird Conservation Plan specifically recommended eradicating introduced predators in the Pacific Islands where the Laysan and black-footed albatross breed.

The purpose of the NWRS is to administer a national network of lands and waters for the conservation, management, and where appropriate, restoration of fish, wildlife, and plant resources and their habitats within the US and outlying territories for the benefit of present and future generations of Americans. Further, the No Action Alternative would be contrary to the USFWS' policy on maintaining the biological integrity, diversity, and environmental health of the NWRS. Finally, it would not achieve the USFWS's project objectives summarized in Section 1.2. It is included here because it is appropriate under the environmental review process mandated by NEPA, and to provide a baseline for comparison with the potential impacts of the proposed action.

2.5 ALTERNATIVES CONSIDERED BUT REJECTED

The USFWS evaluated several different approaches to house mouse eradication. Ultimately the alternative approaches summarized below were rejected from further evaluation because of the lack of evidence that these alternative tools and strategies would have a reasonable likelihood of eradicating mice on MANWR or thus achieving the purpose and need for the Project. These approaches are briefly described in the following subsections.

2.5.1 EMERGING TECHNOLOGIES

Ongoing research continues into the development of technologies for the control of introduced rodents. If these tools, currently in development, ultimately become available they may have either incremental or transformative impacts on the way in which eradication projects are approached. These technologies include: (*i*) reproductive inhibitors; (*ii*) species or genus specific toxins; and (*iii*) genetic bio-control. In a review of rodent control methods, Buckle and Smith (2015) state that reproductive control is not yet safe or effective for field use. Fertility control has been used with limited success as a method of pest management in a few species. Experimental sterilization methods have included chemicals and proteins delivered by vaccine, and genetically-modified viral pathogens. However, the effectiveness of these experimental techniques in the wild, and their impacts to nontarget animals are unknown. Aerial application of rodenticide is a more practical, effective, and a safer method to eradicate rats than repeated baiting of uncertain oral contraceptives on a remote island across seasons or capturing, vaccinating, and releasing every member of a single gender of the Palmyra rat population. This lack of data and tools disqualifies the use of fertility control from detailed consideration (Tobin and Fall 2005).

Currently, however, the several methods mentioned above are in development and none are likely to be available prior to 2023, the deadline for eradication of house mice on Sand Island, Midway Atoll established by the PMMP-ASAP Strategy AS-4. Therefore, this approach was rejected from further evaluation because it would not achieve the project objectives summarized in Section 1.2.

2.5.2 MOUSE ERADICATION USING CHOLECALCIFERAL (AGRID3) RODENTICIDE

Cholecalciferol (Agrid 3 by Bell Labs), a non-anticoagulant rodenticide, can kill rodents more quickly than the anticoagulant rodenticides by disrupting calcium absorption and decreasing calcium excretion in the kidneys. It is an attractive alternative because of its lower toxicity to birds. This product is currently being used at MANWR to control mice (not eradicate them) by hand broadcast in limited areas. However, these non-anticoagulant rodenticides are untested on islands larger than 22 ha (~54 ac) (Howald et al. 2007). Furthermore, there is no cholecalciferal product registered by the EPA for aerial broadcast and the purpose of island-wide eradications for mice. Using MANWR as a test island, without a high probability of success, would be inappropriate due to the high financial cost of the operation. These factors, lack of field-testing on islands comparable to Midway, potential bait avoidance, and greater human safety risk disqualifies them from detailed consideration for use on a MANWR eradication.

2.5.3 USE OF FIRST-GENERATION RODENTICIDE

Island Conservation's *Feasibility Report* (2017) specifically recommends the use of a bait containing brodifacoum and notes that use of a less robust alternative rodenticide could compromise the success of the eradication effort. As mentioned in Section 2.2.3, first generation anticoagulant rodenticides, such as diphacinone, are multi-feed rodenticides and rodents need to consume bait over a sustained period of days to achieve mortality, which may vary from 3-12 days of ingestion of a lethal dose. Diphacinone has been successfully used to eradicate rats from islands, typically delivered by bait stations with relatively few instances of broadcast being the delivery method (DIISE 2016). It has been used in efforts to eradicate house mice on islands only twice, with one instance being a reported success and one a failure (Samaniego 2016).

Second generation anticoagulant rodenticides, such as brodifacoum, can be toxic after a single exposure or feeding event to sensitive rodents (Kaukeinen 1993). In some laboratory trials of brodifacoum, 100% mortality of rats and mice have been reported after a 3-day choice test (Pitt et al. 2011). Globally, a total of 87 house mouse eradication attempts have been carried out, and all but the 2 mentioned above using diphacinone, utilized brodifacoum. Of the 31 house mouse eradication attempts carried out between 2005 and 2015, 28 of them were successful; this represents a 93.3% success rate (DIISE 2016).

The anticoagulants brodifacoum and diphacinone both bind to the same molecular site in the liver. Ingestion of these compounds would only lead to death in the exposed animal if a toxic threshold of one or more of these compounds is maintained in the liver consistently for a sufficient period of time. Brodifacoum molecules bind comparatively tightly in the liver, so the same brodifacoum molecules that are ingested on Day 0 are highly likely to remain in the liver for an extended period (Fisher et al. 2003).

Thus, a single feeding of a threshold quantity of brodifacoum is sufficient to ultimately induce lethal toxic effects in the exposed animal. Diphacinone, on the other hand, binds comparatively loosely in the liver, with a half-life measured in days (Fisher et al. 2003), so diphacinone molecules ingested on Day 0 are much less likely to remain in the liver for multiple days from a single feeding. Thus, to maintain a threshold lethal level of diphacinone in the liver consistently for sufficient time, a rodent needs to consume diphacinone in multiple feedings over multiple days so that it accumulates in the system faster than the liver processes it out. In application, this means bait must be available to each rodent to feed on at multiple times over a few days, and thus a longer period of time compared to brodifacoum.

Comparisons of Diphacinone to Brodifacoum

Diphacinone presents less risk to non-target species than brodifacoum (Howald et al. 2007, Erickson and Urban 2004). As described above, species that might ingest bait pellets opportunistically or accidentally are much less likely to ingest a lethal amount of diphacinone in one exposure (Hoare and Hare 2006). Predatory and scavenger species are also less likely to consume a lethal amount of toxin when preying on individuals that are dead or dying from primary exposure to the rodenticide, since diphacinone is retained only at a low level in body tissues. However, the successful eradication of rodents on islands using baits is partly dependent upon overcoming bait avoidance by rodents and inadequate bait consumption. While diphacinone generally presents less risk to non-target species than brodifacoum, its low retention in body tissues and its multiple feeding requirement results in a higher risk of failure in rodent eradication efforts (Donlan et al. 2003). All other operational considerations being equal, the task of delivering enough bait to all rodents on the island to ensure 100 % mortality is less certain to succeed when using diphacinone than when using brodifacoum. Rodents that survive diphacinone bait application may be resistant to first-generation anticoagulants (e.g., diphacinone), or could be unable to find or consume adequate bait to maintain lethal effects of diphacinone dose, avoid bait after a single feeding, or a combination of these. These rodents, and possibly their offspring, could consequently be more difficult to eradicate from the island in any subsequent attempts. The use of the much more field-tested brodifacoum provides a greater degree of confidence that the eradication program would succeed.

While both sides of this balancing equation are important, the need to ensure eradication success is particularly acute. An incomplete eradication attempt would provide few conservation returns in the long term, since mice at low densities have the ability to reproduce at higher rates and would quickly reoccupy vacant territories throughout the island. The only way to attain cost-effective, and ecologically secure, long-term conservation returns on this investment is through a successful and complete eradication. In summary, the safety risks associated with an aerial or hand broadcast operation can be somewhat mitigated with the use of a more potent toxicant such as brodifacoum. Therefore, the USFWS has rejected this alternative from further consideration.

2.5.4 MOUSE-PROOFING STRUCTURES

Modifying existing manmade structures to be rodent-free may be a viable strategy to eliminate house mice within buildings, but would come with considerable cost and have little utility once mice were eradicated from the remainder of the island. Further, mouse-proofing would not achieve the project objectives outlined in Section 1.2, and therefore has been rejected as an eradication strategy. It is more efficient and cost-effective to specifically target mice in and around manmade structures as part of a comprehensive eradication campaign. Therefore, the USFWS has rejected this alternative from further consideration.

2.5.5 AERIAL BROADCAST RODENTICIDE ONLY

An aerial broadcast only approach to mouse eradication on Sand Island, MANWR would not effectively administer bait to the buildings and other infrastructure located there, whether occupied or abandoned. This factor alone means that a supplemental treatment by some other method, such as hand broadcast, would be required to address this mouse habitat. Conducting a mouse eradication project on Sand Island, MANWR solely relying on aerial broadcast of rodenticide would be incomplete in its application (i.e., within structures and in below-ground infrastructure) and unlikely to attain the project objectives outlined in Section 1.2. Aerial broadcast only would also potentially lead to some bait drifting into the marine environment in areas where the shoreline is too narrow for aerial applications such as causeways or where seawalls and armored shorelines exist. Therefore, the USFWS has rejected this alternative from further consideration.

2.5.6 HAND BROADCAST RODENTICIDE ONLY

If hand broadcast alone were employed, then distribution transects would need to be spaced a maximum of approximately 66 ft. (~20 m) apart to ensure enough bait was available in every mouse territory. To achieve that end, Island Conservation (2017) estimates that more than 200 worker-days would be necessary to achieve a single complete hand broadcast operation across all of Sand Island, MANWR. This approach would: (*i*) be very labor-intensive; (*ii*) would need to be very carefully implemented and managed; (*iii*) would require a period of 2 or more months to complete, assuming a work crew of 40 individuals and between 2 and 3 bait applications across the entire area of Sand Island; and (*iv*) would increase the risk of damage to seabird burrows and vegetation as a result of worker movements. It is unlikely that MANWR's facilities and resources could effectively accommodate the large workforce needed to complete each application in a single day. Reducing the number of individuals working on the eradication would increase the number of days needed per application and would increase the complexity of the project. Finally, this time-estimate does not include applying bait within condemned and abandoned structures, where hand broadcast is not considered a viable method due to human health and safety concerns. Conducting a mouse eradication project on Sand Island, MANWR solely relying on hand broadcast of rodenticide would be time consuming, costly, unable to be adequately applied in some condemned structures, and unlikely to attain the project objectives outlined in Section 1.2. Therefore, the USFWS has rejected this alternative from further consideration.

2.5.7 BAIT STATION RODENTICIDE ONLY

Specific considerations related to using bait stations as the sole means of mouse eradication on Sand Island, MANWR work against this alternative include the following:

2.5.7.1 Non-Target Species

One of the benefits of bait stations is the reduced level of primary exposure to non-target species. On MANWR, bait stations would offer some, but not complete protection to terrestrial birds. Moreover, bait stations would not eliminate the secondary exposure risk through mobilization of rodenticide into the environment by contaminated insects (e.g., cockroaches, ants, etc.) and other invertebrates (e.g., crabs). As such, a bait station approach would minimize the non-target poisoning risk but would not eliminate the need for additional mitigation measures to protect the Laysan duck and shorebirds.

2.5.7.2 Operational Challenges

The logistics of implementing mouse eradication on Sand Island, MANWR using bait stations alone would be significantly more complex than rat eradication, primarily due to their smaller home range, which would require a much higher density of bait stations. Bait stations would need to be deployed at a maximum of approximately 66 ft. (~20 m) intervals, with approximately 33 ft. (~10 m) offering greater confidence that at least one bait station would be accessible to each mouse on the island. Assuming a 33 ft. x 33 ft. (10 m x 10 m) grid across the island, Island Conservation estimates that a minimum of 45,200 bait stations would be needed to cover the total area of Sand Island. This figure does not account for key commensal habitat which would require additional treatments. The *Feasibility Report* (Island Conservation 2017) estimates that more than approximately 280 miles (mi.) (450 kilometers [km]) of trails would need to be opened, flagged and maintained to support crews walking to install, service, monitor, and decommission these stations. These trails would need to be opened in key habitat such as the coastal fringe in high density *Scaevola sp.* and through habitat with Bonin petrel burrows, which are found wherever the substrate allows for excavation by the birds and thus are common on Sand Island. It is likely some burrows would be stepped on and collapse suffocating adults or young. Island Conservation estimates that, assuming a manageable crew size of 40 workers, this would require 200+ days, and an individual station would need to be visited at a minimum of 5-day intervals.

Because conducting a mouse eradication project on Sand Island, MANWR relying solely on bait stations would be time consuming, impactful to sensitive seabird habitat, incomplete in its application (i.e., within condemned structures), and unlikely to attain the project objectives outlined in Section 1.2, the USFWS has rejected this alternative from further consideration.

2.5.8 MOUSE CONTROL

Under this potential alternative, project planners considered mouse removal with the goal of reducing but not eliminating the mouse population on Sand Island, MANWR. A Mouse Control alternative would create and implement a strategic plan for long-term mouse control, with a regimented management plan written and approved, funds allocated, staff assigned, progress reports, and other elements that would distinguish it in scale, intensity, and duration from the mouse control efforts currently underway at Sand Island, MANWR. The net conservation benefit achieved by successful mouse control, as compared to total eradication, could be similar. However, the risk posed to non-target wildlife and island personnel as a result of continued control operations are greater than the risks related to an eradication operation due to the indefinite timeline for which a control operation would need to persist. The long-term presence of rodenticide and the repeated disturbances related to ongoing control operations would place non-target species at a continuous risk.

In addition, should the scheduled operations be interrupted due to inclement weather or some other circumstance, the mice could quickly reproduce to, or beyond, current levels and repopulate Sand Island, MANWR. Should this occur, it would require a further intensification of control operations once more. Control of the island-wide mouse population to levels low enough to eliminate them as an ecosystem-wide threat would require constant maintenance of an ecologically beneficial mouse control program. Doing so would be far less cost-effective, increase personnel safety risks, and would not result in the permanent conservation benefit derived from island-wide eradication of house mice. Because this alternative would not achieve the project objectives in Section 1.2, the USFWS has rejected this alternative from further consideration.

2.6 PROJECT COSTS

The USFWS' total estimated implementation budget for the Midway Seabird Protection Project is $3.5 million dollars.

CHAPTER 3: AFFECTED ENVIRONMENT, ENVIRONMENTAL IMPACTS, & MINIMIZATION MEASURES

3.1 GENERAL DESCRIPTION OF MANWR

MANWR is located at approximately 28˚15′ N and 177˚20′ W in the NWHI, and consists of 3 sandy islets. Sand Island, where the mouse eradication project would take place, is the largest islet at 1,117 acres (452 ha); the other 2 islets are Eastern Island 366 acres (148 ha) and Spit Island 15 acres (6.1 ha) (Figure 1.2). Together, they encompass a total land area of 1,549 acres (627 ha) with a mean elevation of approximately 10 ft. (3 m) above mean sea level (+MSL). Together these 3 islets lie in the southern portion of a large, elliptical barrier reef measuring nearly 5 mi (8 km) in diameter. MANWR is one of the northernmost land masses in the NWHI, located approximately 1,313 mi (2,113 km) northwest of Honolulu, Hawaiʻi (see Figure 1.1).

MANWR became an overlay refuge in 1988, while remaining under the jurisdiction of the Department of the Navy. On October 31, 1996 President William Clinton officially established MANWR as a standalone refuge by Presidential EO No. 13022. On September 13, 2000, the lands and waters of MANWR were designated as the Battle of Midway National Memorial. In addition, on June 15, 2006, the lands and waters of MANWR were incorporated into the PMNM by President George Bush's Presidential Proclamation No. 8031. MANWR's Co-Trustees in administrative matters, along with their respective responsibilities are summarized in Table 3.1 below.

Table 3.1 MANWR Administrative Co-Trustees

Co-Trustee	*Responsibilities*
Secretary of Commerce, National Ocean Atmospheric Administration (NOAA)	Primary responsibility regarding the management of the marine areas of the Monument, in consultation with the Secretary of the Interior.
Secretary of the Interior, USFWS	Sole responsibility for the areas of the Monument that overlay MANWR, the Battle of Midway National Memorial, and the Hawaiian Islands National Wildlife Refuge, in consultation with the Secretary of Commerce.
State of Hawaiʻi, Department of Land and Natural Resources	Primary responsibility for the Northwestern Hawaiian Islands Marine Refuge and State Seabird Sanctuary on Kure Atoll. Nothing in the Proclamation diminishes or enlarges the jurisdiction of the State of Hawaiʻi.
State of Hawaiʻi, Office of Hawaiian Affairs	Consultation on matters pertaining to Native Hawaiian culture.
Source: USFWS (2017)	

Together, USFWS and its Co-Trustees coordinate with the U.S. Coast Guard as they exercise their law enforcement, search and rescue, and medical evacuation responsibilities in the Central Pacific. The Coast Guard works with USFWS to store aircraft fuel on MANWR for mission-related use, and occasionally crews will stay on Midway during extended operations.

Although geographically part of the Hawaiian Islands archipelago, MANWR is not part of the State of Hawaiʻi and is an unincorporated territory of the United States. Therefore, the State Hawaiʻi has no jurisdiction on MANWR. Current funding to operate MANWR comes from the USFWS, supplemented by the FAA, which fully funds airport operations costs and a share of infrastructure operations costs. A small amount of funding is generated by the other users of MANWR, such as other Federal agencies conducting activities on Midway.

3.2 RESOURCE TOPICS EXCLUDED FROM DETAILED ANALYSIS

The resource topics in this section are those that do not have the potential to be affected by the proposed action or action alternatives. They are briefly summarized here in the interest of completeness and to provide context for readers, but there is no attendant discussion of impacts because no such potential exists.

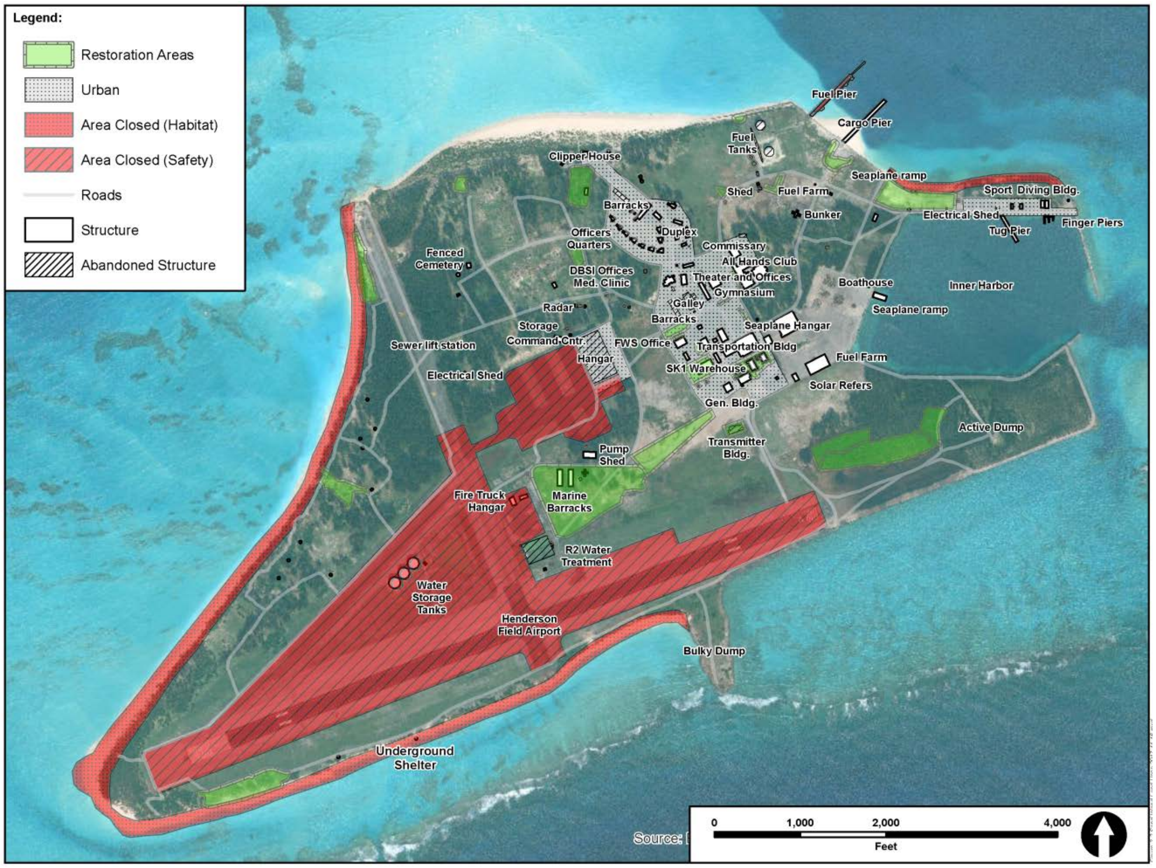
3.2.1 LAND USE

The built environment on Sand Island is extensive and a result of a long history of human habitation and infrastructure, representing over a century of occupation. The structures on Sand Island vary in age, construction type, condition, and on how they are used (if at all). The oldest structure dates back to 1903 and the Commercial Pacific Cable Company (one structure remains from that time); this and other historic buildings are discussed in Section 3.2.12. Nearly all the other structures, except the memorials, date to the Navy's use of Midway from the 1930s to 1993. The types of structures present on Sand Island and their use are summarized in Table 3.2; more generalized land uses are shown in Figure 3.2.

Table 3.2 Summary of the Built Environment on Sand Island, MANWR

Type	*Use*
Inhabited Space	Living spaces, such as housing and dining and recreation facilities, food storage, and food preparation sites. These include: • Clipper House dining hall • Captain Brooks pub • Charlie Barracks • Houses near Charlie Barracks (i.e., Pranee, Dolphin, and Yoodee houses) • Midway Mall, which includes a store among other facilities
	Work spaces, including offices (NWR Visitor Center and Chugach offices), Aircraft Rescue and Fire Fighting (ARFF) facilities, utility buildings, covered storage, covered gardens, and plant nurseries.
Abandoned Structures	Condemned structures where routine access is not permitted due to safety or other concerns, but all buildings can be entered with proper personal protection equipment (PPE).
Memorials	Monuments to the Battle of Midway and other features of historic importance.
Aboveground Utility Infrastructure	Including water tanks, fuel storage tanks, electrical equipment, and other facilities.
Subterranean Utility Infrastructure	The majority of this infrastructure is defunct and has been abandoned in place, but select facilities are still in use in inhabited areas and include utility service boxes, electrical and communications conduits, water and fuel pipelines and valves, and wastewater pipelines and valves.
Source: USFWS (2017)	

Figure 3.1 Generalized Land Uses on Sand Island



Source: USFWS (2017)

In addition to the physical infrastructure summarized above, there are 3 types of land use designations present on Sand Island, MANWR. Each is summarized in one of the following subsections.

3.2.1.1 Wildlife Refuge

As noted above, on October 31, 1996, President William Clinton officially established MANWR as a standalone refuge via EO No. 13022. The refuge encompasses all islands and waters within the 12-nautical mi. territorial sea of the atoll, totaling 581,864 ac. (235,472 ha). The refuge is administered by the USFWS in order to:

- Maintain and restore natural biological diversity within the refuge.
- Provide for the conservation and management of fish and wildlife, and their habitats, within the refuge.
- Fulfill the international treaty obligations of the United States with respect to fish and wildlife.
- Provide opportunities for scientific research, environmental education, and compatible wildlife-dependent recreation activities.

- Recognize and maintain the historic significance of MANWR in a manner compatible with refuge purposes.

NOAA National Marine Fisheries Service (NMFS) also monitors Hawaiian monk seals in MANWR and has taken periodic actions with seals to enhance their survivability as part of a cooperative conservation effort between NOAA, USFWS, USCG, and several non-governmental organizations (NGOs).

3.2.1.2 National Memorial

On September 13, 2000, Secretary of the Interior Bruce Babbitt designated the lands and water of MANWR as being within the Battle of Midway Memorial, “so that the heroic courage and sacrifice of those who fought against overwhelming odds to win an incredible victory will never be forgotten.” MANWR is the first National Memorial co-located with a National Wildlife Refuge. Several monuments are present on Sand Island, honoring those who sacrificed their lives with remnants of the actual historic Battle of Midway during the Second World War.

3.2.1.3 Airport

Henderson Field Airport, designated by the International Air Transport Association as airport code PMDY, has a 7,900 ft. (2,407 m) runway capable of handling almost any type of aircraft. PMDY is a fully-certified airport maintained according to the standards specified in the FAA’s Title 14 CFR, Part 139. Midway is used as a required emergency landing site for extended twin-engine operations (ETOPS) flights across the Pacific Ocean. Under current regulations, twin-engine aircraft must be within a maximum of 180 minutes from a Title 14 CFR Part 139-certified airfield in case of an emergency.

3.2.2 ACCESS

MANWR and PMNM are not typically open to visitors, and only those with a role in the operation, maintenance, or purpose of the refuge or the monument can access Sand Island. The only means of accessing MANWR are via air transport or surface vessel. These means of access currently adhear to a biosecurity plan designed to address a myriad of threats and concerns across the entire PMNM, adhearance to the biosecurity plan to prevent the reintroduction of mice on Sand Island (see Appendix A) will not adversely affect continued access to MANWR and PMNM.

3.2.2.1 Air Transportation

Currently, flights to MANWR are determined on an as-needed basis for the purposes of transporting support staff, scientists, volunteers, and restocking perishable foods. While the frequency of these flights varies, typically 2 flights occur per month, originating from Honolulu International Airport. A Gulfstream III jet aircraft is typically used, with a crew of 2 and a total capacity of 15 passengers.

3.2.2.2 Marine Transportation

The only vessels permitted within MANWR are those that service activities and personnel within the monument, and those transiting through without stopping; as a consequence, very few vessels call at MANWR. Small craft typically enter the inner harbor and moor dockside, or in the harbor. Larger vessels used to resupply Sand Island and research vessels generally make their landing at the cargo pier, inside Midway's lagoon but outside the inner harbor. Larger passenger vessels, when present, are required to remain outside the reef and shuttle passengers onto the atoll via launches or tending craft due to port security requirements.

Annually, visits to MANWR by marine vessels generally include the following: (*i*) 1 barge, associated with construction projects, bringing construction materials as well as general operations material; (*ii*) 2 or more support barges; and (*iii*) between 3 and 5 NOAA research ships.

3.2.3 CLIMATE

The climate of MANWR is influenced by the marine tropical and marine Pacific air masses, depending on the season. During the summer months, the Pacific High-Pressure System becomes dominant, with the ridgeline extending across the Pacific north of Kure and MANWR s. This places the region under the influence of easterly winds, with marine tropical and trade winds prevailing. During the winter, particularly between November and January, the Aleutian Low, a semi-permanent low-pressure system, moves south over the North Pacific, displacing the Pacific High before it. The Kure-Midway region is then affected by either the marine Pacific or marine tropical air masses, depending upon the intensity of the Aleutian Low or the Pacific High-Pressure systems.

The weather on Sand Island, MANWR is monitored at Henderson Field Airport (see Section 3.2.2.1). Two seasons dominate the annual climate-cycle. During the warm season, which typically extends from late June through early October, the average high temperature is 85 ˚F (29 ˚C) and the average low temperature is 78 ˚F (25˚C). During the cool season, which typically spans from late December to mid-April, the average high temperature is 71 ˚F (21˚C) and the average low temperature is 63 ˚F (17˚C). The average annual rainfall is 41.3 in (104 cm), with January being the wettest month with an average of 5 in (13 cm) of rain. June is typically the driest month with 2.2 in. (5 cm) of rain (weatherbase.com). Dramatic variation in precipitation timing and volume is possible during El Niño and La Niña conditions. Sand Island is located at 28 12 N, and daylight hours range from 10:22 and 13:55 hours per day, with the longest day occurring in June during the boreal summer.

The typical seasonality of rainfall at MANWR is depicted in Table 3.3 below, showing higher monthly totals and number of days with precipitation in the winter months. During some exceptional years, such as 2015-2016, the pattern may be reversed. Precipitation normally occurs as rain, ranging from mist to moderately intense rainfall, with total monthly averages ranging up to 5 in (13 cm). Despite significant seasonal fluctuation, rainfall occurs throughout the year, generally in the form of light, intermittent showers. However, rainfall is generally lowest in April, May, June and July (Table 3.3).

Table 3.3 Average Rainfall on Sand Island, MANWR

Average Precipitation 1974-2016 (in.)												
Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
5	3.8	3	2.5	2.3	2.2	3.3	4.3	3.5	3.5	3.8	4.1	41.3
Average No. of Days with Precipitation 1977-2016												
Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
16	14	12	11	9	9	15	15	15	14	14	16	160
Source: Weatherbase.com (2017)												

3.2.4 VISUAL RESOURCES

Sand Island, MANWR is comprised of dunes, grasslands, forested areas, beaches, the protective barrier reef and lagoon, each with its own distinct character and visual appeal. It also encompasses several monuments to the Battle of Midway during the Second World War, as well as other points of human interest. However, none of these features has been formally designated as a protected vista or scenic viewpoint. In addition, because visitation to Sand Island is purposefully limited, there are very few individuals present to observe the natural and manmade environment present.

3.2.5 FUEL FACILITIES

A new jet fuel tank farm was constructed in 2007 with a capacity of 450,000 gallons (1,703,435 liters); the facility consists of 9 50,000-gallon (189,271-liter), aboveground storage tanks located on the southwest side of the Inner Harbor (see Figure 1.3). The tank farm stores a sufficient amount of fuel to operate electrical generators, vehicles, and aircraft for a year. The USCG and USFWS have an interagency agreement that covers this cooperative effort and outlines shared costs associated with fuel.

3.2.6 ENERGY

Electrical power at MANWR is supplied by generators utilizing jet fuel. Two generators operate in automatic duplex mode such that, in most cases, only 1 generator is needed to meet Sand Island's demand. If 1 generator exceeds capacity, the second generator automatically comes online and automatically shuts off when electrical demand reduces. The current system for generating electricity is sufficient for the existing population. Midway has 2 electrical distribution grids. A relatively new electrical distribution grid serves most of Sand Island, but portions of the older grid still provides power to the old airport hangar and the finger pier area. Finally, photovoltaic panels are used to power select energy demands, such as food storage refrigerated containers.

3.2.7 COMMUNICATIONS

Telecommunication is provided by satellite service and includes T-1 data and VOIP service. Communications are provided to the inhabited portions of Sand Island via a fiber optic distribution system. Radio communication is also widely used in place of cellular phone service; the service area extends throughout both Sand and Eastern Islands.

3.2.8 AIR QUALITY

Air quality at Midway is generally excellent. Sources of emissions on the atoll are minimal and include electrical generators, motor vessels, vehicles, tools, and occasional plane flights (U.S. Army Space and Missile Defense Command, 2003).

3.2.9 GEOLOGIC RESOURCES

Midway is one of the northernmost coral atolls in the world and only one other atoll 90 mi. (145 km) to the north of Midway, Kure Atoll, also has emergent land. MANWR is 28.7 million years old. It is the result of a classic geomorphological sequence along the Hawaiian ridge, ranging from brand new volcanic basalt islands at the Southeastern end of the chain to true ring-shaped atolls at the Northwestern end of the chain and submerged seamounts even farther to the northwest.

As its name implies, Sand Island is comprised of coral sand, as is Eastern Island and the relatively recently formed Spit Island. Despite the fact that the foundation of the atoll is volcanic, no in-situ volcanic rocks are found on the islands. The former volcanic island slowly eroded and sank to an elevation well below current sea level. As sea level rose and the island continued to sink, coral grew on top of the volcanic rock to form the atoll that is present today.

Portions of both Sand and Eastern Islands are man-made fill. The fill is primarily believed to be coral sand from the dredging of the channel and harbor at MANWR. Other sources of fill are believed to be relatively minor and include: (*i*) large rocks from Hawai‘i and the US mainland, used to build shoreline revetments; and (*ii*) some organic material, such as soil from the US mainland, reportedly imported to help establish trees on the islands. Landfills, which are discussed in Section 3.3.5, also created landforms, most notably the “bulky dump” finger extending out from the south side of Sand Island (see Figure 1.3).

3.2.10 SOCIOECONOMIC AND ENVIRONMENTAL JUSTICE

Sand Island, MANWR does not have an established demographic or socioeconomic structure. The population of the Atoll fluctuates based on the needs of MANWR and PMNM; all inhabitants are on the Atoll strictly to operate, maintain, and address these two purposes. As all inhabitants are professionals employed in these undertakings, there are no environmental justice populations present there.

The year-round community of people on MANWR includes USFWS staff and volunteers, base operations staff (mostly comprised of Thai nationals employed by Chugach Management) and temporary contractors or research scientists. Sand Island has extensive infrastructure, processes, and utilities in place (see Table 2.2) to support the approximately 60 people that live and work there, including housing, common eating spaces (known as the Clipper House), small scale agriculture, recreation facilities, transportation infrastructure, recycling, and liquid and solid waste disposal systems. In effect, Sand Island is a functioning, albeit small, municipality.

Atoll residents live in renovated Navy housing, including single family homes, duplexes, and Bachelor Officer Quarters (BOQ). One BOQ, known as “Charlie Barracks,” which contains 36 rooms, has been set aside for transient and visitor use. Almost all of the residents and transients eat at the Clipper House, where 3 meals a day are served buffet style. Most supplies, particularly foodstuffs, are flown to the island on chartered aircraft. Approximately twice a year, a ship brings in equipment, additional food, and supplies too large or heavy for air transport.

The typical complement of personnel present on Sand Island, MANWR is summarized in Table 3.4 below.

Table 3.4 Typical Personnel Present on Sand Island, MANWR

Type	*Current Number*	*Purpose*
Refuge Staff	4	Full-time USFWS employees tasked with MANWR operations.
Operations Contractors	37	Chugach Management Services employees responsible for the operation and maintenance of the active infrastructure on Sand Island.
Construction	<30	During construction season, between August and October, additional workers responsible for construction and demolition operations on Sand Island.
FAA-Airport	4	Airport Maintenance and Management
Volunteers	1-4	Volunteers periodically assist the regular MANWR staff in biological and habitat management activities.
Researchers	Variable	Sand Island, MANWR also hosts transient researchers, USFWS employees, and USCG personnel on an irregular and periodic basis.
Transients	Variable	Refuge employees, Co-Trustee staff, USCG and other law enforcement entities, contractors, researchers, and other Federal and state employees.
Source: USFWS (2017)		

3.2.11 SOLID WASTE DISPOSAL

Solid waste generated in MANWR is disposed of via several methods. Most solid waste, such as household and food waste, is temporarily stored in open plastic trash bins with periodic trash collection via flatbed truck. Once collected, the solid waste is then burned in an oil-fired incinerator, dependent on the availability of waste fuel, or burned in an unlined open-air pit. Once burned, the ash is collected and disposed of at the existing landfill present on Sand Island. Aluminum cans are collected, compacted, stored, and then periodically sent to a recycling facility in the main Hawaiian Islands. Glass is collected, crushed, and buried in the landfill. Because the capacity of the existing landfill is limited both in capacity and in the types of waste which it can accommodate, it is only used for items which cannot be incinerated (e.g., some manmade marine debris).

3.2.12 HISTORICAL AND CULTURAL RESOURCES AND VALUES

Study of Midway's heritage resources was initiated in 1986 by the National Park Service when it conducted a survey of World War II-era properties eligible for designation as a National Historic Landmark. Nine structures, all defensive positions on the west side of Sand Island, were identified on Midway to convey a close association with the pivotal Battle of Midway, including ammunition magazines (ARMCO huts), a pillbox, and gun emplacements. Later that year, the 9 defensive positions on Sand Island identified as eligible by the National Park Service and surrounding buffer areas were designated as a landmark.

Between 1992 and 1994, the Navy sponsored studies of the Naval Air Facility on Midway, including archival research, interviews, and field surveys. The initial field effort consisted of an architectural history survey of the structures, buildings, and objects located on Sand and Eastern Islands.

The study of Cold War Resources was conducted in 1993-94 by contractors hired by the Department of the Navy in order to identify the most important Cold War-era resources, even though they were less than 50 years old, as part of the Base Closure process. The historian hired to conduct the inventory, research, and make recommendations regarding the significance of the buildings on Midway was a specialist in the Cold War period. The Cold War-era buildings were constructed on Midway between 1957 and 1969.

The recommendation accepted by the Navy was that the Cold War-era buildings and structures on Midway lacked architectural merit, were not directly associated with President Nixon's visit, and do not convey a direct link to the events that occurred during the Cold War. The Navy subsequently demolished many of the Cold War-era buildings and structures prior to the transfer to the FWS.

In addition to the landmark structures, 69 buildings, structures, and objects associated with the 1903-1945 historic period on Sand and Eastern Islands were determined to be eligible according to criteria established for the National Register of Historic Places. The properties evaluated as significant are associated with 3 major themes: colonization, initial years of base construction and the Battle of Midway, and 1942-1945 base construction.

In 1859, Captain N.C. Brooks was the first Westerner to "discover" Midway aboard the *Gambia* from Honolulu. He claimed Midway for the U.S., based on the Guano Act of 1856, which authorized Americans to temporarily occupy uninhabited islands to obtain guano. Captain Brooks named the atoll "Middlebrooks," reflecting its position between the U.S. west coast, Japan, and himself. The United States took formal possession of the unoccupied islands in 1867. Later, the name was changed to Midway.

The Commercial Pacific Cable Company Site, which includes 5 buildings (Nos. 619, 623, 626, 628, and 643) on Sand Island, has been determined by the Secretary of the Interior to be eligible for inclusion in the National Register of Historic Places. Originally constructed by the Commercial Pacific Cable Company, these buildings are the only remnants of the initial permanent colonization of the Midway Islands.

Archaeological surveys of Sand and Eastern Islands were conducted in 1992 and 1994. Surface inspections, 68 subsurface core samples, and 5 shovel-test units were conducted in disturbed sediments with as much as 2 meters of fill in some areas. Heavy construction and military use since 1940 changed the island considerably. Prior to the military era, these islands were also periodically scoured by storms and high winds that may have removed or buried evidence of pre-1900 use. A review of Hawaiian chants, genealogy, mythology, and oral histories found numerous references to distant low lying islands with abundant birds and marine life. Kuaihelani which translates to "back bone of heaven" is a name that is referenced often with these sources and is potentially associated with Midway. This homeland of the gods is described as a floating island in the sky, which can derive from a lagoon's refection in the clouds, such as at Midway Atoll. Pihemanu is a recent name that was given to the Atoll and means "loud din of birds" perfectly describing the current experience at MANWR. While no evidence of Polynesian/Hawaiian or pre-1900 historic period cultural remains have been found to date, there is still the potential for a buried discovery. In addition the chants, genealogies, mythologies and oral histories confirm that Hawaiians traveled to the islands and atolls within the Northwestern Hawaiian Islands over the span of several centuries.

3.2.12.1 Programmatic Agreement and Treatment of Midway's Historic Properties

In 1996, the Navy's Pacific Division, Naval Facilities Engineering Command, the Advisory Council on Historic Preservation, and USFWS signed a programmatic agreement directing how MANWR's historic properties were to be treated during the closure of Naval Air Facility Midway. These properties were assigned to 1 of 6 categories of preservation treatment: reuse and maintain, secure and abandon in place, abandon in place and leave as is, fill or cover, relocate, or demolish. USFWS was required to prepare a long-term Historic Preservation Plan, which it completed in 1999.

3.2.12.2 Historic Preservation Plan

The December 2010 *Midway Atoll National Wildlife Refuge Historic Preservation Plan* defines a program to integrate historic preservation planning with the wildlife conservation mission of USFWS at MANWR. The plan focuses on the long-term management conditions and goals for preserving and stabilizing historic properties. It also recommends procedures for treating new discoveries, caring for museum collections, and implementing a visitor program that includes historic preservation work. In the future, the Co-Trustees will incorporate submerged cultural resource protection into such plans.

3.3 RESOURCES TOPICS ANALYZED IN DETAIL IN THIS EA

The resource categories in this section are those that have the potential to be affected by the proposed action. In the following subsections the existing condition of each resource is characterized, followed by a discussion of the potential for impacts resulting from the Preferred or No Action Alternatives, including any mitigation activities which could avoid, minimize, or mitigate these potential impacts.

3.3.1 AIRFIELD OPERATIONS

3.3.1.1 Existing Conditions

As described previously in Section 3.2.1.3, the active airport on Sand Island, MANWR is Henderson Field Airport. Henderson Field has a 7,900-foot (2,405 m) runway, is fully certified as an airport maintained according to all applicable FAA standards, and is capable of handling virtually any type of aircraft. Because of its capacity, Henderson Field Airport is used as a required emergency landing site for ETOPS flights across the Pacific Ocean. It is staffed by air traffic control and ARFF personnel sufficient to operate as an ETOPS landing site. This airport is one of the dominant features present on Sand Island and, along with the harbor, is the principal means of accessing MANWR.

3.3.1.2 Probable Impacts

No evidence suggests that the physical airfield, which consists primarily of hardtop asphalt and cement, support house mice. However, the proposed action does call for the treatment of potential mouse habitat in areas immediately surrounding the airport runway, including any subterranean utility access points. This treatment is particularly necessary in areas where vegetation has created significant ground cover and in the airfield utility access points, which create breaks in the otherwise uniformly sealed perimeter surfaces.

A runway safety zone skirting, taxiway safety zone skirting, and 2 blast pads make up the area immediately adjacent to surfaces requiring Foreign Object Debris (FOD) management; these areas are delineated by large, conspicuous painted aircraft control lines on the tarmac. Baiting within these sites—up to but not within the aircraft control lines—and the airfield utility access points was assessed by airfield management and determined not to present a FOD hazard.

Should bait pellets inadvertently drift onto the active airfield, pellets would be removed via an FOD-assessment following each bait distribution event.

Additional flights and helicopter operations would be required to conduct the proposed action. Additional flights would include charter aircraft required to bring personnel, bait, and equipment to Midway. It is anticipated that these additional flights would not exceed an average of 6 operations a day over the 3-week bait distribution period. Given airport staffing levels, the low level of other operations, and apron area size, which once supported frequent and numerous military operations, the increase in operations anticipated to occur during the proposed action would not adversely affect the airport’s ability to continue to serve its ETOPS emergency landing site function or other functions.

3.3.2 WATER RESOURCES

Fresh water is defined as water having a sufficiently low salinity to allow for its consumption without ill effect. Salinity is a measure of the total amount of salt in water. Salinity and total dissolved solids are essentially synonymous. Water is considered “fresh” when its salinity is less than 0.5 parts per thousand (ppt). The salinity of ocean water is generally 35 ppt. Under the Safe Drinking Water Act, the EPA has established a Secondary Drinking Water Regulation concentration limit of 0.5 ppt (which is the same as 500 milligrams per liter (mg/L) and 500 parts per million (ppm)) for total dissolved solids.

3.3.2.1 Existing Conditions: Groundwater

Midway Atoll’s subsurface geology and hydrogeology is similar to other atolls in the Northern Hawaiian chain and elsewhere. The atoll’s geology is discussed briefly in Section 3.2.9. There are no hydrogeology-specific publications publicly available regarding Sand Island’s groundwater resources. However, a hydrogeological study of Wake Island (AFCEE 2006), another atoll where bait has been used to eradicate rodents and annual rainfall is similar, provides insight into atoll hydrogeology. Numerous wells have been drilled into the uppermost saturated zone of Sand Island to assess, remediate, and monitoring landfills and petroleum releases. The results of those investigations have yielded no evidence that Sand Island's groundwater processes or conditions differ meaningfully from other atolls.

Rainfall percolates through the coral sand and joins the underlying groundwater aquifer of Sand Island, MANWR. This unconfined (i.e., not confined under pressure beneath relatively impermeable rock) groundwater remains in contact with the atmosphere due to the porous nature of the coral sand soils. These porous soils at or below sea level—approximately 6 to 8 ft. (1.8-2.4 m) below grade—also are infiltrated and saturated by sea water. As the freshwater encounters the sea water, a zone of brackish water of variable salinity develops as they intermix. The depth and thickness of this brackish layer varies with the magnitude of tidal fluctuations, the amount of rainfall, and the permeability of the sediments through which the tidal signal occurs. The shallowest and most interior portions of Sand Island's aquifer are the freshest, due to saturation with percolating rainwater; this groundwater flows down and outward towards the shore, where it discharges into the ocean. The gradients and flux are small (GeoEngineers 2011); at Wake Island it was assessed that it would take 30 to 50 years for groundwater to migrate from the center of the island to either shore (a distance of approximately 1,000 ft. [305 m]) (AFCEE 2006). Residence times at Sand Island could be as much as 3 times longer because it is roughly 6,000 ft. (1,828 m) across. There are no wells used for potable drinking water on MANWR.

3.3.2.2 Existing Conditions: Surface Water

There are no streams or lakes on Sand Island, MANWR but there are several natural and man-made seeps present on the Atoll, which provide habitat for Laysan ducks, shorebirds, and migratory waterfowl. The seeps include small pools near the water tanks, in the area of former housing along Henderson Street, and west of the active dump (Figure 3.1). There are no 100-year floodplains on Sand Island, MANWR; however, the Atoll is surrounded on all sides by the Pacific Ocean and is periodically subjected to storm surges.

The coral sand that makes up the island is sufficiently permeable that erosion and flowing surface water is not present except where storm water flows are concentrated by hardened surfaces. Storm water is discussed further in Section 3.3.4.

3.3.2.3 Existing Conditions: Potable and Non-Potable Water Systems

Freshwater is a critical resource for people and wildlife present on Sand Island, MANWR. During substantial rain events, runoff from the airport runway is channeled into a pond adjacent to the runway and pumped into 3 large storage tanks for both potable and non-potable uses (Figure 3.2). Each of the 3 tanks has a 4.2 million-gallon (MG) (15,898,729 liters) capacity, for a total holding capacity of 12.6 MG (47,696,188 liters). Water is transferred from these 3 tanks to 2 approximately 80,000-gallon (302,833-liter) tanks in town, as needed, and from there directed into either the potable or non-potable systems.

The non-potable system was originally built by the Navy for its use, and is now used for fire suppression, watering plantings, and other non-potable uses. The potable system consists of a treatment facility and separate piping system that distributes potable water to inhabited buildings. The treatment system for potable water consists of sediment filtration to 5 microns and chlorination. In some of the older buildings, where the plumbing is aging, the water is also filtered at the tap to address secondary particulate. The potable water in use on Sand Island is sampled and tested monthly, at randomly selected points in the system, to ensure the safety of the supply.

Figure 3.2 Water Resources on Sand Island, MANWR

Source: USFWS (2017)

Typically water is transferred from the pond to the 3 large runway tanks once a year, following a heavy rainfall or storm event. As storm events are more frequent during the winter months, water is usually collected and transferred at these times. Total annual water use is approximately 5 MG (18,927,058 liters) across all uses; thus, when the 3 large storage tanks are full they provide over 2 years of water capacity.

3.3.2.4 Probable Impacts

Evaluation criteria for effects on water resources are based on water availability, quality, and use, and the regulations associated with them. A proposed action can be characterized as having adverse impacts on water resources where it can be established that one or more of the following shall occur as a result of its implementation:

- Reduce water availability to supply to existing users;
- Overdraft groundwater basins;
- Exceed safe annual yield of water supply sources;

- Affect water quality adversely;
- Endanger public health by creating or worsening a hazard to human health;
- Threaten or damage unique hydrologic characteristics; or
- Violate established laws or regulations adopted to protect water resources.

The proposed action would not reduce water availability or exceed the safe yield of water supply sources. The 3 water tanks on Sand Island would be filled during the winter rains so that they hold sufficient water to supply all island residents and visitors for a period of roughly 2 years. Because all the water is drawn from the pond that collects storm water runoff from the runways, there is no danger of groundwater basin overdraft when the 3 tanks are filled in the winter season prior to the proposed action. The watershed for the seep is at least 200 acres (81 ha), and is primarily new or aging asphalt pavement. At that size, less than 2 in (5 cm) of rain is necessary to provide sufficient runoff to completely fill the 3 tanks. Winter storms in December, January, and February commonly drop 4 to 5 in. (10-13 cm) of rain each month (Table 3.3).

Because all water for human consumption for a 2-year period would be collected in enclosed tanks prior to broadcasting the bait, no public health threat is anticipated associated with drinking water or other water use.

The effect of flood hazards on a proposed action may also be important if such an action is in an area with a high probability of flood or, with greater relevance to MANWR, storm surge.

With regard to surface water quality, no adverse effects are anticipated as a result of the proposed action. Brodifacoum, the toxin proposed for the mouse eradication effort, has very low water solubility (Primus et al. 2005). Bait that enters any given water column, whether marine or fresh, would dissolve into individual grain particles, and the brodifacoum molecules would remain bonded to these grain particles. In addition, the bait proposed for use during the eradication operation would contain a poison concentration of approximately 0.0025% brodifacoum. At this concentration level, brodifacoum which if inadvertently introduced to surface water, groundwater, or the marine environment, would likely be below risk levels.

Similarly, no groundwater quality adverse effects are anticipated as a result of the proposed action. Should brodifacoum dissolved at low concentrations (it is nearly insoluble) enter the groundwater aquifer, it would be degraded by bacteria in the subsurface, be diluted, and take years or decades for that water to discharge into the marine environment. Hydrogeological studies at Wake Island found that groundwater chemistry and temperature conducive to the biodegradation of organic compounds like brodifacoum, similar conditions are present at Sand Island. The Wake Island study also found that significant dilution, driven by vertical groundwater movement from tidal fluctuations, would occur (AFCEE 2006). Therefore, no short- or long-term discharge of brodifacoum-impacted groundwater into the marine environment is anticipated.

If large pellet fragments containing brodifacoum do enter the marine environment, they could be ingested by organisms present there. However, the pellets would rapidly disintegrate into fragments too small to interest most consumers; these potential impacts are discussed further in Section 3.3.6.

In order to best address the potential for brodifacoum contamination of surface water, groundwater, or the marine environment, USFWS and Island Conservation have developed a series of Best Management Practices (BMPs) to minimize this potential. These measures would be used as needed and may include, but are not limited to, the following:

- Hand broadcast in buffer zones around surface water, including seeps, and non-beach shorelines.
- Directional deflectors mounted on the bait buckets during aerial broadcast in areas adjacent to the shoreline.
- Pre and post application sampling of potable water sources using professional collection and lab processes consistent with procedures used at Palmyra by USDA, APHIS NWRC in 2012. (Pitt, et al. 2012)
- Burying artificial seeps, temporarily avoiding or covering or avoiding natural seeps until at least ten days after broadcast operations are complete or pellets are no longer visible within 10 meters of seeps edge. Guzzlers will be inspected and cleaned before being refilled.

3.3.3 NOISE

3.3.3.1 Existing Conditions

Sound is measured with instruments that record instantaneous sound levels in decibels (dB). A-weighted sound level measurements (dBA) are used to characterize sound levels that can be sensed by the human ear. "A-weighted" denoted the adjustment of the frequency content of a noise event to represent the way in which the average human ear responds to the noise event. All sound levels analyzed in this EA are A-weighted.

Noise levels, which result from multiple, single-events, are used to characterize community noise effects from aircraft operations and are measured in the Day-Night Average (DNL). The noise metric incorporates a "penalty" for nighttime noise events to account for increased annoyance. The DNL metric is the energy-averaged sound level measured over a 24-hour period, with a 10-dB penalty assigned to noise events occurring between 10:00 p.m. and 7:00 a.m. DNL values are obtained by averaging sound exposure level values for a given 24-hour period. DNL is the preferred noise metric of the US Department of Housing and Urban Development, the FAA, the US Environmental Protection Agency, and the Department of Defense for modeling airport environs. Most people are exposed to sound levels of a DNL of 50 to 55 dBA or higher on a daily basis. Noise levels in residential areas vary depending on the housing density and location. As a frame of reference, a normal suburban area is exposed to approximately 55 dBA, increasing to 60 dBA for an urban residential area, and 80 dBA in the downtown section of a city.

For Sand Island, MANWR, aircraft arrivals and departures are too infrequent to establish a reliable and accurate DNL metric. Noise impacts for this EA are calculated using Effective Perceived Noise Level (EPNdB). EPNdB is used by the FAA as the noise certification metric for large transport and turbojet aircraft and helicopters. Maximum sound level is important in contrasting the interference caused by an aircraft noise event with conversation, sleep, or other common activities.

As evidenced by the Hawaiian language name for MANWR —*Pihemanu*, which means "loud din of birds"—the dominant source of noise on Sand Island is the resident bird population. The extreme concentration of birds present on Sand Island combined with wind noise results in a natural, ambient noise level that exceeds 65 dBA during the day. At night seabirds remain active; thus, while reduced, the sound level remains higher than would normally be found in typical undeveloped areas.

The density of human use on Sand Island, MANWR is very low. During normal operations on the Atoll, primary anthropogenic sources of noise include aircraft, engines used to generate power, air compressors, and refrigeration equipment. On relatively still nights when wind noise is limited, the power generation equipment can be heard throughout the inhabited portion of Sand Island when outside. Other sources of transient noise include construction and demolition activity, utility vehicles, and golf carts.

3.3.3.2 Probable Impacts

Noise impact analyses typically evaluate potential changes to the existing noise environment that would result from implementation of the proposed action. Potential changes in the acoustic environment can be:

- *Beneficial*, if they reduce the number of sensitive receptors exposed to unacceptable noise levels or reduce the ambient sound level;
- *Negligible*, if the total number of sensitive receptors to unacceptable noise levels is essentially unchanged; or
- *Adverse*, if they result in increased sound exposure to unacceptable noise levels or ultimately increase the ambient sound level.

Projected noise effects were evaluated quantitatively for the proposed action.

Excessive noise can cause annoyance or irritation. Noise annoyance is defined by the EPA as any negative subjective reaction to noise by an individual or group. Aircraft noise effects can be described according to 2 categories: annoyance and human health concerns, such as hearing loss and sleep disturbance. Annoyance, which is based on perception, represents the primary effect associated with short-term aircraft noise. EPNdB is an acceptable unit for quantifying community annoyance to general environmental noise, including aircraft.

Under the proposed action, 2 helicopters would be used to aerially disperse bait across Sand Island, MANWR. While no final decision has yet been made as to the type of helicopter which would be used, most helicopters of the size and range required for this project would present an EPNdB of between 85 and 91 dB in the vicinity of the aircraft. As a frame of reference, 2 models of helicopter that have been proposed for use in other rodent eradication projects on islands are the Bell 206B Jet Ranger and the Bell 206L4 Long Ranger. Table 3.5 below depicts effective perceived noise levels for these 2 aircraft.

Table 3.5 Effective Perceived Noise Level of Selected Aircraft

Aircraft Model	*Flyover EPNdB Level*	*Takeoff EPNdB Level*	*Approach EPNdB Level*
Bell 206B Jet Ranger	85.4	88.7	90.6
Bell 206LR Long Ranger	85.2	88.4	90.7
Source: 15th Airlift Wing USAF (2009)			

The use of 2 helicopters to disperse bait would be conducted during daylight hours and would only disperse bait for approximately 2 days per drop for 20 hours each drop. Three applications are planned, resulting in a total of 60 hours of helicopter time. The noise generated by the helicopter would present a noticeable, albeit short term annoyance to the human and animal populations present on Sand Island, MANWR. The contractors operating the helicopter and bait bucket would wear standard protective hearing devices in accordance with Occupational Safety and Health Administration (OSHA) standards. Other operational personnel carrying out the proposed action would wear standard issue ear plugs, to be used at their discretion when in proximity to the aircraft. Other than the aircraft used to transport personnel to and from Sand Island, MANWR and the operation of the helicopter itself, the other aspects of the proposed action such as bait stations and bait dispersal by hand would not produce elevated levels of sound.

It is anticipated that the proposed action would cause temporary adverse noise impacts during the bait distribution procedure(s). Once those treatments are complete, there would be no significant or lasting effect on the existing acoustic environment on Sand Island, MANWR. The No Action Alternative would not produce any noise and would have no impact on the acoustic environment of the Atoll.

3.3.4 WASTEWATER AND STORM WATER

3.3.4.1 Existing Conditions

The potable water system (see Section 3.3.2.3) on Sand Island, MANWR incorporates collections points wherever potable water is used and conveyed to a septic system and leach field located in the central portion of the island between the runways and the housing (see Figure 1.3). The septic system and leach field was first installed in 1998, and is located in an elevated area with no threat of ponding during heavy rainfall.

The previous Navy-built drainage system co-mingled wastewater and storm water, and the existing wastewater conveyance system utilizes portions of that older Navy system. Because of this, some storm water continues to be mixed with wastewater. Steps have been taken to reduce the storm water component by disconnecting building downspouts from the system and reducing the hardened surface areas that collect rainfall, allowing for more natural percolation into the ground.

There is no storm water drainage system of the type common in urban areas and military basis in Hawaiʻi and the mainland. The coral sand that makes up the island is very permeable and storm water quickly infiltrates and becomes groundwater, resulting in essentially no storm water flowing into the ocean on the ground surface. The few exceptions to this are:

- At the few locations where hardscape extends to the shoreline, which is generally confined to the inner harbor and the eastern end of Runway 6-24.
- There are a few catch basins and ditches that direct storm water to the pond and sump where fresh water is collected for potable and non-potable uses. This system primarily serves to concentrate storm water for collection, not discharge to the ocean. The system does include "overflow ditches" on the south side of Runway 6-24 so that in the event a storm event overwhelmed the pond and the ability for the coral sand to absorb storm water, excess storm water can flow to the Pacific Ocean. Overflow does not occur during typical years, suggesting that a 10-year or greater storm event is necessary to generate an overflow condition.

3.3.4.2 Probable Impacts

The proposed action would not have any direct effect on the wastewater and storm water infrastructure. The wastewater system was designed and built when many more people were present on Sand Island and is more than sufficient to handle the increased wastewater flow associated with the increased number of people that would be present on Sand Island during the eradication effort. Similar numbers of people are present on Sand Island during annual bird counts, and no adverse effects to the system have been experienced at those times.

The few locations where storm water flow occurs are those areas where rodenticide application is not necessary (i.e., hardscape of runways and the inner harbor) or where rodenticide would be hand broadcast (i.e., non-beach shorelines and the water catchment system between the runways). Furthermore, the application would be conducted during the relatively dry portion of the year when storm events do not typically occur.

Based on these considerations, the potential effects to wastewater and storm water infrastructure, flows, and quality would be less than significant.

3.3.5 HAZARDOUS MATERIALS AND WASTES

3.3.5.1 Existing Conditions

Hazardous material is defined by the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA) and the Toxic Substances Control Act (TACA), as any substance with physical properties of ignitability, corrosivity, reactivity, or toxicity that might cause an increase in mortality, serious irreversible illness, or incapacitating reversible illness, or pose a substantial threat to human health or the environment.

Hazardous waste is defined by the Resource Conservation and Recovery Act (RCRA), which was further amended by the Hazardous and Solid Waste Amendments, as any solid, liquid, contained gaseous, or semisolid waste, or any combination of wastes that poses a substantial present or potential hazard to human health or the environment. In general, hazardous materials and hazardous wastes include substances that, because of their quantity, concentration, physical, chemical, or infectious characteristics, might present substantial danger to public health or welfare or the environment when released or otherwise improperly managed.

Evaluation of hazardous materials and wastes in this EA focuses on the storage, transport, and use of pesticides, fuels, petroleum, oil, other lubricants, and other chemicals. Evaluation may also extend to generation, storage, transportation, and disposal of hazardous wastes when such activity occurs at or near the site of the proposed action. In addition to being a threat to humans, improper release of hazardous materials and wastes can threaten the health and wellbeing of wildlife, botanical habitats, soil systems, and water resources. In the event of a release of hazardous materials or wastes, the extent of contamination varies based on the type of soil, topography, and water resources.

Sand Island, MANWR, as former Naval Air Facility (NAF) Midway, has undergone hazardous material removal operations, but still contains chemicals of potential concern (COPC). Therefore the Navy has implemented Land Use Controls (LUC) at the sites to limit exposure to contaminated material. These sites are listed in Table 3.6 below.

Several different types of LUCs were established at 4 landfills and 1 asbestos disposal area located on the Atoll. The landfills contain either municipal or bulky solid waste (i.e., construction debris) and the asbestos disposal area contains asbestos roofing materials. The landfills and the disposal area have been closed and covered with 1.5 to 4 ft. (0.5 to 1.2 m) of clean soil. The following activities are prohibited at the landfills and asbestos disposal area:

- Excavation or soil disturbance resulting from human activities that could compromise the integrity of the landfill or soil cover;
- Changing the intended land use of the landfill or disposal area;
- Modifying or altering the landfill in any way that may adversely affect the landfill area or release or expose subsurface waste.

The USFWS does conduct some operations in the LUC areas on an ongoing basis, including *Verbesina encelioides* eradication and annual albatross counts. Any project work conducted on Sand Island, MANWR, including any earthmoving activities with the potential to disturb contaminated soils, require communication with USFWS' onsite refuge managers and engineers based in Portland, Oregon. All work plans are reviewed and must be checked by the Refuge Manager, and all visitors are given a briefing related to hazardous materials and provided with a map indicated restricted areas, including LUC sites, as part of their orientation upon arrival.

Table 3.6 LUC Sites on Sand Island, MANWR

Site No.	*Site Name*	*Description Prior to Remediation*
01	Old Bulky Waste Landfill (OBWLF)	The OBWLF is an artificial peninsula extending from the south side of Sand Island, formed by the dumping of approximately 64,000 yd3 of bulky metal wastes, construction debris, vegetation waste, and scrap metal into the ocean. The ocean-exposed sides of the OBWLF are protected by concrete riprap. The marine and nearshore environment on the northeastern side of the OBWLF includes the location where a tug and a garbage barge were grounded next to the seawall, on the eastern side of the revetment (Ogden 1996).
02	Runway Landfill	The Runway Landfill is located in a filled area beyond the east end of Runway 6-24. The landfill is surrounded by trees and is predominantly grass-covered (Ogden 1996). In operation from 1970 to 1997, the Runway Landfill received all non-hazardous, non-bulky municipal solid waste generated on Sand Island. To reduce the volume of debris, the waste placed in the landfill was burned and covered with soil.
04	New Asbestos Disposal Area	The New Asbestos Disposal Area is located near the east end of Runway 6-24 on the east side of the Runway Landfill. The New Asbestos Disposal Area comprises approximately 18,000 $ft.^2$ and contains corrugated asbestos roofing material in plastic bags.
09	Pesticide Storage Area, Former Bldg. 629	The Pesticide Storage Area, Former Bldg. 629, is located near the corner of Morrell and Cannon Avenues. The building was destroyed by fire several years before the EBS (Ogden 1994) was conducted. Records of the types and quantities of pesticides stored in the building were reportedly lost in the fire (Ogden 1997). Pesticide contamination likely occurred at the site due to past pesticide handling practices and possible pesticide spillage during the fire.
20	Old Power Plant, Bldg. 354	The Old Power Plant, Bldg. 354, located in the Superblock Area bound by Nimitz, Branon, Cannon, and Morrell Avenues, was once the main diesel power plant for Sand Island. The Superblock Area consisted of 8 centrally located maintenance and power generation facilities. Bldg. 354 housed diesel generators, oil-filled drums, sumps, switches, transformers, ASTs, and several USTs with evidence of leaks from multiple sources. Cable trenches, production distribution piping, and a storm drain leading to the Inner Harbor were also associated with the site.
34	Pesticide Shop, Bldg. 361	The Pesticide Shop, Bldg. 361, is located near the corner of Nimitz and Branon Avenues. It was formerly used as a transformer substation. Pesticides were mixed and stored at this site, and a sink in the building was reportedly used for pesticide mixing and washing. The facility contained numerous containers of pesticides and herbicides, which appeared to be properly labeled and stored (Ogden 1996).
53	Bldg. 348	Bldg. 348 is located at the southwest corner of the Superblock Area on Sand Island. Bldg. 348 was the former Public Works/Administration Building. Discarded electrical equipment parts observed behind the building were identified as potential PCB sources that may have impacted surface soil (Ogden 1996).
n/a	New Bulky Waste Landfill, Sand Island	The New BWLF on Sand Island is located near the northern edge of Runway 15-33. Demolition- and removal-action-related debris, including concrete, metal debris, PCB-contaminated marine sediment, and asbestos, were placed in this landfill. This landfill also contains a CAMU where stabilized PCB- and pesticide-contaminated soil from various Midway removal actions was placed.
Source: Third Five Year CERCLA Review of 12 Sites, Dept of Navy, NAVFAC (2013)		

3.3.5.2 Probable Impacts

Effects on hazardous materials or hazardous waste management may be considered adverse if the proposed action results in noncompliance with applicable Federal and state regulations, increases the amounts generated or present on Sand Island over current levels, or overwhelms existing hazardous waste management procedures and capacities. The effects of the proposed action may also be considered adverse if the proposed action disturbs or creates contaminated sites, resulting in adverse effects on human health or the environment.

As noted in the previous section, as a former NAF (and battleground), the Atoll has several hazardous material, waste transfer, and storage areas. These existing conditions are the subject of other planning documents, including 5 Year CERCLA Reviews by the Naval Facilities Engineering Command. These project-related hazardous materials are summarized in Table 3.7 below.

Table 3.7 Project Related Hazardous Materials, Waste, and Toxins

Substance	***Use***
Fuel(s)	For use in all operational vehicles, including aircraft.
Oils or Lubricants	For use in all operational vehicles, including aircraft.
Brodifacoum	Rodenticide toxin.
Source: Planning Solutions, Inc. (2017)	

While vehicular fuel and lubricants are important to consider, the primary substance of concern is brodifacoum, a coumarin-based anticoagulant toxin. It is a vertebrate toxicant that acts by interfering with the blood’s ability to form clots, causing sites of even minor tissue damage to bleed continuously. Before brodifacoum can have a measurable physical effect, levels of the toxin in the liver must reach a toxic threshold, which varies widely by species. For a detailed discussion of the potential for adverse biological impacts related to the proposed broadcast of brodifacoum, see Section 3.3.6. Brodifacoum was the most commonly used rodenticide in the United States and was widely available for household use (Erickson and Urban 2004) until 2014 when the EPA prohibited second-generation anticoagulant rodenticides for use in products geared toward consumers. Now they are only registered for the commercial pest control and structural pest control markets. Second-generation anticoagulants registered in the United States include brodificoulm, bromadiolone, difenacoum, and difethialone.

It is anticipated that the proposed action of broadcasting brodifacoum bait across Sand Island, MANWR through a combination of aerial, hand, and bait station dispersal methods (see Section 2.3) would have no long-term adverse impact on LUC sites or issues associated with the handling or management of hazardous waste. Operational staff carrying out the eradication project would adhere to all LUCs and other guidelines for vehicle refueling, disposing of hazardous wastes, and managing hazardous materials throughout its implementation. No aspect of the proposed action would require the alteration of the LUCs in force at the present time, or involve physical disturbance of contaminated sites, hazardous materials management, or hazardous waste disposal processes.

3.3.6 BIOLOGICAL RESOURCES

3.3.6.1 Evaluation Criteria for Effects on Biological Resources

The significance of effects on biological resources is based on: (*i*) the importance (i.e., legal, commercial, recreational, ecological, or scientific) of the resource, (*ii*) the proportion of the resource that would be affected relative to its occurrence in the region, (*iii*) the sensitivity of the resource to proposed activities, and (*iv*) the duration of ecological effects. It is anticipated that the primary result of the Proposed Action to introduce a toxicant to achieve the purpose and need would be a shift in the plant and animal communities and ecosystem processes on MANWR toward a state more representative of its ecosystem before mice were accidentally introduced. Using previous successful studies and similar applications of a toxin to remove mice from other islands, it is anticipated that this shift would include an increase in the breeding success of several species of seabirds on the island. However, there are too many variables that would contribute to the post-eradication ecosystem responses for effective analysis within the scope of this document. The short-term impacts from exposure to brodifacoum or any other rodenticide to individual animals is determined by 2 factors as follows:

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

The toxicity of a particular compound on an individual animal is often expressed as LD (Lethal Dose). A common value used to express toxicity is "LD_{50}" which means that the dosage (D) of a toxin that is lethal (L) to 50 % of animals of the species in a laboratory test. The EPA has compiled laboratory data on the LD_{50} quantity of brodifacoum for a number of species. However, due to the difficulty and expense of obtaining extensive laboratory data, the LD_{50} values for most species remain unknown. Therefore, for the purpose of estimating impacts to wildlife, this document will use the following LD_{50} values to generalize potential toxicity for birds and mammals respectively using data from Erickson and Urban (2004) and USEPA (1991):

For birds, an LD_{50} value of 4.1 x 10^{-6} ounces/pound (0.26 mg/kilogram) of body weight for bait containing brodifacoum at a concentration of 25 ppm will be used – this is the average LD_{50} value for the mallard (*Anas platyrhynchos*).

For mammals, an LD_{50} value of 6.4 x 10^{-6} ounces/pound (0.4 mg/kilogram) of body weight for bait containing brodifacoum at a concentration of 25 ppm will be used – this is the average LD_{50} value for the laboratory rat (*R. norvegicus*).

In comparison to real-world values that toxicologists have obtained from a wide class of species, these values are conservative. This toxicity model assumes that an animal's body mass is the primary determinant of how much brodifacoum is required for that animal to reach an LD_{50} threshold, within each taxonomic category (in this case, birds and mammals). However, there are other variables that affect LD_{50} as well, but using conservative LD_{50} values such as those above decreases the possibility that the model would underestimate the risk or potential impact to each species considered. The LD_{50} value for mallards used for the assessment of toxicity to birds for the proposed action is 4.1 x 10^{-6} ounces/pound (0.26 mg/kg) (Ross et al. 1980, USEPA 1991).

Erickson and Urban (2004) use a similar model to determine the amount of bait needed to reach an LD_{50} threshold for birds with a mass of 0.88 ounces (25 grams), 3.53 ounces (100 grams), and 35.3 ounces (1,000 grams), compared to the average daily food intakes for each of these size classes (Table 3.8).

Table 3.8 Generalized proportion of daily food intake that must be bait for birds to reach an LD50 threshold where the dosage (D) of a toxin is lethal (L) to 50% of animals of the species in laboratory tests

Body Size Class	***Amount of Bait for LD_{50}***	***% of Daily Food Intake***
0.88 oz. (25 grams)	0.0092 oz. (0.26 grams)	4.2
3.53 oz. (100 grams)	0.037 oz. (1.04 grams)	10.8
35.3 oz. (1,000 grams)	0.37 oz. (10.4 grams)	19.2
Source: Adapted from Erickson and Urban (2004), using a brodifacoum concentration of 25 ppm.		

Erickson and Urban (2004) use a similar model to determine the amount of bait needed to reach an LD_{50} threshold for mammals, using the same size classes as Table 3.8 above.

Toxicants are also evaluated by their sub-lethal effects on animals. These are represented by metrics, such as NOAEL (no observable adverse effect level) and LOAEL (lowest observable adverse effect level). NOAEL is a dose or exposure level of a toxicant that produces no measurable toxic effects on the test group of animals and LOAEL is the lowest dose or exposure level of a toxicant that produces a measurable toxic effect on the test group of animals. Sub-lethal effects observed from anticoagulant exposure may include a variety of mild adverse effects, including prolonged clotting time, internal bleeding, piloerection, lethargy, diarrhea, bloody diarrhea, and/or anorexia (Anderson et al. 2011). The NOAEL value for mallards is $<3.2 \times 10^{-6}$ ounces/pound (<0.20 mg/kg) (EPA 1991).

3.3.6.2 Non-Target Species

Implementation of the Midway Seabird Protection Project would pose inherent risks to non-target species. These risks are summarized in Table 3.9 below.

Table 3.9 Summary of Risks to Nontarget Species

Risk	***Description***
Primary	Poisoning of nontarget species due to consumption of bait with rodenticide.
Secondary	Poisoning of nontarget species from consuming primary-contaminated prey (e.g., contaminated mice, crabs, insects, fish, etc.).
Tertiary	Poisoning of nontarget species from consuming secondary-contaminated prey.
Disturbance	Risks to non-target species from personnel and equipment conducting eradication (e.g., disturbance to resting monk seals from overflight noise).
Crushed Burrows	Risks of crushing the burrows of nesting seabirds as ground personnel walk into these areas during the baiting operation.
Bird Strike	Collisions between flying birds and helicopter during aerial operations.
Source: USFWS (2017)	

From a toxicological perspective, the risk to nontarget species during an eradication project is a function of the species present on the island and their behavior. Specific factors which require consideration include: (*i*) toxicological properties, composition, and delivery method of bait; (*ii*) the susceptibility of those species to the toxin; and (*iii*) the probability of exposure to the rodenticide by directly consuming it or indirectly by feeding on contaminated prey (Howald et al. 2007). Spatial and temporal risks should be eliminated, minimized, or mitigated to the maximum practicable extent, with due consideration to the species, their conservation status, and the population significance.

On MANWR, although there is no single time of year during which all species with a potential nontarget concern are absent, there are times of the year when some species that have potential nontarget risks are present in very low numbers. Thus, examining the annual use of the island by each species can be used to identify the greatest risk periods so that they can be avoided (see Figure 3.3 below), along with using the latest population estimates of each species on the refuge. Rodenticide exposure, disturbance impacts, risk of crushing burrows, and bird strike hazards can be minimized by timing the eradication operation to avoid the seabird breeding season, and to target periods when migratory shorebirds are on breeding grounds in Alaska (Wegmann et al. 2014, Howald et al. 2005). Careful timing of the project can also minimize risks to avoid specific behavior or key windows for some species, such as avoiding the monk seal pupping period and avoiding the time period when large numbers of albatross chicks are still present and exposed to bait pellets on the ground. Albatross chicks have been observed to occasionally swallow small items that they pick up and manipulate referred to as pica behavior. “Pica” means to display an indiscriminate preference for eating non-food items; in this case, albatross chicks pecking and ingesting rocks, sticks and other foreign objects (See “Pica” in Glossary of Terms). Other minimization and mitigation strategies may include captive holding and releasing animals after the risk period passes (e.g., Howald et al. 2005, Wegmann et al. 2014), hazing (scaring away from an area), as well as maintaining the antidote, Vitamin K, on hand if an individual animal is demonstrating signs of toxicosis and can be captured and held for treatment (e.g. Wegmann et al. 2014).

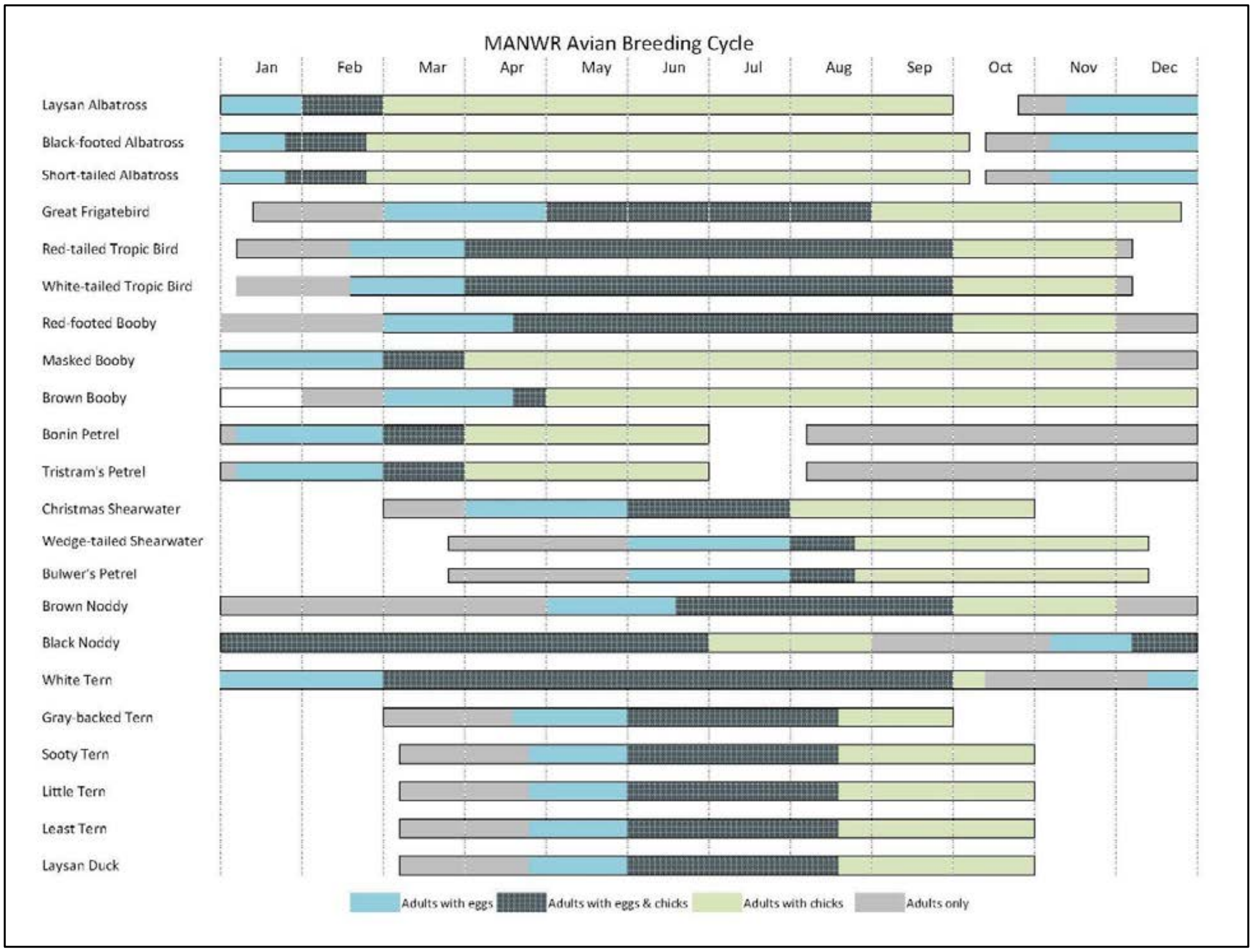
The Service will strive to implement all reasonable and prudent avoidance, minimization, and mitigation measures to reduce take of birds.

The analysis of impacts, along with specific mitigation actions, will take into consideration the potential short-term impacts through mortality of individuals due to mouse eradication activities, and will weigh these against the benefits of long-term species recovery and protection afforded by mouse eradication. Mitigation activities can minimize overall impacts, but in some cases, may not eliminate risks completely.

The presence of wildlife on and around islands targeted for eradications present an inherent challenge. In essence, the operation must be able to deliver bait to every mouse on the island while minimizing availability of the rodenticide to other species. In addition to the toxicological risks, the operation may also impose disturbances and habitat alterations that could have negative impacts on the ecosystem.

Although impacts to native species are only ecologically significant if they pose a population level effect, as a principle, any risks to wildlife should be avoided, minimized, or mitigated whenever reasonably possible. The long-term benefits of the eradication must outweigh the short-term environmental impacts and mitigation strategies must be considered in the trade-off framework (Broome et al. 2014).

Figure 3.3 Monthly Species Abundance or Breeding Activity on Sand Island, MANWR



Source: USFWS (2017)

Although there are no species endemic to MANWR, the refuge is of high significance for several terrestrial and marine species, including:

- The critically endangered (non-migratory, resident) Laysan duck, extant on Sand and Eastern Island;
- The endangered short-tailed albatross that has bred in the recent past on Eastern Island and recently is represented by one pair of birds attending a site on Sand Island;
- High density breeding populations of Laysan albatross and black-footed albatross present for about 8-9 months of the year;
- Globally important populations of Bonin petrels and red-tailed tropicbirds;
- A resident population of spinner dolphins (*Stenella longirostris*) in the lagoon;

- Overwintering shorebirds, such as the bristle-thighed curlew (*Numenius tahitiensis*), a species of special concern among the shorebirds at Midway due to its small world population size;

- Threatened Hawaiian green sea turtles that use beaches for resting and nesting and Endangered hawksbill sea turtles;

- Endangered monk seals that use the beaches and foreshore vegetation for resting and pupping, and can be found on the island year-round;

- Two endangered plants present on Sand Island, the Pōpolo (Solanum nelsonii), a trailing shrub, and the Nihoa fan palm (*Pritchardia remota*), or Loulu.

A general risk assessment to each species was developed to examine the likelihood of effects to the species from primary and secondary rodenticide exposure, risk of collision with the helicopter, risk of disturbance from the helicopter and ground personnel, risk of crushing burrows, and significance of the risk relative to the global population of the species (see Table 3.10).

3.3.6.3 Environmental Fate of Brodifacoum in Soil and Water

The chemical compound brodifacoum, the active ingredient in the Brodifacoum-25D bait, has low or extremely low solubility in water and bind tightly to organic matter in soil where the rodenticide would be degraded by soil micro- organisms and exposure to oxygen and sunlight. The solubility in water at 20°C is 0.0038 mgl^{-1}, which is considered low. The typical persistence time (DT50) is listed as 84 days which is considered moderately persistent. The half-life in soil is ~84 to 175 days for brodifacoum. The rate of microbial degradation would be dependent on climatic factors such as temperature, light, humidity, and the presence of molds and soil microbes that potentiate degradation. Therefore, in general, degradation time would be more rapid in warm sunny places like NWHI than in colder climates (Eason and Wickstrom 2001, Eisemann and Swift 2006). Bait trials for the eradication of rats on the island of Lehua, Hawai'i indicated inert (placebo) pellets of a composition similar to the inert matrix of Brodificoum-25D, in the terrestrial environment would break down and be undetectable in 35-40 days when under vegetation and around 65 days on rock or bare ground (Mazurek 2015). The results of a degradation study in soil indicate that only minor metabolites are formed (<3.5% of parent compound). In rats, no toxicologically relevant metabolites have been identified which could be introduced in soil via urine or feces (European Parliament and Council 2010). Because of the rapid breakdown of the rodenticide, the Preferred Alternative would be unlikely to directly or indirectly cause persistent contamination of soil on Sand Island. The potential presence of brodifacoum in groundwater is discussed in Section 3.3.2.

Table 3.10 Preliminary Risk Assessment by Species, Consequence, and Potential Mitigation

Species	*Poisoning Risk*		*BASH Risk*	*Disturbance Risk*		*Global Population Significance*	*Mitigation Measures*
	Primary	*Secondary*		*Ground*	*Air*		
Laysan Albatross (adults)	Low	Low	Med	Low	Low	64%	n/a
Black-footed Albatross (adults)	Low	Low	Med	Low	Low	22%	n/a
Short-tailed Albatross (adults)	Low	Low	Low	Low	Low	0.05%	n/a
Albatross (chicks; all spp)	Low	Low	Med	Low	Low	-	For Short-tailed albatross, and only if chick is present from single pair attempting to breed on Sand Island - Implement regimen of checking for and removing bait pellets from around the nest or use bait boxes.
Wedge-tailed shearwater	Low	Low	Low	High	Low	0.20%	Ground crews are: (*i*) to stay on established trails when possible; (*ii*) avoid walking close to nesting birds and exhibiting any actions that flush birds, especially those with eggs and young chicks; (*iii*) stay alert for bird burrows and avoid crushing them; (*iv*) if a burrow is crush in, gently dig out the bird.
Bonin petrel	Low	Low	Low	High	Low	< 0.01%	
Black noddy	Low	Low	Med	Low	Low	< 0.01%	n/a
Brown noddy	Low	Low	Med	Low	Low	0.60%	n/a
Gray-backed tern Sooty tern	Low	Low	Low	Low	Low	-	n/a
White tern	Low	Med	High	Low	Low	Low	n/a
Great frigatebird	Low	Med	Med	Med	Low	0.01%	n/a
Red-tailed tropicbird	Low	Low	High	Med	Low	19%	n/a
Brown booby	Low	Low	Low	Low	Low	< 0.01%	n/a
Small shorebirds	High	High	Low	Low	Low	0.15 - 1.1%	n/a

Species	***Poisoning Risk***		***BASH Risk***	***Disturbance Risk***		***Global Population Significance***	***Mitigation Measures***
	Primary	***Secondary***		***Ground***	***Air***		
Pacific golden plover	High	Med	Low	Low	Low	0.15-0.83%	Trap as many as is feasible; hold in pens; release after after the risk period has passed.
Bristle-thighed curlew	High	High	Low	Low	Low	2.42%	Trap as many as is feasible with 2 options: (*i*) hold in aviary (as opposed to pens) and release after the risk period has passed; (*ii*) clip wing feathers and place on Eastern Island.
Laysan duck	High	High	Low	High	Med	> 50%	Live capture 100% of population (or a majority of the population) with: (*i*) hold in captivity on Sand Island and then Eastern Island after operation commences until the risk period passes; (*ii*) clip wing feathers of birds on Sand Island and translocate to Eastern Island; (*iii*) a combination of the above strategies.
Cattle egret Atlantic canary Common Myna	High	High	Low	Low	Low	-	Mitigation measures for the Atlantic canary due to its cultural significance. Trap and hold as many as is feasible; release after the risk period has passed.
Hawaiian Monk seal	Low	Low	n/a	Low	Low	5%	Measures to reduce pellets entering water; ground crews maintain a 100 ft. (30.5 m) buffer from Hawaiian monk seals; helicopters to avoid hovering near seal basking and pupping areas, and to minimize distribution of pellets over seals on the beaches.
Dolphin spp.	Low	Low	n/a	n/a	Low	-	n/a
Green sea turtle	Low	Low	Low	Low	Low	-	Measures to reduce pellets entering water; ground crews maintain a 100 ft (30.5 m) buffer from sea turtles; helicopters to avoid hovering near turtle basking areas and to minimize distribution of pellets over turtles on the beaches.
Pōpolo and Nihoa fan palm (Loulu)	n/a	n/a	n/a	Low	n/a	-	Staff will be trained to recognize the pōpolo and loulu and monitor their work areas at all times for the presence of these two species. They will exercise extreme care when hand broadcast of bait is necessary or when servicing bait stations to minimize any damage to listed plants.

Source: USFWS (2017)

The amount of time bait pellets will be available on Sand Island plays a major role in risk of exposure to non-target species. Bait pellet longevity is influenced by many factors such as environmental conditions and bait uptake by mice and non-target species. Bait longevity may be high in some areas of Midway Atoll due to other factors (USFWS, Unpublished). Besides uptake by target species and exposure to environmental factors, bait pellet disappearance rates are also influenced by uptake by invertebrates like land crabs and cockroaches. Bait disappearance, in these cases, would vary depending upon the abundance and distribution of these invertebrates. While not driven by land crabs, the bait trials on Midway suggest that bait disappeared at high rates in some habitats (USFWS, Unpublished). Bait disappearance in some areas on Midway Atoll may be just as high as that found after bait operations for the eradication of rats on Palmyra Atoll, even though Midway Atoll has much lower populations of land crabs. The reasons for this occurring on Midway are unclear, but one possible explanation is that pellet disappearance on Midway was driven by cockroaches and other invertebrates. Moreover, the bait density proposed in this EA are based on data collected at Midway Atoll and tailored to Midway and its unique ecosystem.

Bait pellets may inadvertently fall into the ocean, but small amounts entering the ocean is not considered a great risk. This is illustrated from monitoring conducted on 2 rodent eradication projects using Brodifacoum-25D. On Anacapa Island, divers and land-based observers monitored bait for entry at 7 separate locations (Howald et al. 2009). Sites were selected based on their probability of bait entering the water (e.g., near or under steep cliffs). The application rate on the project was 13.4 lbs./ac. (15 kg/ha) and no bait was observed to directly enter the water, though small quantities indirectly entered at 3 locations, and densities were estimated at 0.15 pellets/10.8 ft^2 (1 m^2). On Isabel Island, Mexico, where the application rate was 18.4 lbs./ac. (20.6 kg/ ha), divers monitoring the operation documented bait in the sub-littoral zone at <1 pellet/108 ft^2 (10 m^2 or 0.1/m^2) (Samaniego-Herrera et al. 2014). Fisher et al. (2011) summarized the results of environmental monitoring for brodifacoum residues after rodent eradications in a fenced reserve at Maungatautari, New Zealand and on the offshore islands Little Barrier, Rangitoto and Motutapu, New Zealand. Brodifacoum was not detected in extensive fresh water monitoring at Maungatautari, or in fresh water samples from Little Barrier Island. Residual concentrations were present in soil samples from underneath degrading bait pellets on Little Barrier and decreased to near the limit of detection 100 days after application. No brodifacoum was detected in marine shellfish sampled from Little Barrier, Rangitoto or Motutapu.

However, examples exist where large quantities of bait entered the marine environment. During the Palmyra rat eradication, where the documented bait application was extremely high, 75.6 lbs./ac. (84.8 kg/ha) for the 1st application and 71.5 lbs./ac. (80.1 kg/ha) for the second application, the average density of bait entering the water was as high as 40 lbs./ac. (44.7 kg/ha) during the first application and 41 lbs./ac. (46.3 kg/ha) during the second (Engeman et al. 2013). A variety of factors are thought to have contributed to the high quantity of bait entering the marine environment at Palmyra, which include: an irregular coastline, baits drifting in the wind, pilot difficulty locating the shoreline due to overhanging palm trees, and an ineffective and broken bait deflector. The shoreline of Sand Island is much more regular, there are no trees overhanging shorelines or beaches with which the pilot must contend, some of the beaches are wide and bare of vegetation so that the pilot would not have to be near the high tide line, and the bait density would be less than at Palmyra, with an application rate on Sand Island at 65 lbs./ac.

(73 kg/ha). The application rate at Palmyra was 10-16% higher than that proposed for Sand Island. Complete breakdown of pellets in the water would be quick, especially for the exposed shorelines on the southern side of Sand Island. For the northern shorelines adjacent to the lagoon and protected by coral reefs, a channel was dredged by the military between Sand Island and Eastern Island into the lagoon, which allows a significantly larger tidal flux in and out of the lagoon and harbor than would otherwise occur. During the inert bait trials on Lehua in 2015, data collected show that pellets disintegrated within 30 minutes after application to seawater, and no pellets were found after 24 hours (Mazurek 2015).

In trials on Kapiti Island, New Zealand, inert bait pellets were seen to disintegrate within 15 minutes (Empson and Miskelly 1999) and on Isabel Island, pellets "sank immediately and disintegrated by wave action within a few minutes" (Samaniego-Herrera et al. 2014). During a rat eradication project on Anacapa Island in southern California, bait that entered the ocean completely dissolved within 5 hours (Howald et al. 2009). Sampling of seawater 24 and 48 hours post-application, conducted in conjunction with the Anacapa project, tested negative for brodifacoum residues.

In the process of breaking down, pellets would consist of suspended cereal grain flocculants and dissolution of the active ingredients into seawater. The solubility of brodifacoum in water is 3.2 x 10^{-5} oz./gallon (0.24 mg/l) (USEPA 1991). Any effect of salt water on solubility has not been reported. For the rat eradication on Mōkapu, Hawaiʻi and the first attempt on Lehua, seawater samples were collected 5 and 7 days after the last application of rodenticide baits. No diphacinone was detected in the seawater samples from either operation (Gale et al. 2008, Orazio et al. 2009). Because very little of the rodenticide is expected to enter the water, its low solubility in water, and the rapid breakdown in water, the Preferred Alternative would be unlikely to directly impact seawater on or around Sand Island.

3.3.6.4 Terrestrial Environment

3.3.6.4.1 Terrestrial Vegetation: Existing Conditions

The first vascular plant inventory was conducted on Midway Atoll in 1904 by William Bryan who documented 13 species (Bryan 1905). Since that time, over a dozen visits have been made by botanists to the remote islands for the purpose of investigating the plant life occurring there (e.g., Christophersen and Caum 1931, Apfelbaum et al. 1983, Bruegmann 1998, Conant et al. 1983, Neff and DuMont 1955). In all, 389 species have been recorded, 350 of which are exotic (see Figure 3.4 below). Introductions of exotic species to Midway have occurred via a variety of means, beginning with the planting of gardens to provide food for residents of the Pacific Commercial Cable Station during the first decade of the 20th century. Other species were brought in accidentally.

Not all plant species introduced to Midway have persisted or thrived. Less than half of the exotic plants once observed on Midway, 170 species, occur there today. Regular botanical inventories have been conducted at MANWR since 1999 (Starr and Martz 1999, Starr and Starr 2008, Starr and Starr 2015). As with earlier investigators, the bulk of the information produced has consisted of lists of the plant species observed, collection of voucher specimens for new occurrences, and locations of some of the plants observed with qualitative notes on distribution and abundance.

Figure 3.4 Map of Vegetative Cover on Sand Island, MANWR

Source: USFWS, *Draft Midway Atoll Habitat Management Plan* (2014)

Annual weed monitoring has been conducted on MANWR since 2012, and has focused almost exclusively on detecting trends in cover of golden crown-beard (*Verbesina encelioides*), a highly invasive plant species that has been the subject of a refuge-wide eradication campaign. Past monitoring was conducted at 100 sites (50 sites each on Sand and Eastern islands) and entailed *visually* estimating the foliar cover of golden crown-beard within a 15.4 ft (4.7 m) radius plot. This monitoring effort served the refuge well in documenting the steep decline of golden crown-beard, which decreased from approximately 50% cover to <1% across a 5-year period.

3.3.6.4.2 Dominant Vegetation Types

The land cover classes from the *Draft Midway Atoll Habitat Management Plan* offer a snapshot of vegetation communities and plant associations on MANWR in December 2014 (see Figure 3.4 and Table 3.11 below). Spatially, the classification includes areas managed for human use, such as the "town" area, as well as areas primarily managed for habitat. The classes are arranged based on canopy type, starting with the highest tree canopy (forest) and ending with unvegetated classes. When more than 1 canopy layer is present, the highest layer determines the cover class. For example, woodland includes a sparse (<25%) tree canopy layer and a field layer, but in some areas a secondary tree canopy and shrub layer are also present.

Table 3.11 Vegetation Communities and Plant Associations on Sand Island, MANWR

FOREST: Casuarina Forest Association with overall tree canopy cover >25%.
Tree canopy may range from open to closed. Casuarina seedlings are rarely present. The dominant species is *Casuarina equisetifolia*, although *Casuarina glauca* occurs in a few areas. Formerly, *Pluchea carolinensis* formed a sub-canopy in some areas, but *P. carolinensis* has largely been eliminated except for seedlings in areas where Casuarina has been removed. Adjacent to beaches, a thin shrub layer of *Scaevola taccada* may encroach a short distance into the forest. There is often no ground cover. When present, ground cover species include *Verbesina encelioides* and *Euphorbia cyathophora*. *Euphorbia peplus, Coronopus didymus* or *Eustachys petraea* may occur in forest openings. In areas underlain by pavement or cement, there are few petrel burrows; organic matter, needles and organic debris form the ground cover. Here, the trees are easily wind-thrown and there may be a tangle of downed trees. In dunes and sandy soils, petrel burrows abound and the soil shows weakly stratified layers of sand and organic duff.
WOODLAND: Mixed Woodland Association with Casuarina tree canopy cover <25%.
Usually distinguished from forest by understory and/or ground cover composition, the mixed woodland association is dominated by large diameter, mature *Casuarina equisetifolia* or *Casuarina glauca* trees. *Coccoloba uvifera, Hibiscus tiliaceus, Terminalia catappa* and various other non-native trees may also occur, forming dense thickets. In combination with *Casuarina*, these other species may increase overall tree canopy above 25%. Behind beaches, *Scaevola taccada* may form a discontinuous subcanopy. A range of herbland communities may be present, but common ground cover includes *Cynodon dactylon* (around the town area), *Stenotaphrum secundatum, Boerhavia repens* and various other herbaceous species or bare ground. The sandy soil does not have a visible layer of tree detritus or needles. The south half of Sector 4 and many areas around "town" are mixed woodland. The *Casuarina* forest also intergrades into woodland in some areas.
SHRUBLAND: Scaevola Shrub Association with shrub canopy cover >25%.
Scaevola taccada dominates the shrub association except in areas bordering beaches, where *Tournefortia argentea* may co-dominate. Both are considered widespread, halophytic, pioneer species, and they can be found in monotypic stands, or co-dominant and mixed forest (Niering 1963, Kepler and Kepler 1994). Below the canopy, very dense shrub stands eliminate most ground cover, resulting in bare ground covered with dead sticks. In Sector 4, beachside *Scaevola* encroaches on the neighboring *Casuarina* forest and woodland. *Casuarina* seedlings are scattered throughout the shrubland backing North and West Beaches on Sand Island. *Eustachys petraea, Verbesina encelioides* and an occasional *Bidens alba* may climb up through the shrubs. *Conyza* spp. also occur. *Scaevola* shrub association is found in small patches inland, usually where it has been planted for soil stabilization or cover. A mosaic of shrub and herbaceous associations occurs on the northeastern portion of Eastern Island. On Spit Island, *Solanum nelsonii* grows in the shrubland.
VINES: Viney Perennial Association with >50% cover of viney perennials in the field layer. For landcover mapping purposes, both the Tribulus-Boerhavia Association and the Ipomoea Association are combined into the viney perennial association.
Tribulus-Boerhavia Association*:* *Tribulus-Boerhavia* is the dominant cover class on Eastern Island. It intergrades with the *Lobularia-Cynodon* herbaceous association, making classification difficult depending on the season. The invasive mustard *Brassica nigra* is strongly associated with viney perennials on Eastern Island. Herbicide use in the fall and late winter significantly reduces *Tribulus* foliage, reducing competition with *Lobularia maritima*. During these times, the *Lobularia-Cynodon* association is prominent. *Tribulus-Boerhavia* vines persist from a woody base, and by early summer, account for >50% cover, masking underlying *Lobularia* plants. The vines also spread across abandoned runways, forming an important component of the partially vegetated runway class. Species common in this layer include *Tribulus cistoides, Boerhavia repens, Lobularia maritima, Brassica nigra, Verbesina encelioides, Coronopus didymus*, and occasional patches of *Cynodon dactylon* and other grasses. Ipomoea Association: >50% cover in the field layer; limited distribution on Sand and Eastern Islands. A few scattered patches of *Ipomoea pes-caprae* occur on or near beaches, often with *Dactyloctenium aegyptium* encroachment. *Ipomoea indica* occurs inland on Sand Island. An aggressive vine, it is usually associated with and overruns the *Lobularia-Cynodon* association, also occasionally climbing onto *Eragrostis variabilis* and various trees or shrubs nearby.

HERBLAND: Lobularia-Cynodon Herbaceous Association where herbaceous vegetation accounts for >75% of cover but may be less, as long as it exceeds woody plant cover.
The dominant non-forest cover class on Sand Island, this herbland is composed of forbs and low-growing grasses. *Lobularia* and *Cynodon* intergrade throughout the island, with up to 100% cover of *Cynodon* in the "town" area and 100% *Lobularia* in other locations. Predominant species include *Lobularia maritima, Cynodon dactylon, Solanum americanum, Lepidium virginicum, Coronopus didymus, Eleusine indica* and other low-growing non-native forbs and grasses that may change throughout the year. Small patches of the tall grass *Stenotaphrum secundatum* are included when completely surrounded by herbland. These are generally remnants of former *Casuarina* forest or woodland that has been removed and converted to herbland. On Eastern Island, the *Lobularia-Cynodon* Herbaceous Association occurs in low-lying swales backing the beach and shrub zones along the north shore, and around the building foundations and previously developed areas near the pier. Herbs are also an important component of the *Tribulus-Boerhavia* viney association and seasonally appear to be the dominant cover class. Predominant species include *Lobularia maritima, Cynodon dactylon, Tribulus cistoides, Boerhavia repens, Coronopus didymus, Brassica nigra,* and *Verbesina encelioides.*
BUNCHGRASS: Eragrostis Bunchgrass Association is generally present in small patches spreading from out-planted nuclei on all 3 islands.
Eragrostis variabilis has been the primary species used for restoring native plant cover. In recent years, the grass started seeding and some *Eragrostis* patches are now expanding on their own. Near beaches, *Eragrostis* is occasionally overgrown by *Scaevola taccada.* Other species include *Lobularia maritima, Coronopus didymus, Conyza* spp, and other herbaceous species. On Eastern Island, *Tribulus cistoides* may occasionally overrun *Eragrostis* plantings. *Chenopodium oahuense* and other native shrubs and forbs are being restored to this community.
WETLAND: Wetland Cyperus Association with >50% cover of wetland-associated plants, primarily sedge.
Runway 24 east extension on Sand Island is the main expression of this association, but small patches occur in low-lying areas that intermittently flood. The main species is *Cyperus polystachyos.* Other species include *Cyperus laevigatus, Cyperus involucratus, Andropogon virginicus, Sesuvium portulacastrum, Heliotropium procumbens, Phyla nodiflora* and *Portulaca oleracea.* This category usually does not apply to the areas surrounding most of the ponds and former seeps since their soils do not support hydrophytic species. Some facultative wetland species occur at Catchment Pond shoreline and the former Sunrise and Mauka-Makai seeps on Sand Island.
BEACH STRAND: Includes herbaceous cover and open beach from the mean tide mark to a shrub belt or herb-covered terrace above the beach.
While most of the beaches are unvegetated, a few species occur in patches or at low densities: *Lepturus repens, Sesuvium portulacastrum, Ipomoea pes-caprae,* and sparse *Tournefortia argentea* seedlings. Large, dense patches of *Sesuvium portulacastrum* surrounded by beach, such as the *S. portulacastrum/Fimbristylis cymosa* on Spit Island, are included in this class.
BARREN: Where there is <5% vegetation due to management activities or erosion rather than artificially hardened substrate, excluding beaches.
The substrate and transitory nature of barren areas distinguishes this class from the unvegetated class. The barren substrate will support plant growth, whereas the hardened, artificial substrate in the unvegetated class will not until the surface is broken. Barren areas are not vegetated due to recent removal of plant cover, usually for restoration purposes or contaminants remediation. For example, large scale ironwood removal projects result in barren areas until restored to another land cover type, such as an herbaceous plant community. In future landcover maps, barren areas will be classified into the appropriate vegetation association. On Eastern Island, naturally-occurring barren areas occur on the tops of some revetments, however normal erosion processes will eventually result in plant growth. Barren areas also occur in erosive features behind sea walls where vegetative cover is destroyed by waves. Note that barren and unvegetated are somewhat arbitrary distinctions and could be combined into a single unvegetated cover class for mapping purposes.
PARTIALLY VEGETATED: Partially Vegetated Former Runway/Pavement/Foundations which are 5-25% covered with vegetation.
On Sand Island, common species are *Casuarina equisetifolia, Fimbristylis cymosa, Eustachys petraea, Andropogon virginicus, Dactyloctenium aegyptium, Sporobolus indica, Bidens alba, Pseudognaphalium sandwicensium* and various herbaceous weeds. Many abandoned runways on Eastern Island are now nearly indistinguishable from off-runway vegetated areas and will usually contain a mix of species from the Tribulus-Boerhavia association as well as a number of incipient weeds.

UNVEGETATED: Unvegetated Structures/Runways with <5% vegetation.
Runways, concrete, asphalt, buildings, piers, structures.
Source: USFWS (2017)

Where noted, a few "orphan" plant types, generally remnants from previous land uses, are lumped into the cover class surrounding them or a structurally similar class. For example, the tall grass *Andropogon virginicum,* an upland species, intermixes with *Cyperus polystachyos*, the dominant wetland sedge, at the Catchment Pond area. In this case, it is classified as part of the wetland sedge association. Where *A. virginicum* has spread onto the adjacent abandoned runway, it is classified as "partially vegetated runway." Some plant associations change dramatically with the seasons, such as viney associations and herblands on Eastern Island. These situations are noted and, while they may affect community composition at various times of the year, the overall effect on habitat structure is negligible. Because management activities and stochastic events create a dynamic system at MANWR, cover classes recognized in previous years have changed and, in some cases, disappeared. No longer is "Verbesina shrubland" a viable cover class, a testament to the success in controlling an invasive weed that caused significant degradation of seabird habitat.

3.3.6.4.3 Endangered Plants

Kāmanomano is a short-lived rare perennial grass that has two recognized varieties: *Cenchrus agrimonioides var. agrimonioides*, found on the islands of O'ahu, Lāna'i, and Maui, and *C. agrimonioides var. laysanensis*, known historically from the Northwestern Hawaiian Islands of Laysan, Kure, and Midway (Service 2009). Populations of *C. agrimonioides var. laysanensis* were last collected in 1973 on Kure Atoll, Midway Atoll, and Laysan (Wagner et al. 1999, Service 2009). The relatively isolated occurrences of kāmanomano in the northwestern Hawaiian Islands are negatively affected (on the low-lying islands) by nonnative plants and by stochastic events such as tsunami. An assessment by Fortini et al. (2013) concluded that kāmanomano is moderately vulnerable to the impacts of climate change. This plant was federally listed as endangered in 1996. *Cenchrus agrimonioides* var. *laysanensis*, a variety of this species endemic to the Northwestern Hawaiian Islands, became extinct in the 1980s (Bruegmann and Caraway 2003). Therefore, the species has not been seen on MANWR for years, even though botanical surveys have been conducted on Sand Island, so it is very likely no longer present here and will not be addressed further.

Pōpolo is a sprawling or trailing shrub up to 3 ft (1 m) tall, in the nightshade family (*Solanaceae*). Pōpolo is a plant species listed as endangered throughout all of its range (USFWS 2016). No critical habitat has been designated. Typical habitat for this species is coral rubble or sand in coastal sites up to 490 ft (150 m), in the coastal ecosystem (Symon 1999, TNCH 2007, HBMP 2010). Historically, pōpolo was known from the island of Hawai'i, the island of Ni'ihau, Nihoa Island, Laysan Island, Pearl and Hermes Reef, and Kure Atoll (Lamoreaux 1963, Clapp et al. 1977, HBMP 2010). Currently, pōpolo occurs in the coastal ecosystem, on the islands of Hawai'i and Moloka'i, and on the northwestern Hawaiian Islands of Kure, Midway (on Sand, Eastern and Spit Islands) (Klavitter 2013), Laysan, Pearl, Hermes, and Nihoa (Aruch 2006, in litt.; Rehkemper 2006, in litt.; Tangalin 2006, in litt.; Bio 2008, in litt.; Vanderlip 2011, in litt.; Conry 2012, in litt.; PEPP 2013).

The relatively isolated occurrences of pōpolo in the northwestern Hawaiian Islands are negatively affected (on the low-lying islands) by nonnative plants and by stochastic events such as tsunami. Climate change may result in alteration of the environmental conditions and ecosystems that support this species. Pōpolo may be unable to tolerate or respond to changes in temperature and moisture, or may be unable to move to areas with more suitable climatic regimes (Fortini et al. 2013).

The Nihoa fan palm, or loulu, is a federally endangered species of palm (USFWS 1998) endemic on the island of Nihoa, Hawaiʻi, and later transplanted to the island of Laysan. It is listed as it is a smaller tree than most other species of *Pritchardia*, typically reaching only 13-16 ft. tall (4–5 m) tall and with a trunk diameter of 5.9 in. (15 cm). The loulu is a long-lived perennial tree and is among three species endemic to the Island of Nihoa that were listed under ESA in 1996. At the time of listing, the plant was limited to two extant populations on Nihoa. Since then, seeds from the palm have been brought to MANWR, planted in the greenhouse, and outplanted within the atoll with a few surviving plants on both Sand and Eastern Island.

3.3.6.4.4 Probable Impacts: No Action Alternative

Under the no-action alternative, the mouse population would not be eradicated, and the population size would continue to fluctuate within an annual cycle. It is likely that population levels would increase during the rainy season and decline during the dry season.

Anecdodal evidence suggests that native plant communities (including the pōpolo and loulu plant species) and vegetation restoration activities on Sand Island would continue to be limited in their productivity from herbivory of seeds and young plants by mice. When collecting seeds from species to plant and grow in the greenhouse for restoration purposes, biologists have noted that seeds from these species are much more abundant on Eastern Island where there are no mice. In addition, mice are eating the seeds and damaging young plants grown in the greenhouse, which are used for the restoration plantings. Adoption of the No Action Alternative would not meet the management objective of restoring the MANWR ecosystem.

Under the no-action alternative, some vegetation would be exposed to the hand broadcasting of $AGRID_3$ bait pellets for seabird and listed candidate plant protection, in areas where mouse predation of seabirds and mouse damage to listed or candidate plants is detected. (See Section 2.4 “Alternative 2: No Action” detailing current control efforts).

3.3.6.4.5 Probable Impacts: Preferred Alternative

Primary Exposure

Plants are not known to be susceptible to toxic effects from rodenticides. Brodifacoum is strongly bound on soil particles and is not taken up by plants (WHO 1995).

Operational Hazard (Noise Disturbance and Trampling)

Helicopters would be taking off and landing from paved staging areas, which are clear of vegetation. Plants, including the two-listed species above, would not be affected by helicopter operations. There would be potential for trampling of some plants as a result of ground-based operations. However, ground-based operations are only expected to take approximately 240 personnel hours to complete over a 3-week period. Therefore, only minor effects would be likely to occur from the proposed operation.

A biosecurity plan has been in place on MANWR for many years and any additional bio-security measures would only occur if there was a new incursion of a non-native species. There could also be some additional impact to terrestrial plants during implementation of the monitoring plan for the eradication project. New biosecurity measures enacted could include rapid response to an incursion by non-native invasive species and implementing the project monitoring plan would include follow-up observations and the collection of samples (see Appendix A and B). Potential impacts such as trampling of vegetation could occur with the additional monitoring activities. Given the minimization measures that will be in place to protect endangered plants, we expect any additional impacts to be minor and short-term. Implementing the biosecurity plan is only expected to have beneficial effects to listed plants.

Positive indirect effects from the Preferred Alternative would be expected. Removal of mice may result in an increase in the number and diversity of native plants growing on Sand Island, a long-term indirect effect of eradicating mice. Positive effects of the action include the elimination of mice that might eat the seeds and parts of the pōpolo and loulu. The nature of the changes to the plant composition would be complex and it is uncertain how native plants would respond compared to non-native plants under potentially increased competition and reduced predation (Eijzenga 2011). It is possible that some species of plants being planted for vegetation restoration projects on Sand Island may spread faster without the negative effects of seed herbivory by mice. The most common invasive introduced taxa on MANWR include ironwood (*Casuarina equisetifolia*), golden crown-beard (*Verbesina enceloides*), wild poinsettia (*Euphorbia cyanospora*), haole koa (*Leucaena leucocephala*), sweet alyssum (*Lobularia maritima*), buffalo grass (*Stenotaphrum secundatum*), peppergrass (*Lepidium virginicum*), and Bermuda grass (*Cynodon dactylon*).

<u>*Mitigation*</u>

Staff will be trained to recognize the pōpolo and loulu and monitor their work areas at all times for the presence of these two species. They will exercise extreme care when hand broadcast of bait is necessary or when servicing bait stations to minimize any damage to listed plants. By implementing these measures, the proposed project will avoid potential adverse effects to the pōpolo and loulu.

As part of the project to restore plant communities on Sand Island and eliminate invasive weeds, vegetation restoration sites and invasive weed populations would be monitored post-mouse eradication. Annual weed monitoring has been conducted on Midway since 2012 and would continue, including detecting trends in the cover of golden crown-beard. Any significant changes to the success of these programs would be closely monitored and adaptive management actions taken if needed. All personnel visiting or working on MANWR would adhere to current biosecurity protocols to prevent any new botanical alien species from becoming introduced to Sand Island (Appendix A). In addition, the compressed grain bait pellets are manufactured to ensure that no active seeds are embedded into the baits, thereby preventing accidental introduction. The USFWS has a long-term commitment to successfully restore the MANWR ecosystem and monitor the results.

3.3.6.5 Seabirds

MANWR provides a refuge for some 3 million seabirds (USFWS 2014). Twenty-one species are known to breed or roost on Sand Island (see Table 3.12 below). All species of seabirds at MANWR are protected under the MBTA. One species, the short-tailed albatross, is Federally listed as Endangered (Federal Register; July 31, 2000).

Table 3.12 Breeding Seabirds of MANWR (n = 21 species)

Name				
Common	***Scientific***	***Hawaiian***	***IUCN-list***	***Federal Status***
Laysan albatross	*Phoebastria immutabilis*	Mōlī	Near Threatened	-
black-footed albatross	*Phoebastria nigripes*	ka'upu	Near Threatened	-
short-tailed albatross	*Phoebastria albatrus*	-	Vulnerable / Endangered	Endangered
wedge-tailed shearwater	*Puffinus pacificus*	‘ua‘u kani	Least Concern	-
Christmas shearwater	*Puffinus nativitatis*	-	Least Concern	-
Bulwer’s petrel	*Bulweria bulwerii*	‘ou	Least Concern	-
Bonin petrel	*Pterodroma hypoleuca*	-	Least Concern	-
Tristram’s storm-petrel	*Hydrobates tristrami*	-	Near Threatened	-
black noddy	*Anous minutus*	Noio	Least Concern	-
brown noddy	*Anous stolidus*	noio kōhā	Least Concern	-
sooty tern	*Onychoprion fuscatus*	‘ewa‘ewa	Least Concern	-
little tern	*Sternula albifrons*	-	Least Concern	-
least tern	*Sternula antillarum*	-	Least Concern	-
gray-backed tern	*Onychoprion lunatus*	pakalakala	Least Concern	-
white tern	*Gygis alba*	manu-o-ku	Least Concern	-
great frigatebird	*Fregata minor*	‘iwa	Least Concern	-
white-tailed tropicbird	*Phaethon lepturus*	koa‘e kea	Least Concern	-
red-tailed tropicbird	*Phaethon rubricauda*	koa‘e ‘ula	Least Concern	-
red-footed booby	*Sula sula*	‘ā	Least Concern	-
brown booby	*Sula leucogaster*	‘ā	Least Concern	-
masked booby	*Sula dactylatra*	‘ā	Least Concern	-
Source: USFWS (1983, 2014)				

Details on the distribution, population status and trends, ecology, and conservation concerns for these 21 species can be found in the Regional Seabird Conservation Plan, Pacific Region (USFWS 2005) and the International Union on the Conservation of Nature (IUCN) Red List for Endangered Species (IUCN 2017a). The greatest threats to the seabirds of MANWR include introduced and invasive species, fisheries interactions, ocean contaminants, marine debris, and climate change (USFWS 2005).

3.3.6.5.1 Existing Conditions: Albatrosses

Three albatross species are found at MANWR, (*i*) Laysan albatross, (*ii*) black-footed albatross, and (*iii*) short-tailed albatross. Adults forage offshore; their diet consists primarily of fish, squid, and crustaceans. Albatross pairs are philopatric and mate retention is high (USFWS 2005). Albatrosses are not agile flyers, due to their long wingspans and heavy body weight. Chicks exhibit pica behavior and occasionally ingest soil, rocks, and paint chips when pecking the ground (Finkelstein et al. 2003). Adult albatross are subject to mortality at sea during interaction with commercial fishing operations. Adults and chicks are subject to mortality when on land during periods of low wind when birds die from overheating in the sun. Mortality can also occur from other causes like starvation or injury (USFWS, Unpublished b).

Laysan albatross. The global population is estimated at 1.5 to 1.6 million individuals (Arata et al. 2009, 2017b, ACAP 2012b, USFWS, Unpublished b). Over 70% of the global population depends upon MANWR for breeding. Of MANWR's population, over 60%, or approximately 719,530 birds, nest on Sand Island (USFWS, Unpublished b). Individuals measure about 31.0-32.0 in. (79-81 cm) in length, have wingspans of 76.8–79.9 in. (195–203 cm), and on average weigh about 5-8 lbs. (2,200-3,600 g) (Whittow 1993b). The species is present from November to July (USFWS, Unpublished b). Nests are built on bare ground and among vegetation; birds use surrounding grasses, shrubs, and dirt piled into large mounds as a nest cup into which a single egg is laid (USFWS 2005).

Black-footed albatross. The global population of this albatross of the northern Pacific Ocean is estimated at 140,138 breeding individuals (Flint 2007, Naughton et al. 2007, ACAP 2012a). Thirty-seven percent of the global population or about 51,230 birds depend upon MANWR, with 22% of the refuge's population (approximately 30,168 birds) using Sand Island (USFWS, Unpublished b). Individuals measure about 25-29 in (64-74 cm) in length, have wingspans of 76-85 in (193-216 cm), and on average weigh about 5-9.5 lbs. (2200-4300 g) (Whittow 1993a). The species is present on MANWR from November through June (USFWS 2005). Nests are similar to Laysan albatross nests in construction but occur in more open areas with sparse vegetation; primarily near coastal beach areas (Reynolds et al. 2017).

Short-tailed albatross. Federally listed as Endangered, this species historically occurred throughout the North Pacific Ocean (USFWS 2005). Currently, 85% of the global population breeds on Torishima Island in Japan (USFWS 2005). At MANWR, two birds, representing 0.05% of the global population of 4,200 birds (IUCN 2017a), arrived on Sand Island in recent years but have yet to successfully breed (USFWS, Unpublished b). Individuals measure about 84- 33-37 in (94 cm) in length, have wingspans of 84-90 in (213-229 cm), and on average weigh about 8-14.5 lbs. (3,700-6,600 g) (USFWS 2008). The species is present November through June (USFWS 2008a, b). Nests are similar to Laysan albatross nests in both construction and placement (USFWS 2005). The primary threat to this species is from volcanic activity, which has the potential to destroy or disturb the Torishima Island colony.

3.3.6.5.2 Existing Conditions: Nocturnal seabirds

Nocturnal seabirds include: (*i*) wedge-tailed shearwater, (*ii*) Christmas shearwater, (*iii*) Bonin petrel, (*iv*) Bulwer's petrel, and (*v*) Tristram's storm-petrel. All 5 of these species nest in subterranean burrows or in cryptic rock crevices or rubble; Christmas shearwater also nest underneath trees, shrubs and dense bunch grasses on the ground (Reynolds et al. 2017). These species fly to and from their colonies at night. Impacts to Tristram's storm-petrel would be low because birds are absent from MANWR during the proposed baiting operation. Impacts to Christmas shearwater and Bulwer's petrel would be low given that nesting by these species on Sand Island has not been documented to date (USFWS, Unpublished b). Of the 5 nocturnal species, only wedge-tailed shearwaters and Bonin petrels may be negatively affected by the operation.

Wedge-tailed shearwater. This wide-ranging flyer is one of the most common seabirds in Hawai‘i. About 10,000 individuals nest on Sand Island (USFWS, Unpublished b), representing about 0.2% of the global population estimated at around 5,200,000 birds (Brooke 2004). Individuals measure about 16-18 in. (41-46 cm) in length, have wingspans of 38-41 in. (97-104 cm), and on average weigh about 0.86-0.9 lb. (390-404 g) (USFWS 2015, Gross et al. 1963). Adult arrival is in late March and eggs are laid in June; hatching occurs from late July to late August and chicks fledge mid-October to mid-November (USFWS 2005). This species feeds mostly on fish, but also cephalopods, crustaceans and marine insects, catching prey mainly on the wing by dipping and surface-seizing or pursuit-plunging (IUCN 2017a).

Bonin petrel. The Bonin petrel population at MANWR rebounded after rat eradication efforts from 1994-1997, but suffered a set-back from flooding caused by a 2011 tsunami (Pyle and Pyle 2017). The global population of this species is not known, but estimated at around one million individuals (IUCN 2017a, Seto and O’Daniel 1999) with most of those occurring on Laysan, Lisianski and Sand Islands. These birds measure 11.8 in (30 cm) in length with wingspans of 24.8-28 in (63-71 cm), and a mean body mass of 0.45 lb. (203.7 g) (Seto and O’Daniel 1999). The nest is a shallow sandy burrow where a single egg is laid in mid-January; chicks fledge by June (Mitchell et al. 2005). This species feeds offshore and surface dips for prey like fish, squid, marine insects, and crustaceans (Seto and O’Daniel 1999). Bonin petrel leave Sand Island in June but return again in August-September (Grant et al. 1983), resulting in a short absence window (USFWS 2005). The proposed eradication period coincides with this period when the lowest numbers of Bonin petrels are expected to be present.

3.3.6.5.3 Existing Conditions: Noddies

Both black and brown noddies are present on Sand Island year-round (USFWS, Unpublished b). Both species may be negatively affected by the operation.

Black noddy. The global population of black noddy is estimated to be 3-4.5 million birds (IUCN 2017a), of which, 0.003% or about 12,000 birds, occur on Sand Island. Black noddy measure 14-16 in. (35–40 cm) in length, with a wingspan of 25-28 in. (65–72 cm), and a body mass ranging between 0.2-0.3 lbs. (85–140 g) (Gauger 1999). In Hawai‘i, this species is an asynchronous and aseasonal breeder, meaning that eggs are laid year-round, the synchronous timing of egg-laying among individuals varies, and peak egg-laying occurs in different seasons in different years (USFWS 2005). Nests are built in tree and shrub canopies and 1 egg is laid per breeding attempt (Gauger 1999). Black noddy forage in the surf along beach shoreline (USFWS, Unpublished b), in lagoons of atolls, and brackish water of coastal ponds; most feeding is <6.2 mi. (<10 km) from shore (Gauger 1999). Food items include small fish, squid, and crustaceans that are seized from the surface of the water or just below it. Birds tend to concentrate over nearshore waters.

Brown noddy. The global population of brown noddy is estimated to number 180,000-1,100,000 individuals (Delany and Scott 2006), with approximately 7,200 birds occurring on Sand Island, or 0.6% of the global population (USFWS, Unpublished b). Adults are about 16-18 in. (40–45 cm) in length with a body mass of about 0.35 lbs. (180 g) (Chardine and Morris 1996). Brown noddy breed synchronously, with peaks in breeding activity occurring in both the spring and summer months (USFWS 2005). Eggs are present from March through August; a single egg is laid in a nest built on the ground or in a tree. Flight habit is to concentrate over nearshore waters, but mainly feeds offshore on small fish and squid it catches at the sea's surface by dipping or seizing (Chardine and Morris 1996).

3.3.6.5.4 Existing Conditions: Terns

On MANWR, these species include the: (*i*) white tern, (*ii*) little tern, (*iii*) least tern, (*iv*) gray-back tern, and (*v*) sooty tern. Population levels of all 5-tern species, except the white tern, are low on Sand Island, and the sooty tern only nests on Eastern Island. The operation would be unlikely to affect little, least and grey-backed terns because their flight behavior and nest locations make aircraft strikes unlikely. Of the 5 terns, only the white tern may be negatively affected by the operation.

White Tern. The common white tern has a distribution across the tropics of the world, found year-round on islands in the south Atlantic Ocean, the Indian Ocean, and the western and central Pacific. This species is difficult to census accurately, because of the protracted breeding season, cryptic coloration of eggs and chicks, and inaccessibility of cliff nesting sites. The population at MANWR has increased greatly in past 50 years, owing to introduction of ironwood trees that have provided suitable nesting habitat (Niethammer and Patrick 1998). Population in Northwestern Hawaiian Islands was estimated at 80,700 individuals: 50,840 (63%) non-breeders and 29,860 (37%) breeders (USFWS 1983). The global population of white tern is not known but is thought to be stable (IUCN 2017a). Approximately 49,420 birds occur on Sand Island (USFWS, Unpublished b).

As the name implies, this tern is all-white and is 11-13 in. (27.5–33 cm) in length, has a wingspan of 27.6-34.2 in (70–87 cm), and a body mass ranging between 0.17-0.35 lbs. (77–157 g) (Niethammer and Patrick 1998). White tern on Sand Island breed year-round, and most nests are on branches of ironwood (*Casuarina equisetifolia*) trees or on buildings and other human-made structures at MANWR (Howell 1978). No nest is made; instead, it lays its single egg, often delicately balanced, on a branch, building, or rock. Newly hatched chicks have well-developed feet and claws with which they cling to their perilous nest sites. Adults carry small fish and squid in their bills, often several at a time, to feed chicks. Adults seem tolerant of disturbance, often rearing their young near human activity (Niethammer and Patrick 1998). Most egg-laying occurs February to June (USFWS 2005). White terns forage primarily in the surf along the beach shoreline, along shoals and banks, and offshore for fish and squid (Niethammer and Patrick 1998).

3.3.6.5.5 Existing Conditions: Great Frigatebird

The great frigatebird comes to Sand Island not to breed but to roost, and do so in relatively small numbers (USFWS, Unpublished b). The global population is estimated to be between 500,000-1,000,000 individuals (Gauger et al. 2002, USFWS 2005), with approximately 0.01%, or 140 birds occurring on Sand Island. Individuals are 33.5-41.3 in. (85–105 cm) in. length, have a wingspan of 81-90 in. (205–230 cm), and a body mass of 2.2-4 lbs. (1-1.8 kg) (Gauger et al. 2002). The bird is an aerial acrobat, foraging for flying fish and squid at the ocean's surface over deep, offshore waters (Gauger et al. 2002, USFWS 2005). The great frigatebird may be at some risk during the operation.

3.3.6.5.6 Existing Conditions: Tropicbirds

Both red-tailed and white-tailed tropicbirds are present at MANWR. At MANWR, the white-tailed tropicbird is a rare breeder on Sand Island, and represented by only a few pairs (USFWS, Unpublished b). The red-tailed tropicbird is more numerous and would be breeding on Sand Island during the operation. Therefore, some negative impact on this species is possible. Both species behaviorally make showy aerial displays around midday at Sand Island, flying 98-164 ft. (30-50 m) in the air (Fleet 1974). Additionally, both species feed far offshore primarily on fish and squid (IUCN 2017a, USFWS 2016).

Red-tailed tropicbird. The global population of the red-tailed tropicbird is estimated to number 60,000-80,000 individuals (Schreiber and Schreiber 2009), with approximately 19%, or 15,000 of birds occurring on Sand Island. The streaming red central rectrices are a striking characteristic for this species that is about 17-18.5 in. (44-47 cm) in body length and has a body mass ranging from 1.4-1.7 lbs. (650-780 g). Red-tailed tropicbirds are aseasonal breeders on Sand Island, and nests occur in a variety of available substrates. Eggs are typically laid on the ground in small depressions in the sand, soil, humus, or fine coral rubble under vegetation, or tucked into cliff crevices (Morrell and Aquilani 2000, USFWS 2005).

3.3.6.5.7 Existing Conditions: Boobies

Three booby species, red-footed, brown, and masked, are present at MANWR year-round. There are approximately 475 breeding pairs of red-footed booby on Eastern Island. Some red-footed booby individuals temporarily roost on Sand Island. The masked booby only nests in extremely low numbers on Eastern Island and are too few in number to be affected by the operation. There are generally fewer than 5 masked booby pairs nesting per year on Eastern Island, with no historical information indicating they were previously more numerous (USFWS, Unpublished b). The brown booby, once considered the most common booby at MANWR in the 1930s until rats were introduced, now number only 2 pair nesting on Eastern Island. This species is the only 1 of the 3 that forages in nearshore waters. Given that all 3-species nest on Eastern Island, with low numbers roosting on Sand Island, impacts would be minor.

3.3.6.5.8 Probable Impacts: No Action Alternative

Under the No Action Alternative, mice would not be eradicated on Sand Island and would continue to impact seabird colonies and the vegetation they use for nesting and cover. Over 3 million seabirds, encompassing 21 different native species, nest on MANWR's 3 islands and many of them are susceptible to predation by mice. If mice are able to prey upon adult Laysan albatrosses, one of the largest seabirds on Sand Island, then other ground nesting and burrowing seabirds, adults and chicks, are at risk from similar impacts. Introduced mice would continue to prey on nesting seabirds on the island, preventing them from reaching their full population potentials, and if the predatory behavior spreads at the rate observed in 2016/2017, then the predation would likely contribute to accelerated declines in affected seabird populations. Brooke et al. (2017), drawing on data regarding eradication of non-native mammals on islands from around the world, examined the population growth rates of 181 seabird populations (of 69 seabird species) following successful mammal eradication projects. This analysis included the recovery of Bonin petrels following the eradication of the black rat at MANWR in 1996. After successful eradication, the median population growth rate (lambda) was 1.119 and seabird populations, with positive growth rates greatly outnumbering those in decline. The study confirmed that invasive mammal eradication is usually followed by growth of seabird populations.

Under the No Action Alternative, Sand Island's mouse population would not be the subject of a targeted eradication project, but mouse control efforts to protect breeding albatross, which were started in 2016, would continue and expand as deemed appropriate. (See Section 2.4 "Alternative 2: No Action" detailing current control efforts).

Eradication of the house mouse from MANWR would facilitate the protection and restoration of native plants present in the refuge. Beyond the predation of seabirds, mice likely have deleterious effects on many other components of the ecosystem of MANWR. No action would result in the continued presence of mice and a continuing long-term adverse impact on biological resources (see Section 1.2 and Section 1.3). Rodents are known to be a disease vector (de Bruyn et al. 2008, Avenant and Smith 2003), feed opportunistically on plants, and alter the floral communities of island ecosystems (Campbell and Atkinson 2002). They also sometimes compete with native species and degrade the quality of nesting habitat for birds that depend on the vegetation (Wegmann 2009, Young et al. 2010). Rodents can also prey on intertidal invertebrates and reptiles and thus affect their abundance and age structure (Navarrete and Castilla 1993), along with negative effects to marine algae abundance (Kurle et al. 2008). The presence of rodents has also been shown to lower total soil carbon, nitrogen, phosphorous, mineral nitrogen, marine-derived nitrogen, and pH relative to rodent-free islands (Fukami et al. 2006).

3.3.6.5.9 Probable Impacts: Preferred Alternative

Primary Exposure

The potential for exposure of adult seabirds to rodenticides on Sand Island would be limited. Consumption of bait pellets by adults would not be a risk, as all species are carnivorous, feeding on fish, squid, eggs, or crustaceans. Almost all of the 21 seabird species reported from MANWR (Table 3.12) typically forage many miles away from the island in deep water; the exceptions include black noddy, brown booby and white tern, which are assessed for secondary poisoning in the next section.

Primary poisoning would be a potential risk for some species of seabird chicks. Ten species of seabirds have been documented to nest on Sand Island: Laysan albatross, black-footed albatross, short-tailed albatross, wedge-tailed shearwater, Bonin petrel, black noddy, brown noddy, white tern, white-tailed tropicbird, and red-tailed tropicbird. Of these, 4 nest on the surface of the ground and might have young in the nest during the period when bait would be on the ground. These species include the Laysan albatross, short-tailed albatross, brown noddy, and red-tailed tropicbird. The majority of black-footed albatross chicks fledge from Sand Island by late June, prior to when bait would be on the ground. However, only Laysan albatross and short-tailed albatross are at risk of ingesting non-food objects on land. These species nest on the ground, and their chicks are known to peck at or sometimes swallow objects found on the ground such as rocks, sticks, and foreign objects. This tendency is known as pica behavior. This behavior would only be detrimental to the young if they actually pick up a bait pellet and then ingest it. Both the red-tailed tropicbird and brown noddy were nesting on Palmyra during the 2011 rat eradication project and neither species was detected as having ingested brodifacoum after the operation. In addition, there are no descriptions of the red-tailed tropicbird or brown noddy manipulating or swallowing foreign objects on land. In a study of the effects of chemical weapons incineration on a nesting colony of red-tailed tropicbirds on Johnston Atoll in the central Pacific, Schreiber et al. (2001) found that the ingestion of heavy metals from soil was not considered to be a problem since red-tailed tropicbirds did not feed on land and did not tend to pick up objects with their bill while on land. The method of feeding at sea by red-tailed tropicbirds is very different from that of albatross that do pick up and sometimes ingest items on land (chicks only) (Work and Smith 1996). Albatross adults sit on the water and pick up potential food items and it is normal for chicks to do this on land instinctively as they learn to use their bill. However, red-tailed tropicbirds dive from the air to feed at sea and thus neither the adults or chicks appear to ingest particles on land and no soil is found in their stomach contents (Ashmole and Ashmole 1967, Schreiber and Schreiber 1993).

The likely start date for the bait drop on Sand Island is early July. In a detailed study by Fisher and Fisher (1969) of the nesting chronology of Laysan albatross on MANWR, researchers using study plots found that the number of adult and juvenile Laysan albatross on June 11 was 19% of peak counts in April and only 7.1% of the peak population by June 29. Nestlings begin to leave the colony about June 20 and those that survived were essentially gone by August 2 or 3. In the 3 years of study 10-26% left before July 1. The period of most rapid departure was July 5 to 25, but 50% of the young albatrosses were gone by July 15 in 1961, July 16 in 1962, and by July 9 in 1963 (Fisher and Fisher 1969). Therefore, 50% of young Laysan albatross would likely be gone after the first 2 weeks of the bait drop. In addition, many of the young albatross that do not leave the island by late July often succumb to exposure to the heat and/or starvation, as the adults are no longer returning to feed them.

For primary poisoning risks associated with pica behavior, objects within about 3 ft. (1 m) of the nest would be accessible to a Laysan albatross chick. At later ages, however, chicks wander even farther from the nest, to find shade for example. In an area with a 3-foot radius, which is 28 ft.^{2} (2.6 m^2), about 0.67 oz. (19.2 g) of brodifacoum bait would be available under the proposed maximum application rate of 65 lbs./ac. (73 kg/ha). This represents 19 pellets since each pellet weighs 0.03 oz. (1 gram). For brodifacoum, an albatross chick would need to ingest about 0.73 oz. (20.8 g), or 21 pellets, for a potential lethal dose (Table 3.13). This is 11.1% of its expected daily food intake. A chick would need to ingest about 0.07 oz. (2 g), or 2 pellets, for a sub-lethal dose. Therefore, for a Laysan albatross chick to receive a potential lethal dose, it would need to pick up and ingest every bait pellet (and more) within a 3 ft. (1 m) radius of its nest while the bait is still available and then range outside of this area and pick up and ingest another 2 pellets. This would be unlikely given that the bait is expected to be taken up rapidly by mice and invertebrates (e.g. cockroaches), and that the primary diet of albatross chicks is fish and squid brought by the parents. This latter point of primary diet also applies to chicks that wander further from their nest so that it would be unlikely for them to consume 21 pellets or more via pica behavior.

For the short-tailed albatross, only 1 pair is present on Sand Island and they have not had an active nest to date. Therefore, it is unlikely an active nest with a chick would be present during the bait drop. However, the pair is monitored each year, and if a chick is present, all bait pellets within reach of this chick would be collected and removed as a mitigation strategy.

The above risk of primary exposure for albatross is likely overestimated, primarily because most bait pellets from the first application would be rapidly consumed or cached by mice and cockroaches. Subsequent applications would occur after most albatross chicks have fledged. Also, not all birds would pick up the bait, and of those that do, not all would ingest significant amounts because of their main diet of fish and squid provided by the parents. Therefore, it would also be unlikely that any Laysan albatrosses would be killed or sub-lethally affected by primary poisoning from brodifacoum.

Secondary Exposure

While there would be potential for secondary poisoning of black noddy, brown booby, white tern and great frigatebird, that risk would be low. Of the 21 species of seabirds on Sand Island, only the black noddy, brown booby and white tern sometimes forage in the nearshore marine environment around Sand Island. This foraging habit puts these species at risk of potentially ingesting fish contaminated with brodifacoum, and potential exposure to persistent residues post-operation. The great frigatebird could be at risk of secondary poisoning from scavenging dead mice.

Table 3.13 Primary and Secondary Toxicity of Brodifacoum

Primary toxicity presented as grams of bait and secondary as grams of fish. "N/A" indicates that there is no feeding behavior for this pathway and no risk from poisoning. The mg of active ingredient is abbreviated as a.i.; LD_{50} is that the dosage (D) of a toxin that is lethal (L) to 50% of animals of the species in laboratory tests.

			Brodifacoum				
Species	***Body Wt (g)***	***Daily Food Intake (g)[1]***	***LD_{50}[2] (mg/kg)***	***LD_{50} (mg of a.i./bird)***	***LD_{50}[3] (g of bait)***	***LD_{50} 2[4] (g of fish)***	***%[5] of Daily Food Intake***
black noddy	110	26.9	0.26	0.029	N/A	24.7	91.7
brown noddy	180	37.4	0.26	0.047	N/A	N/A	N/A
brown booby	1,356	144.7	0.26	0.353	N/A	303.9	210.0
great frigatebird	1,400	147.8	0.26	0.364	N/A	56.4[6]	38.2
white tern	110	26.9	0.26	0.029	N/A	24.7	91.7
Laysan albatross chick	2000	187.7	0.26	0.520	20.8	N/A	11.1
black-footed albatross chick	3,400	267.9	0.26	0.884	35.4	N/A	13.2
short-tailed albatross chick	6,400	409.3	0.26	1.664	66.5	N/A	16.3
red-tailed tropicbird chick	660	89.3	0.26	0.172	6.9	N/A	7.7

Notes:
1. Daily food intake calculated from allometric equation (Bird Feeding Rate = 0.059 x ($W^{0.67}$) (USEPA 1995).
2. LD_{50} of brodifacoum based on mortality of mallard ducklings at the lowest dose, 0.26 mg/kg body weight = 0.00026 mg/g (Ross et al 1980, EPA 1991).
3. This is also the number of bait pellets that would need to be consumed to be lethal to 50% of the animals.
4. Based on mortality of fish at 1.16 mg/kg = 0.00116 mg/g (Pitt et al 2015).
5. Calculated as LD_{50}2 grams of bait or prey/daily food intake (g).
6. For the predatory great frigatebird, this is grams of whole rat. Contamination based on highest reported residues in rat carcasses (6.45 mg/kg liver = 0.00645 mg/g) (Pitt et al. 2015).

Black noddy forage within a few yards of the shore and so could be at risk of secondary poisoning if they consume small intoxicated reef fish. Surveys indicate approximately 12,000 birds could be present on Sand Island in July and August. However, black noddy feed on fish at the surface of the water, which are species less likely to consume any bait that falls in the water compared to bottom feeding fish (mullets, etc.). Although it is possible that black noddy could forage on fish exposed to rodenticide, the overall liklihood that this would occur is low. The relatively small quantity of bait that could enter the water and rapid degradation and dispersion of the rodenticide would combine to greatly reduce the probability of a noddy being exposed to an intoxicated marine fish or invertebrate. This is supported by results from post-application sampling of the near shore marine environment from 2 eradication projects in Hawaiʻi. The results showed no detectable levels of diphacinone in fish, invertebrates, or seawater (Gale et al. 2008; Orazio et al. 2009). However, during the second 2017 Lehua rat eradication effort, fish were caught from shore and gut contents examined for signs of bait material and the pyranine biomarker fluorescence. Bait material and/or the biomarker were observed in some specimens of fish but not others (see details in Section 3.3.6.14.3). During rat eradication on Palmyra Atoll, the carcasses of 12 seabirds were recovered including 2 sooty terns, 6 red-footed boobies, and 1 black noddy. None of these were confirmed to have died from ingesting brodifacoum, which is noteworthy considering the permitted application rate was 6 times higher than normal due to the rapid consumption of the bait by numerous land crabs (Pitt et al. 2015). In addition, an individual bird the size of a black noddy (110 g) would have to consume 0.9 oz. (24.7 g) of toxic fish to receive a potential lethal dose (Table 3.13) of rodenticide, which is 91.7% of its daily food intake. Because very little of the rodenticide is expected to enter the water, the rapid breakdown in water (see impacts to physical environment section), and the large % of a bird's daily intake required for a potential lethal dose, the Preferred Alternative would be unlikely to result in the mortality of any black noddy adults or chicks.

Brown booby could also be at risk of secondary poisoning since they forage for a variety of fish and squid either at sea or in the surf along the beach shoreline (Schreiber and Norton 2002) and are often observed loafing atop the channel buoys on MANWR. However, only 2 pairs of birds nest on Eastern Island and no breeding occurs on Sand Island. In addition, an individual adult booby would have to consume 10.7 oz. (304.0 g) of toxic fish to receive a potential lethal dose (Table 3.13) of rodenticide, which is 210% of its daily food intake. Due to the low number of birds on MANWR, the large % of a bird's daily intake required for a potential lethal dose, and the low likelihood of encountering toxic fish, the Preferred Alternative would be unlikely to result in the mortality of any brown booby adults or chicks.

White tern could be at risk from secondary poisoning since they forage primarily in the surf along the beach shoreline and along shoals and banks as well as offshore for fish and squid (Niethammer and Patrick 1998). However, an individual adult white tern would have to consume 0.87 oz. (24.7 g) of toxic fish to receive a potential lethal dose (Table 3.13) of rodenticide, which is 91.7% of its expected average daily food intake. Because very little of the rodenticide is expected to enter the water, the rapid breakdown of bait pellets in water (see impacts to physical environment section), and the large % of a bird's daily intake required for a potential lethal dose, the Preferred Alternative would be unlikely to result in the mortality of any white tern adults or chicks.

Frigatebird are at risk of secondary poisoning from scavenging dead mice and a maximum of 140 birds have been reported on Sand and Eastern Islands. These birds are known to take unattended seabird chicks, thus there exists potential for scavenging or predation of mice that are dead or dying from ingestion of rodenticide. However, several factors reduce the risk of the frigatebird preying or scavenging on intoxicated mice. First, exposure risk would be relatively low, because most mice dying from anticoagulant rodenticide often do so in areas inaccessible to avian predators (Lindsey and Mosher 1994). Second, while the behavior of foraging on land (i.e, preying on chicks) is documented, it does not appear to be exhibited by all members of the population (Megyesi and Griffin 1996). In addition, based on the body weight of this species and the LD_{50} value, it would take the consumption of 2.0 oz. (56.4 g) of whole mice contaminated with brodifacoum for an individual bird to reach a potential lethal dose. This is 38% of its estimated daily food intake. Therefore, it is extremely unlikely that any individuals would be at risk from secondary poisoning.

Based on the above analysis, it is unlikely that black noddy, brown booby, white tern, or great frigatebird would be killed or sub-lethally affected by secondary exposure to brodifacoum from the Preferred Alternative.

Operational Hazard (Bird Strike and Noise/Human Disturbance)

Crushed Burrows. There is a risk that ground crews that are hand broadcasting bait or conducting monitoring can accidentally collapse active seabird burrows containing adults, eggs, or chicks. There are 4 burrow-nesting seabirds on Sand Island: wedge-tailed shearwater, Bonin petrel, Bulwer's petrel, and Tristram's storm-petrel. All 4 species nest in subterranean burrows or cryptic rock crevices, and adults make flights to and from their nests at night. On Sand Island, nesting Tristram's storm-petrels would not be present during the operation and no nests of Bulwer's petrel have been documented (USFWS, Unpublished b). Bonin petrel are not expected to be impacted because a majority of these birds would have left Sand Island and few, if any, would be left during the operation. On MANWR, in 1993 and 1994, mean fledging dates for Bonin petrel was 6 Jun ± 5.2 d SD (range 24 May–17 Jun, n = 36) and 4 Jun ± 5.0 d SD (range 26 May–15 Jun, n = 47), respectively (Seto 1994).

The main species of concern is the wedge-tailed shearwater, which would be present and breeding during the operation. There are an estimated 5,000 pairs breeding on Sand Island (USFWS, Unpublished b). During the targeted period of July-August, the majority of birds would be at the egg stage and into the beginning of the chick rearing stage of breeding (USFWS 2005, 2015).

Hand broadcast application of bait and monitoring on Sand Island would be conducted by personnel skilled in recognizing seabird burrows and trained in mitigation measures. Hand broadcasting is being limited to a few sites including narrow shorelines, ponds and freshwater seeps, and around certain structures. Bait is typically distributed by a team who systematically walk on parallel transects stopping at predetermined intervals to distribute pellets as evenly as possible. For Sand Island, an estimated 240 total person-hours would be needed to hand broadcast for the entire operation (3 scheduled drops, 8-person team, working 10-hour days). However, after the initial hand broadcast operation, crews would be walking the exact same transect lines for the second and third bait applications. Therefore, it is less likely that any additional burrows would be crushed after the first walk-through. This initial hand broadcast operation is expected to take a total of 80 personnel hours. The success rate of rescuing birds from a crushed burrow is high if mitigation protocols described below are followed. The exceptions are very deep sandy burrows for which it is difficult to find both passageways as a person digs or when a person actually steps on the chamber and crushes the egg or kills the bird. Regardless of whether an adult or chick is pulled out or a damaged burrow is repaired that has an occupant, it would still be counted as a “take” on project monitoring reporting forms.

No data is available to gauge exactly how many burrows would be at risk. However, assuming a worst-case scenario, that 1 burrow is crushed for every 3 hours of personnel time, this would result in the risk of 26 burrows being damaged or crushed during the 1st bait drop. However, not all of these burrows would be active nest sites and may not be in use. In addition, for active nest burrows, some of the birds would be rescued by having personnel dig out the collapsed burrows.

On Lehua, nocturnal shearwaters did not seem bothered by personnel on the ground and reacted by moving a few feet away from the person (USFWS and HDLNR 2017). Given the limited number of sites being hand treated, the low number of people on the ground, the few active shearwater burrows per acre, and the protocol and mitigation strategy in place, there would be a low risk of crushing a large number of wedge-tailed shearwater burrows with adults, eggs, or chicks. Ground crews have been very successful at minimizing impacts to surface and subterranean nests using the additional avoidance and mitigation protocols described below. By adhering to these protocols during ground operations, it is possible that up to 26 shearwater burrows could be collapsed containing an egg, chick, or adult resulting in injury or death. Due to the low number of anticipated mortalities relative to their population size on Sand Island, direct impacts would be minor. Effects would be detectable, but localized, small, and of little consequence shearwater populations on MANWR or globally.

We expect there to be some additional impact to burrow nesting seabirds should the need arise to implement the rapid response portion of the refuge’s biosecurity plan and during implementation of the project monitoring plan. A biosecurity plan has been in place on MANWR for many years and any additional bio-security measures would only occur if there was a new incursion of a non-native species. Biosecurity measures enacted would include rapid response to an incursion by non-native invasive species and implementing the monitoring plan would include follow-up observations and sample collecting (see Appendix A and B). Potential impacts such as trampling of burrows and crushing birds or eggs in the burrows could occur along with additional human disturbance. Given the minimization measures that will be in place to protect burrow nesting seabirds, we expect any additional impacts to be minor, localized, and short-term. Implementing the biosecurity plan is only expected to have beneficial effects to seabirds.

Mitigation Measures for Burrow Nesting Seabirds

Ground-based personnel would be instructed to avoid walking over known wedge-tailed shearwater burrows or other visible burrows. If a burrow is accidentally collapsed by personnel, it would be excavated to re-open the nest entrance to allow adults access to chicks. Burrows would be rebuilt as best as possible to provide chicks or eggs protection from the elements. To avoid impacting nest burrows, biologists would, whenever possible, stay on established trails.

Airstrike Hazard

Bird airstrike data from airplanes landing and taking off from Henderson Airfield on Sand Island were summarized from 2004 to 2010 (USFWS, Unpublished b). Albatross were the greatest hazard to aircraft movements at Midway because of their body sizes (wingspan approximately 6.5 ft. or 2m), abundance, and lack of maneuverability. Albatross, frigatebird and booby would be the most dangerous to aircraft, because of their large body masses and wingspan. Birds with wingspans of 6.5 ft. (2 m) are large and may be difficult to avoid (Klavitter 2004). To minimize bird strikes, all aircraft are now required to land and takeoff during darkness when albatross are present at Midway from November to July. This can sometimes cause nocturnal seabirds to be struck and killed. However, the practice of landing at night has been an effective measure to mitigate albatross and other bird strikes, since albatross typically do not fly during hours of darkness. However, in emergencies, and at other times of the year, aircraft do sometimes land at Henderson Field during the day. In addition to albatross, approximately 900,000 Bonin petrel (wingspan about 18 in. or 46 cm) are found at Midway from August to May. The petrel is most active at night, but typically have lower numbers around the airfield (Klavitter 2004). All species of seabirds on MANWR are diurnal, except for those listed in Section 3.3.6.5.2 (Existing Conditions: Nocturnal seabirds).

From 2004 to 2010 there were a total of 59 bird strikes during 1,280 aircraft movements at Henderson Field. This is 1 strike for every 21.7 movements at Midway, or 460 strikes per 10,000 aircraft movements. This strike rate is 81 times that of commercial airlines, which as of 2010 was 5.7 strikes per 10,000 movements (Klavitter 2004). The higher strike rate at Henderson Field is due to the high populations of nesting seabirds on Midway compared to any other airfield in the nation.

Sixty-three % of the strikes were from Laysan and black-footed albatrosses (Table 3.14). Species contributing to more than 10% of the total strikes also included Bonin petrel and brown noddy (Table 3.14). Two Department of Defense helicopter flights occurred on Midway during this period and no strikes were observed to these species.

Table 3.14 Number and Species of Birds Reported Struck by Airplanes at Henderson Field, MANWR: 2004-2010

Species	***Number Struck***	***% of Total Reported Strikes***
Black-footed albatross	7	11.9
Bonin petrel	6	10.2
brown noddy	6	10.2
great frigate	1	1.7
Laysan albatross	30	50.8
Unknown	3	5.1
white tern	5	8.5
yellow canary	1	1.7
Totals	**59**	**100**
Source: USFWS 2017, unpublished.		

Timing of the eradication on Sand Island in the July-August period would place it outside of the peak breeding season for most seabirds, limiting collision risks to these species. Operations during the months of July and August would also occur before the majority of shorebirds arrive on MANWR, thus minimizing bird airstrike hazard (BASH) to the helicopters and risks to these species.

The helicopters broadcasting the rodenticide would fly at speeds ranging from 29–58 mph (46-93 km/hr.) and at an average expected altitude of approximately 164 ft. (50 m) above the ground. The bait hopper would be on a long-line 20-30 ft. (6-9 m) slung below the helicopters. Therefore, the bait hopper would be approximately 134-144 ft. (41-44 m) above the ground during the rodenticide drop. Consequently, except for landings and take-offs on the runway, the helicopters would fly at an average altitude of 164 ft. (50 m) and the bucket would be >134 ft. (41 m) above the ground most of the time. The height of the helicopters would likely be higher when above forested areas or buildings. These numbers are an estimate and may change as needed to complete the baiting operation safely and effectively.

Due to the significantly lower air speed of the helicopters compared to planes and jets landing at Midway, the risk of bird collisions with a helicopter would be much lower. In addition, all helicopter operations would only occur during daylight, when visibility for birds and the pilot are optimal. Therefore, nocturnal seabirds would not be at risk, which include the wedge-tailed shearwater, Christmas shearwater, Bonin petrel, Bulwer's petrel, and Tristam's storm petrel. Further, impact to Tristram's storm-petrel would be low because birds are mostly absent from MANWR from July to October, a period coinciding with the baiting operation; impacts to Christmas shearwater and Bulwer's petrel would be low given that nesting by these species on Sand Island has not been documented to date (USFWS, Unpublished b). Although 6 Bonin petrels were struck by aircraft at Henderson Field on Sand Island (Table 3.14), the majority of these birds were struck after 8:00 p.m. or in the early morning hours during night landings. Black-footed albatross would have finished nesting and are unlikely to be present on Sand Island during the baiting operation. Population levels of all 5 tern species, except the white tern, are low on Sand Island, and sooty tern only nest on Eastern Island. Therefore, only the white tern is at a high risk during the operation. At MANWR, the white-tailed tropicbird is a rare breeder on Sand Island and only the red-tailed tropic bird would be at high risk of collisions.

Three species of booby are present at MANWR year-round, red-footed booby, masked booby, and brown bobby. The red-footed booby does not nest on Sand Island and the number of total pairs is low, however some of the red-footed booby will temporarily roost on Sand Island. The masked booby and brown booby only nest in extremely low numbers on Eastern Island. Therefore, booby are unlikely to be at risk from the helicopter operations. In addition, with the helicopters flying at an average altitude of 164 ft. (50 m) and the bucket >134 ft. (41 m) above the ground, these heights would allow most birds to flush below the aircraft and temporarily disperse. Great frigatebird are expected to be at risk due to their large body size and habit of soaring above the island although their populations are small on Sand Island.

Three bait drops are planned on Sand Island, using 2 helicopters to maximize the chance of completing each drop in a single day. These drops would be spaced 7 to 10 days apart. It is expected each drop would take a total of 20 flight hours or 60 total flight hours for the entire operation. Total flight times could be longer. Using helicopter strike data from the Palmyra rat eradication, and the number of hours of helicopter time used on Palmyra, we calculated the average number of small bodied <1.8 lbs. (<800 g) and large bodied >1.8 lbs. (>800 g) birds killed per hour on Palmyra. Small bodied birds (sooty tern and 2 unidentified birds) were struck at a rate of 0.085 birds per hour while large birds (red-footed booby) were struck at a higher rate of 0.119 birds per hour. We then applied these collision rates to each of the remaining species of seabirds at risk of strike hazard on Sand Island, but to be conservative, we assumed each species in the 2 body size classes was at equal risk to the 2 species killed on Palmyra, thus likely overestimating risk. These included large seabirds (Laysan albatross and great frigatebird) and small seabirds (black noddy, brown noddy, red-tailed tropicbird, and white tern). After calculating the number of individuals at risk of a strike for each species based on the total helicopter time expected on Sand Island, we adjusted the numbers up or down based on the difference in total population numbers of each species of large or small bodied seabirds at Palmyra versus Sand Island. This adjustment thus accounted for the total number of birds expected to be in the air, based on their population size on Sand Island during the baiting period. For a small seabird, if the population of the white tern on Sand Island was 1/3 that of the sooty tern population on Palmyra, final mortality estimates were adjusted lower by 1/3.

Although Laysan albatross populations are large on Sand Island and potentially a high strike hazard, in a detailed study by Fisher and Fisher (1969) of the nesting chronology of albatross on MANWR, researchers found that as the chicks mature in June and July, adults frequent the island even less often and for shorter periods of time. In the 60-day interval of mid-May to mid-July, when a number of the older young have already fledged, each parent probably visits the island at intervals of about 3 or 4 days, as indicated by the frequency of the feeding of the young. Therefore, after mid-May the parents may make 15 round trips to MANWR, and only spend 3% of the time in the colony. Over the entire year, males and females only spend 18% and 12% of their total time on land, respectively. To rear a chick successfully during the total nesting period of 230 days requires only 160 trips to the colony by both parents combined (Fisher and Fisher 1969). In addition, adult breeding birds start to leave in mid-June, and by the first of August few of them may be seen in the colony. Adult albatross are also known for the brief duration of their visits to feed older chicks. In their study plots, Fisher and Fisher (1969) found the number of adult and juvenile Laysan albatross on June 29 was only 7.1% of the peak population. After August 7, adults of any category are seldom observed on Midway. Therefore, for Laysan albatross, we calculated that only 7.1% of adults would still be present on Sand Island at the start of the operation in early July.

During the 2015 aerial bait trials on Lehua, field crews noted that seabirds were not disturbed (e.g., flushing) due to helicopter operations (Mazurek 2015). Seabirds and shorebirds are also somewhat conditioned to planes landing at Midway, with hundreds of landings and take-offs occurring per year. However, air operations would be expected to kill some seabirds. Using the results of our calculation above, based on the data from the eradication operation on Palmyra, there would be likelihood that 6 species of seabirds could be killed from air operations on Sand Island under the Preferred Alternative. This mortality includes a maximum of 15 Laysan albatross, 1 black noddy, 1 brown noddy, 1 red-tailed tropicbird, 2 white terns, and 1 great frigatebird. These numbers represent a worst-case scenario, based on maximum numbers of birds expected to be on Sand Island, and high probabilities of collision assumed with the helicopter.

Due to the low number of anticipated mortalities relative to their overall population levels (see Table 3.10), the Preferred Alternative could cause a direct impact, but those impacts would be minor. Effects would be detectable but localized, small and of little consequence to their global populations. There are no specific mitigation measures that would be expected to reduce the amount of the impact from helicopter operations. Eradication of mice would be expected to directly benefit several species of seabirds, including the Laysan albatross, short-tailed albatross, black-footed albatross and other species. Elimination of risk from predatory mice would allow these species to increase their population sizes. The eventual population-level benefits to seabirds from eradication of predatory mice on Sand Island outweigh the small number of potential mortalities that might occur through implementation of the Preferred Alternative.

3.3.6.6 Shorebirds

3.3.6.6.1 Existing Conditions

MANWR supports overwintering, year-round, and vagrant populations of shorebirds (Table 3.15). Species include bristle-thighed curlew, Pacific golden-plover, wandering tattler, ruddy turnstone, and sanderling, and occasionally grey-tailed tattler, long-billed dowitcher, wood sandpiper and others. While some young birds stay at MANWR year-round, the bulk of shorebirds that had spent the summer breeding elsewhere arrive around August/September for the winter, and depart around April/May, making the preferred window to carry out the application of bait on Sand Island in the July/August period (Figure 3.3). Due to their habit of breeding elsewhere, the summer population of shorebirds on MANWR consists of juveniles and non-breeding birds.

Table 3.15 Ducks, shorebirds, and wading birds of MANWR (n = 7 species)

Common Name	***Scientific Name***	***Status, IUCN-list***
Laysan duck	*Anas laysanensis*	Critically endangered
ruddy turnstone	*Arenaria interpres*	Least concern
wandering tattler	*Tringa incana*	Least concern
Pacific golden plover	*Pluvialis fulva*	Least concern
bristle-thighed curlew	*Numenius tahitiensis*	Vulnerable
sanderlings	*Calidris alba*	Least concern
cattle egret	*Bulbucus ibis*	Least concern
Source: USFWS (2017)		

There are only 4 species of shorebirds present on MANWR in any significant numbers during the summer months of July and August, when the application of rodenticide is expected to occur. These include 4 species of concern, the bristle-thighed curlew, Pacific golden plover, wandering tattler, and ruddy turnstone. The bristle-thighed curlew and Pacific golden-plover are designated as species of high conservation concern in USFWS National and Regional Shorebird Plans, including the U.S. Pacific Islands Regional Shorebird Conservation Plan (Engilis Jr. and Naughton 2004). Both of these species overwinter at Midway, with low numbers of juvenile or non-breeding birds also present through the summer months. All of the shorebird species using MANWR demonstrate a pattern of greater abundance during the winter months, with very few or no individuals remaining throughout the summer when adult birds return to the breeding grounds in the Arctic (USFWS, Unpublished a). More details on the bristle-thighed curlew can be found in Section 3.3.6.7.

3.3.6.6.2 Pacific golden plover

This species has been sighted regularly on the shoreline of all 3 islets at MANWR, in the forested areas, and in open, grassy areas (USFWS, Unpublished b). This species has an extremely variable body mass range, about 0.2-0.4 lbs. (100-200+ g) within an annual cycle (Johnson and Connors 2010). These plovers spread out while foraging; they are visual foragers that feed by running and seizing prey. At MANWR, they prefer open spaces, low vegetation fields, roadsides, sandy beaches, and mudflats. Their diet consists primarily of terrestrial invertebrates (and some freshwater and marine invertebrates), and includes berries, leaves, and seeds. Although these plovers do not nest in the tropical Pacific, they may return to the same winter foraging island each year (Pratt et al. 1987). Therefore, breeding birds are absent at MANWR from about May to August, but low numbers of juvenile and non-breeding birds are present throughout the summer months (USFWS, Unpublished b).

The global population estimates range from 185,000 to 250,000 (Delaney and Scott 2006) with one estimate of 1,000,000 birds (Bamford et al. 2008, Johnson and Connors 2010). The highest documented count of this species on Sand Island from 1993 to 2001 was 1,540 birds, or 0.15-0.83% of the global population.

3.3.6.6.3 Ruddy turnstone

Ruddy turnstone occurs on Sand Island, with a majority on Eastern Island. Breeding birds are absent at MANWR from about May to August, but low numbers of juvenile and non-breeding birds are present throughout the summer months (USFWS, Unpublished b). Individuals measure 8-10 in. (21-26 cm) in length, have a wingspan of 20-22 in (50-57 cm), and a body mass ranging 0.2-0.4 lbs. (84-190 g) (Nettleship 2000). This stocky, orange-legged shorebird forages on sandy and rocky beaches, coral reefs, tidal pools, and mudflats for marine insects, crabs, clams, and mussels.

Ruddy turnstone are common throughout the Pacific Islands, but the wintering population in this region is small compared to the global total (Engilis and Naughton 2004). Estimates of wintering populations range from 259,000 to 544,000 birds (Nettleship 2000, Van Gils and Wiersma 1996). The highest documented count of this species on Sand Island from 1993 to 2001 was 880 birds, or 0.16-0.34% of the global population.

3.3.6.6.4 Wandering tattler

Wandering tattler occur on Sand Island. Breeding birds are absent at MANWR from about May through July, but low numbers of juvenile and non-breeding birds are present throughout the summer months. Individuals measure 10-12 in. (26–30 cm) in length, with a wingspan of 19-21 in. (50–55 cm), and a mean bill length 1.3-1.7 in. (3.4–4.2 cm) and an average body mass of 0.2-0.3 lbs. (100–140 g). Wandering tattlers wade while they actively forage, making jerky bobbing movements, and repeatedly return back to the same spot over very short time intervals. They feed on rocky coasts, exposed reefs, sandy beaches, and mudflats (Gill et al. 2002), for crustaceans and marine worms, but they also eat insects (only when breeding) and small vertebrates.

The global population is estimated to range from 10,000 to 25,000 individuals (Engilis and Naughton 2004). The highest documented count of this species on Sand Island from 1993 to 2001 was 108 birds, or 0.4-1.1% of the global population.

3.3.6.6.5 Sanderling

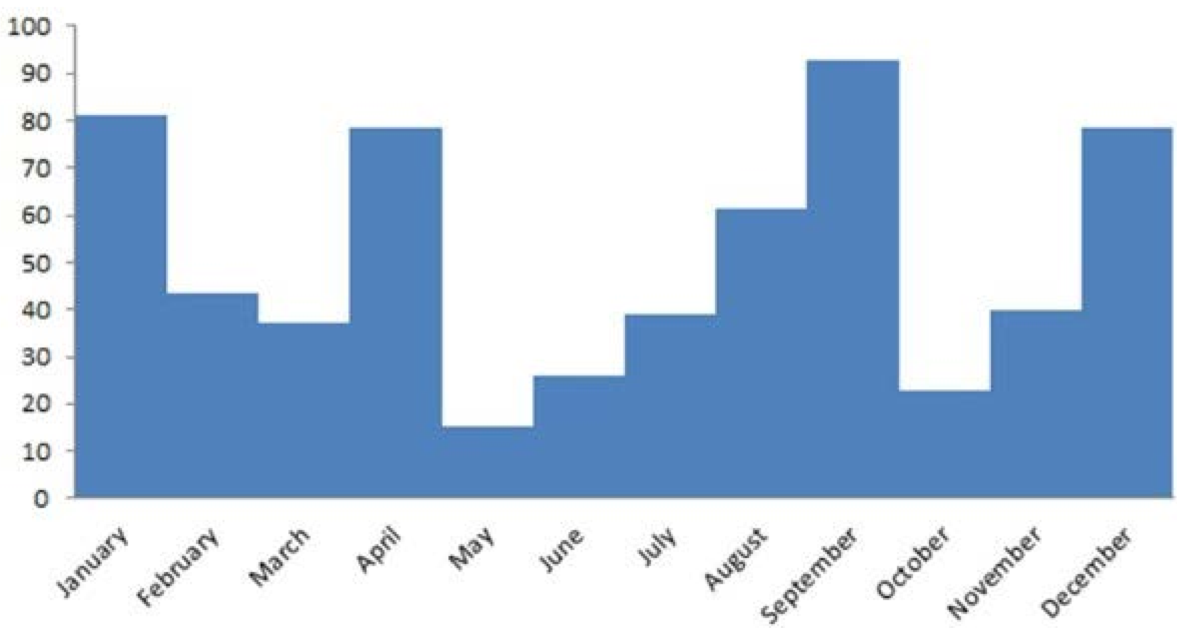
Sanderlings occur in very low numbers on Sand Island. No individuals of this species were recorded on MANWR during avian surveys conducted in June, July, August and September

2017. Breeding birds are absent at MANWR from about May to September, but low numbers of juvenile and non-breeding birds can be present throughout the summer months. Individuals measure 7-8 in. (18-20 cm) in length with a body mass of 0.09-0.22 lbs. (40–100 g) (Macwhirter et al. 2002). These plump shorebirds are faithful to mudflats, beaches, and open marshes, and are primarily found on sandy stretches of coast lines, the outer reaches of estuaries, and along rocky shores (Van Gils and Wiersma 1996). Sanderling feed on small mollusks, marine crustaceans, polychaete worms and insects in adult, larval and pupal stages (e.g. Diptera, Coleoptera, Lepidoptera, Hemiptera and Hymenoptera), as well as occasionally fish and carrion. This species is considered of "limited importance" in the Pacific Islands since the vast majority of birds winter in other parts of the world. The global population is unknown (Engilis and Naughton 2004).

Other shorebird species occasionally visit MANWR. These species can include the grey-tailed tattler, long billed dowitcher, black-bellied plover, wood sandpiper, and others. Such vagrants for example, can be birds that are blown off their normal migration routes. Vagrants do not breed at MANWR, nor do they use the refuge as annual wintering grounds.

Because these 4 shorebird species do not breed at Midway, but use it as non-breeding habitat in the boreal winter, one simple method for reducing the risk to shorebirds during broadcast application of rodenticide bait is to time the dates of application to coincide with the period of lowest shorebird presence on Sand Island, specifically, the summer months of June, July, and August (see Figure 3.3 and Figure 3.5 below). This timing does not eliminate the exposure potential because in any given year, a certain proportion of the population may not migrate north. The subset of the population that remains on MANWR is made up of younger, non-breeding birds and those that may not be in good enough physical condition to make the journey north.

Figure 3.5 Mean counts for years 1993-2001 and 2017 of bristle-thighed curlew, Pacific golden plover, wandering tattler, and ruddy turnstone combined by month on MANWR

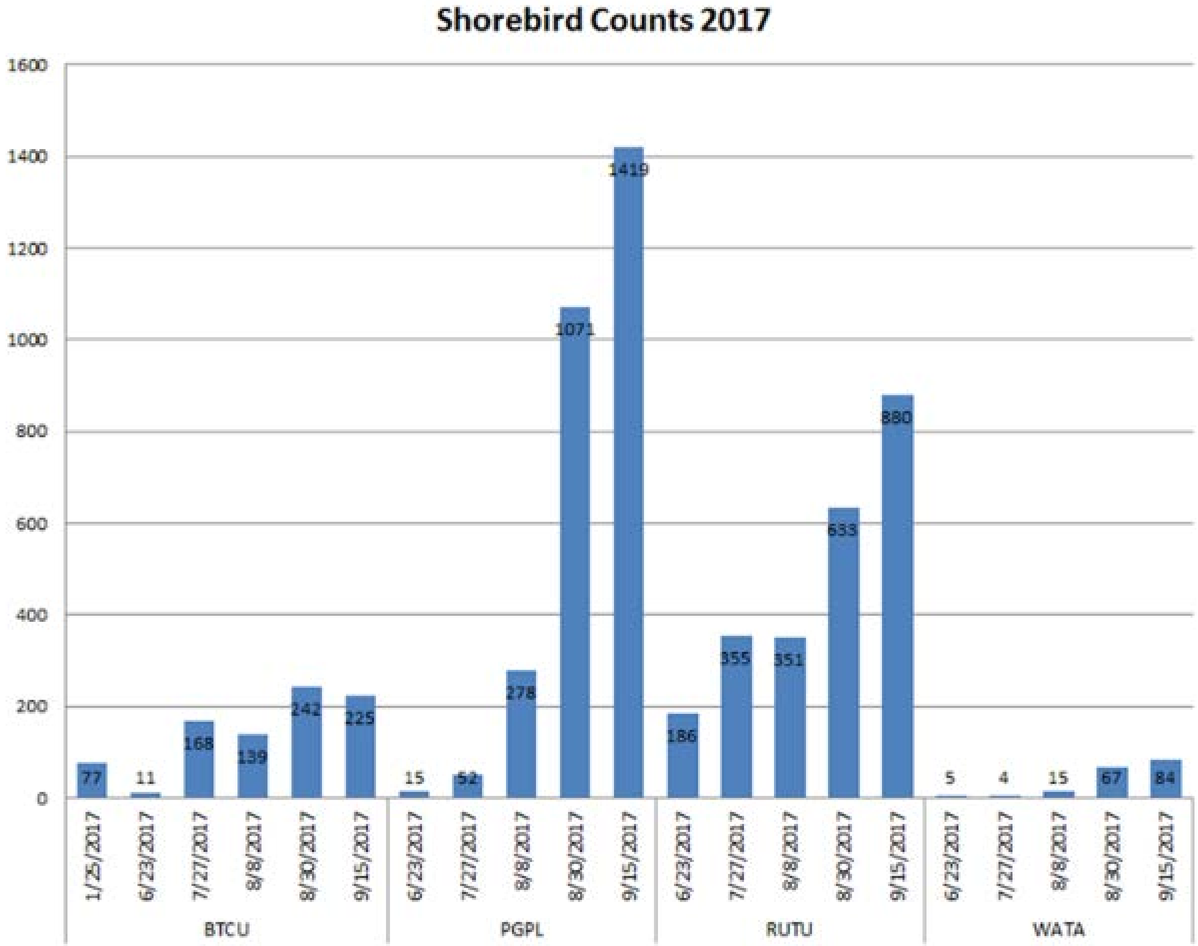


Note: Data were sometimes influenced by pulses of greater numbers that may represent waves of birds coming from further south and stopping to rest or forage on MANWR.

Mean counts of bristle-thighed curlew, Pacific golden plover, wandering tattler, and ruddy turnstone at MANWR were derived from various sources. Data from 1993-2001 compiles counts gleaned from annual systematic surveying efforts, like the Christmas Bird Count, and from literature sources like MANWR trip reports and incidental counts by Refuge staff and visiting biologists. During 2017, monthly shorebird surveys were conducted simultaneously and systematically on all 3 islands (Sand, Eastern, and Spit) to count every shorebird and passerine for 3 hours in the morning (0700-1000); observers walk/bike assigned units to ensure complete coverage of each island, and to record time, species, location, and direction of travel if birds are in flight (Goodale 2017). The highest recorded numbers from 1993 to 2001 for each species during June, July, and August, respectively, were bristle-thighed curlew (12, 168, 242); Pacific golden plover (300, 202, 1,071), wandering tattler (12, 6, 67), and ruddy turnstone (186, 355, 633). The average number of each species over June, July, and August during monthly systematic shorebird counts on Sand, Eastern, and Spit Islands in 2017 were 106 bristle-thighed curlew, 115 Pacific golden plover, 297 ruddy turnstone, and 8 wandering tattler (USFWS, Unpublished b). These numbers exclude surveys conducted on 8/30/17 when numbers for each of the 4 species increased significantly (see Figure 3.6 below) and outside of the time when the operation is scheduled to occur.

Bristle-thighed curlew, Pacific golden plover, wandering tattler, and ruddy turnstone are a concern because of their numerical presence at MANWR, their foraging habits, and documentation of their vulnerability during similar operations at ecologically comparable sites (Engilis and Naughton 2004). The Pacific Islands function as an essential migratory habitat for maintaining many global shorebird populations. All of the shorebird species using MANWR demonstrate a seasonal pattern of greater abundance during the fall and winter months beginning in August/September, and very few individuals of some species remain throughout the summer when the breeders are elsewhere (Engilis and Naughton 2004).

Figure 3.6 Monthly counts on MANWR conducted in 2017 for bristle-thighed curlews (BTCU), Pacific golden plovers (PGPL), wandering tattlers (WATA), and ruddy turnstones (RUTU)



Source: USFWS (2017)

3.3.6.6.6 Probable Impacts: No Action Alternative

Under the No Action Alternative, brodifacoum would not be used island-wide to eradicate mice on Sand Island, except for targeted control with the less toxic $AGRID_3$. Since the rodenticide AGRID3 used under the no action alternate is not known to be harmful to shorebirds, there would be no effects to these species under the no-action alternative.

3.3.6.6.7 Probable Impacts: Preferred Alternative

Primary and Secondary Exposure

As summarized above, the Pacific golden-plover, wandering tattler, and ruddy turnstone are regularly seen on Sand Island. At MANWR during 2017, monthly shorebird surveys have been conducted simultaneously and systematically on all 3 islands (Sand, Eastern, and Spit) to count every shorebird and passerine for 3 hours in the morning (0700-1000); observers walk/bike assigned units to ensure complete coverage of each island, and to record time, species, location, and direction of travel if birds are in flight (Goodale 2017). The highest recorded numbers for each of these species during July and August 2017 surveys (excluding surveys conducted on 8/30/17 because the proposed action is not scheduled for this time) were 278 Pacific golden-plover, 351 ruddy turnstone, and 15 wandering tattler. Significantly higher numbers of each of these species were recorded on surveys conducted on August 30 and September 15, 2017 with maximum counts of 1,419 Pacific golden plover, 880 ruddy turnstone, and 84 wandering tattler (Figure 3.6) (USFWS, Unpublished b).

These 3 species primarily consume a wide range of invertebrate and possibly vertebrate prey, which makes secondary poisoning a potential risk. Each is also documented to consume foods comprised of vegetable matter (natural and man-made); however, this is usually a minor component of the diet, making primary poisoning a relatively low risk.

Table 3.16 indicates that to ingest a lethal dose of brodifacoum, any of these 3 shorebird species would only need to eat between 0.3 to 0.39 oz. (9-11 g) of contaminated invertebrates on a single day. This is only 35 to 37% of their estimated daily food intake. In addition, the ingestion of 2 pellets of bait (0.07 oz. or 2 g) would constitute a potential lethal dose for an individual of each species. This would amount to only 7% or more of each species daily normal food intake of non-animal matter (Table 3.16).

Table 3.16 Primary and secondary toxicity of Brodifacoum to shorebirds on MANWR along with the Laysan duck and cattle egret

Primary toxicity presented as grams of bait and secondary as grams of invertebrate prey. Mg of active ingredient is abbreviated as a.i. LD_{50} is that the dosage (D) of a toxin that is lethal (L) to 50% of animals of the species in laboratory tests.

Species	Body Wt (g)	Daily Food Intake (g)(1)	Brodifacoum				
			LD_{50}(2) (mg/kg)	LD_{50} (mg of a.i./bird)	LD_{50}(3) (g of bait)	LD_{50}2(4) (g of prey)	%(5) of Daily Food Intake (prey)
Pacific golden plover	110	29.9	0.26	0.029	1.14	9.4	34.9
ruddy turnstone	130	30.1	0.26	0.034	1.35	11.1	36.8
wandering tattler	120	28.5	0.26	0.031	1.25	10.2	35.9
bristle-thighed curlew	497	73.9	0.26	0.129	5.17	42.4	57.4
cattle egret	370	60.6	0.26	0.096	3.85	14.9(6)	24.6
Laysan duck	500	74.2	0.26	0.130	5.20	42.6	57.5

Notes:
1. Daily food intake calculated from allometric equation (Bird Feeding Rate = 0.059 x ($W^{0.67}$) (USEPA 1995).
2. LD_{50} of brodifacoum based on mortality of mallard ducklings at the lowest dose, 0.26 mg/kg body weight = 0.00026 mg/g (Ross et al. 1980, EPA 1991).
3. This is also the number of bait pellets that would need to be consumed to be lethal to 50% of the animals.
4. Cockroach contamination based on highest reported value of 3.05 mg/kg = 0.00305 mg/g (Pitt et al. 2015).
5. Calculated as LD_{50} 2 grams of prey/daily food intake (g).
6. For the predatory cattle egret, this is grams of whole rat. Contamination based on highest reported residues in rat carcasses (6.45 mg/kg liver = 0.00645 mg/g) (Pitt et al. 2015).

In a study of mortality of shorebirds after the Palmyra rat eradication using brodifacoum, Pitt et al. (2015) found that all bristle-thighed curlew, Pacific golden plover, ruddy turnstone, and the wandering tattler mortalities collected had detectable brodifacoum residues. Six bristle-thighed curlew, 2 Pacific golden plover, 2 ruddy turnstone, and 1 wandering tattler were found dead after the rodenticide application. Bristle-thighed curlews had the highest average brodifacoum residue relative to the other birds analyzed. Results from Palmyra Atoll indicate that non-target deaths of shorebirds are a concern (Pitt et al. 2015). The number of shorebird mortalities from the eradication attempt were likely underestimated because some avian mortalities probably went undiscovered. Although the USFWS (2011) estimated that more than 20,000 rats were killed during the Palmyra eradication, only a few dozen rat carcasses were found during the project. To estimate the total maximum number of shorebirds that may have been killed due to poisoning, Pitt et al. (2015) used the low tide shorebird survey counts conducted prior to the operation (June 3, 2011) and compared these counts to the numbers of birds counted after completion of the bait drop, but prior to the arrival (July 30, 2011) of post-breeding birds in autumn. Maximum estimates of mortality Pacific golden plover, ruddy turnstone, and the wandering tattler using this method were 28, 8 and 10 birds respectively. Using these data, we can calculate the minimum and maximum % mortality of shorebirds from the Palmyra operation. Using 2010 survey data, the maximum population estimates of these 3 species on Palmyra were 62 Pacific golden plover, 35 ruddy turnstone, and 48 wandering tattler. The minimum and estimated maximum of the total population of each shorebird species sub-lethally impacted or killed was 3.2-45.2% for Pacific golden plover, 5.7-22.8% for ruddy turnstone and 2.1-20.8% for wandering tattler.

Based on the above analysis, after the application of brodifacoum on Sand Island, it would be likely that 9-125 plovers, 20-80 turnstones, and 1-3 tattlers, would be sub-lethally impacted or killed by either primary or secondary poisoning from brodifacoum during the operational window. This estimate assumes that the maximum count of all shorebirds recorded from all 3 islands would all be present on Sand Island, which is unlikely. Mortality estimates for bristle-thighed curlew are presented in Section 3.3.6.7.3 below.

Brodifacoum can persist in the environment for 6 months to a year and have impacts beyond the proposed operational window (Rueda et al. 2016; Pitt et al. 2015), such that any returning shorebirds would be at risk from secondary poisoning. Therefore, additional shorebirds could be killed in the months following the application of brodifacoum. Taking the estimated maximum % of each species killed on Palmyra and using the highest count of each species recorded on MANWR since 1993, we calculated the potential additional mortality of shorebirds over the fall and winter after the bait drop. There could be an additional 584 Pacific golden plover, 182 ruddy turnstone, and 17 wandering tattler at risk over the next 12 months after the baiting operation. This is a worst-case scenario based on conservative LD_{50} toxicity values, maximum expected number of birds on Sand Island, and maximum expected mortality rates. However, because of the high degree of site fidelity for birds on their wintering grounds, it would be likely that mortality of shorebirds from rodenticide poisoning would decline in subsequent months. In addition, some shorebirds would be expected to forage on Eastern Island and Spit Island, and therefore not experience primary or secondary exposure to the rodenticide. Combining the potential estimated mortality from the initial bait drop and over the subsequent year, the total estimated mortality of Pacific golden plover (709), ruddy turnstone (262), and wandering tattler (20) from primary or secondary poisoning is only 0.37%, 0.10%, and 0.2% of their estimated minimum global populations and therefore would not have a measurable effect on those species' populations.

Operational Hazard (Bird Strike and Noise/Human Disturbance)

It is unlikely ground operations associated with the Preferred Alternative would impact any shorebirds, as no nesting occurs on the island. Air operations have the potential to disturb shorebirds, but observations from field personnel during pre-project surveys indicate this disturbance would be minor and may cause birds to temporarily flush from their location. No shorebirds were known to be killed from collisions with the helicopter during the Palmyra operation, however, based on the data of small bodied birds (sooty terns and unidentified birds) killed from helicopter collisions on Palmyra (0.085 birds per hour), and using the estimated hours of helicopter time for the Sand Island operation and expected population of shorebirds during the drop, the estimated mortality is less than 1 bird for each of the 3 species of shorebirds. Calculations are based on the maximum number of birds observed in 2017 during the planned drop period.

We expect there could be some additional impact to shorebirds should the need arise to implement the rapid response portion of the refuge's biosecurity plan and during implementation of the project monitoring plan. A biosecurity plan has been in place on MANWR for many years and any additional bio-security measures would only occur if there was a new incursion of a non-native species. Biosecurity measures enacted would include rapid response to an incursion by non-native invasive species and implementing the monitoring plan would include follow-up observations and sample collecting (see Appendix A and B). Potential impacts, such as causing shorebirds to flush, could occur from the additional human disturbance. However, we expect any additional impacts to be minor, localized, and short-term.

Mitigation

Several mitigation options have been proposed that could minimize exposure of shorebirds to bait containing the rodenticide during the eradication campaign on Sand Island. These include:

- Timing implementation of the eradication for when the population is lowest before the majority of birds arrive at MANWR from their breeding grounds (July/August);
- Keeping bait pellets away from shorebird feeding areas to the extent possible by not broadcasting in intertidal zones;
- Trapping as many individuals as possible and keeping them in captivity until risk of exposure is eliminated or greatly reduced.

As many shorebirds as possible would be trapped and either kept in captivity or their feathers would be clipped and they would be released on Eastern Island before the rodenticide is applied to Sand Island. The above estimates of mortality do not consider this mitigation action, as shorebirds can be very difficult to capture.

Combined potential mortalities from primary and secondary poisoning, along with possible mortalities from airstrikes, represent insignificantly small numbers relative to overall global populations of these species, and represent a worst-case scenario based on maximum numbers of birds documented on Sand Island, upper extremes of toxicity, and high probabilities of collision with the helicopter. Due to the low number of anticipated mortalities relative to their overall global population levels, the Preferred Alternative would be unlikely to adversely impact shorebird populations on MANWR. The impacts would be readily detectable and localized with likely measurable consequences to shorebirds, but not readily detectable or measurable beyond the immediate area of impact.

3.3.6.7 Bristle-thighed curlew

3.3.6.7.1 Existing Conditions

The bristle-thighed curlew is a medium-sized curlew with a wingspan of approximately 15.7-17.3 in. (40-44 cm) and blue-gray legs (see Figure 3.7). The birds have a moderately long and decurved bill, which is flesh-colored at the base, turning to brown near the tip, and a dark lateral crown is present on the head along with eye stripes. Their name comes from the bristle-like extensions at the base of their legs, although these are generally inconspicuous. Females are heavier than males and have longer wings and a shorter bill. Mean weight of adults was 1.09 lbs. (497.4 g) and ranged from 0.84-1.29 lbs. (393-584 g) for 61 unsexed birds caught in the Northwestern Hawaiian Islands from October through November (Marks 1993). Juveniles are similar to adults except for the presence of larger cinnamon-buff spots on the upperparts, and virtually unstreaked underparts (Marks et al. 2002).

Figure 3.7 Bristle-thighed curlew

Source: USFWS (2017)

Classified as Vulnerable on the IUCN Red List 2012 (BirdLife International 2016a), bristle-thighed curlew are considered species of high conservation concern because of their small population size and anthropogenic pressures on the wintering grounds, which include habitat loss, habitat degradation, and introduced mammalian predators. The bristle-thighed curlew has also been designated as a Bird of Conservation Concern by the USFWS at the regional and national scale (USFWS 2008a) due to limited breeding and non-breeding distributions, low relative abundance, and threats during the non-breeding season. Although the birds' tundra breeding grounds have remained largely undisturbed, some researchers believe that bristle-thighed curlew are negatively impacted by introduced mammalian predators, including rats, on their wintering grounds and atolls, including Palmyra Atoll (Marks et al. 1990). The risk of a steep and sudden population decline is a serious threat because these birds are long-lived and site-faithful. Bristle-thighed curlew occur on Sand Island. Breeding birds are absent at MANWR from about May through the end of July, but low numbers of juvenile and non-breeding birds are present throughout the summer months (USFWS, Unpublished b).

During the breeding season, bristle-thighed curlew are found in the remote mountainous regions of western Alaska in the Andreafsky Wilderness Area north of the Yukon River mouth and on the central Seward Peninsula (McCaffery and Peltola Jr. 1986, Kessel 1989, Gill et al. 1990, Marks et al. 2002). During the non-breeding season this species is found on remote Pacific Ocean islands and atolls (Marks et al. 1990) including the Hawaiian Islands. Sub-adults may remain in the Pacific until they are nearly 3 years old (Collar et al. 1992). Site fidelity on both the breeding and wintering grounds is high, with many birds returning to the same location on an island for multiple years (Marks and Redmond 1996). Habitat preference in the Northwestern Hawaiian Islands includes beaches and shorelines with coral ledges, but birds are often found inland among grass- and forb-dominated areas (Woodward 1972, Ely and Clapp 1973, Amerson et al. 1974, Clapp and Wirtz II 1975, Marks et al. 2002). In fall of 1988, Laysan Island populations were predominantly inland (68% of 2,521 sightings), and only 1% on beaches (Marks et al. 2002). Birds walk as they pick up items from the ground, also probing in soil or mud with their long bills, to feed on crustaceans, small fish, insect grubs, and snails. This species has also been observed catching and eating mice. This species has been sighted regularly on the shoreline of all 3 islets at MANWR, in the forested areas, and in open, grassy areas (USFWS, Unpublished b).

Comprehensive surveys of known breeding range from 1988 to 1992 yielded about 3,200 breeding pairs (Marks et al. 2002), while Engilis and Naughton (2004) estimate that the global population is 10,000 birds and is limited by restricted breeding and non-breeding distributions, a low relative abundance, and threats during the non-breeding season. Numbers may be declining, although data on population trends are not available (Marks et. al. 2002). In total, about 800 birds are thought to winter in the Northwestern Hawaiian Islands during the same period (1980 to 1990), which included 300–350 birds on Laysan Island, 300–400 on Lisianski Island, and 100 on MANWR (Marks and Redmond 1994).

A survey has been employed on MANWR to count shorebirds, including bristle-thighed curlew. The age of birds was not recorded because adult and sub-adult curlews can be somewhat difficult to distinguish. However, birds remaining through the boreal summer are most likely sub-adults, which do not migrate back north until they are approximately 34 months old (Marks 1993, Marks and Redmond 1996). Bristle-thighed curlew counts on MANWR from June to September 2017 ranged from 11 to 242 birds, with the maximum number of birds counted on August 30 (Figure 3.7). Although survey methods varied, using avian survey data collected from 1993 to 2001, along with the 2017 surveys, counts from January through December on MANWR ranged from 12 to 242 birds with the lowest counts in June. The maximum counts on MANWR during the expected drop period in July/August was 168 birds in 2017. The highest documented count of this species on Sand Island from 1993 to 2001 was 242 birds, or 2.42% of the global population. Since there are no marked birds, it is not known how many of these birds are winter residents versus migrants stopping before they head further south.

3.3.6.7.2 Probable Impacts: No Action Alternative

Under the No Action Alternative, rodenticides would not be used island-wide to eradicate mice on Sand Island, except for targeted control with the less toxic $AGRID_3$. Since the rodenticide $AGRID_3$ used under the No Action Alternate is not known to be harmful to shorebirds, there would be no effects to the bristle-thighed curlew under the No Action Alternative.

3.3.6.7.3 Probable Impacts: Preferred Alternative

Primary and Secondary Exposure

The mouse eradication project places non-resident migratory shorebirds, including bristle-thighed curlew, at risk of both primary and/or secondary exposure to rodenticide bait that would be broadcast across the island. Research has shown that shorebirds may consume rodenticide bait pellets directly (Pierce et al. 2008) or may sustain secondary or tertiary exposure to rodenticides after ingesting smaller organisms that previously consumed bait. In the non-breeding season, bristle-thighed curlew forage primarily in terrestrial habitats, consuming spiders, land crabs, insects, seabird eggs, lizards, and carrion (Marks 1993). Stomach contents of 14 curlews collected in Polynesia contained vegetation, crustaceans, insects, gastropods, and scorpions (Johnsgard 1981).

Given the diverse diet of this species there are several potential secondary/tertiary exposure pathways for the bristle-thighed curlew including:

- Feeding on crabs that have consumed bait or scavenged mice carcasses;
- Feeding on insects that have consumed bait or scavenged mice carcasses;
- Feeding on lizards/geckoes that have consumed insects that have ingested the bait; and/or
- Feeding directly on live mice or mice carcasses that have consumed bait.

Research conducted on Palmyra Atoll using remote cameras indicated bristle-thighed curlew showed little interest in the bait placed on the ground or in the carcasses of rats put out by the researchers (USFWS 2011). Curlew were ever-present throughout the atoll during these studies and were frequently captured in photographs by the motion sensing cameras that were monitoring bait stations, tracking tunnels, and rat carcasses. Though frequently sighted, curlew, plover, wandering tattler, and booby seemed more interested in the camera itself than in the bait pellets or carcasses. Birds were occasionally photographed looking in the direction of a carcass or bait station, yet no close inspection or contact was made. Although it was estimated that more than 20,000 rats were killed during the eradication project on Palmyra, only a few dozen rat carcasses were found during the project after the bait was applied (Pitt et. al. 2015). It is expected that this same result would occur on Sand Island. Thus, it is expected that there will be a few carcasses available for bristle-thighed curlew to find.

A June 2011 rat eradication effort on Palmyra Atoll using brodifacoum reported 6 bristle-thighed curlew individuals found dead after the bait drop and Pitt et al. (2015) estimated as many as 68 could have been killed after the application of rodenticide. Using these numbers, 3.3 to 37.4% of the islands population may have been sub-lethally impacted or killed by either primary or secondary poisoning from brodifacoum during the operational window. However, bait densities were very high for this effort and included 75.6 lbs./ac. (84.8 kg/ha) applied in the first drop and 71.5 lbs./ac. (80.1 kg/ha) applied on the second drop, with a third application in some areas. This is 10-16% higher bait density than that proposed for the MANWR Preferred Alternative. Two of the curlew were confirmed to have been exposed to bait prior to capture and were successfully treated on Palmyra. Other eradication projects reported non-target mortality of bristle-thighed curlew (Pierce et al. 2008). Pierce et al. (2008) reported 2 dead curlew found 13 days after the first spread of brodifacoum bait on Rawaki Island, Republic of Kiribati, in the Central Pacific, while 8 other live curlew were also recorded after the bait drop, which is a mortality rate of 25%. However, surveys for dead or dying shorebirds were not comprehensive for most eradication projects (USFWS 2011). It is also likely that most carcasses are rapidly consumed by scavengers, making estimations of mortalities resulting from rodenticide bait difficult to predict. Merton et al. (2002) showed high shorebird mortality in brodifacoum broadcast eradications on islands in the Seychelles. However, these eradications were timed to coincide with the lull in the tourist season rather than a seasonal low in shorebird numbers, so birds were present on the islands in great numbers during the eradication. For the Asiatic whimbrel, a related species of the bristle-thighed curlew, 20% mortality was observed on one of the islands. For the ruddy turnstone, the mortality rates ranged from 20% to 90% on the 4 islands, with exceptional mortality rates possibly enhanced due to the birds being fed by people (Merton et al. 2002). The individuals over-summering on MANWR are the young non-breeders.

Using data from bristle-thighed curlew mortality rate on Palmyra in 2011 (3.3 to 37.4%), the mortality documented on the Seychelles for the closely related whimbrel (20%) and the bristle-thighed curlew mortality reported from Rawaki Island (25%), and the number of birds expected to be on Sand Island during the July/August drop period, we calculated the minimum and maximum % mortality to bristle-thighed curlew from the Sand Island rodenticide application. It is anticipated that the bait application could sub-lethally affect or incidentally kill 5-52 bristle-thighed curlew on MANWR without mitigation (trapping and holding birds in captivity or clipping wings and releasing birds on Eastern Island). Birds that remain on Eastern Island during the drop would be unlikely to experience any primary or secondary exposure. However, without trapping and clipping the wings of birds, individuals would be able to fly from Eastern to Sand Island. In addition, because it is not a closed population and because breeders would not be taken, it is unlikely there would be any negative long-term population-level effects to this species from this alternative.

Brodifacoum could persist in the environment for 6 months to a year and have impacts beyond the proposed operational window if bait were available to foraging curlews (Rueda et al. 2016, Pitt et al. 2015), such that any returning shorebirds would be at risk from secondary poisoning. Therefore, additional bristle-thighed curlew could be killed in the months following the application of brodifacoum. Taking the estimated maximum % of bristle-thighed curlew killed on Palmrya (Pitt et al. 2015) and using the highest count of this species recorded on Sand Island since 1993, we calculated the potential additional mortality of bristle-thighed curlew over the fall and winter after the bait drop. There would be an additional 71 bristle-thighed curlew at risk over the next 12 months after the baiting operation. Combined with the estimated morality from the initial bait drop, this is 50% of the highest count of birds on MANWR. This is a worst-case scenario based on conservative LD_{50} toxicity values, maximum expected number of birds on MANWR, maximum expected mortality rates, and no mitigation. However, because of the high degree of site fidelity for birds on their wintering grounds it would be likely that mortality of shorebirds from rodenticide poisoning would decline in subsequent months. Combining the potential estimated mortality from the initial bait drop and over the subsequent year, the total estimated mortality of bristle-thighed curlew (n=123) from primary or secondary poisoning is 1.23% of the estimated global population.

A population viability analysis (USFWS 2011) was completed for the Palmyra rat eradication project to explore the implications of incidental poisoning mortality and other mortalities of bristle-thighed curlew due to activities associated with the proposed application of brodifacoum. The model investigated the likely effects on global bristle-thighed curlew populations from the mortality of 10, 50, and 150 bristle-thighed curlew individuals on Palmyra Atoll. They assumed, given the timing of the rat eradication, that the majority of mortalities would be sub-adult birds remaining at MANWR during the breeding season, but they conservatively assume that 50% of the mortalities would be adults. For all scenarios, a second conservative assumption of an additional 50 bristle-thighed curlew lost due to a simultaneous but unrelated one-time event was added, again assumed to be 50% adults. They then modeled population trajectories over 50 years and reported the extinction risk and projected median and lower 90^{th} percentile of population size. Therefore, the mortality scenarios they considered on Palmyra included 60 to 200 individuals which represented a 3-8% increase in adult mortality and a 13-31% increase in sub-adult mortality of the global population for one year. They concluded that these one-time mortality events appeared to have a minor and diminishing effect on projected future populations. The one-time mortality events did not alter future population growth rate and did not appear to put the population in danger of increased risk of stochastic extinction over a 50-year period. Therefore, extrapolating from that model, the expected mortality of 5-123 bristle-thighed curlew from the MANWR mouse eradication project, even without the mitigation described below, is not expected to have long-term adverse effects to the global population.

Operational Hazard (Bird Strike and Noise/Human Disturbance)

It would be unlikely ground operations associated with the bait drop would impact any bristle-thighed curlew, since no nesting occurs on the island. Air operations have the potential to disturb bristle-thighed curlew but observations from field personnel during pre-project surveys on Palmyra indicate this disturbance would be minor and may cause birds to temporarily flush from their location (USFWS 2011). Bristle-thighed curlew could be at risk of collisions with the helicopter during bait drop operations. However, no shorebirds were known to be killed from collisions with the helicopter during the Palmyra operation, and no bristle-thighed curlew have been recorded killed by aircraft at Henderson Airfield on Sand Island. In addition, shorebirds including bristle-thighed curlew are not concentrated in locations on Sand Island but scattered across a larger area. Most are also fast and maneuverable, and thus better able to avoid helicopters, particularly as the helicopters will be flying at approximately 50 meters above ground. We know of no records of bristle-thighed curlew colliding with a helicopter (USFWS, Unpublished b), although the occasional plover may be hit. Therefore, the risk of bristle-thighed curlew colliding with a helicopter are very low. However, based on the data of small-bodied birds (sooty terns and unidentified birds) killed from helicopter collisions on Palmyra (0.085 birds per hour), and using the estimated hours of helicopter time for the Sand Island operation and expected population of bristle-thighed curlew during the drop, the estimated mortality is less than 1 bird for the curlew. Calculations are based on the maximum number of birds observed in 2017 during the planned drop period.

We expect there could be some additional impact to bristle-thighed curlews should the need arise to implement the rapid response portion of the refuge's biosecurity plan and during implementation of the project monitoring plan. A biosecurity plan has been in place on MANWR for many years and any additional bio-security measures would only occur if there was a new incursion of a non-native species. Biosecurity measures enacted would include rapid response to an incursion by non-native invasive species and implementing the monitoring plan would include follow-up observations and sample collecting (see Appendix A and B). Potential impacts, such as causing birds to flush, could occur from the additional human disturbance. However, we expect any additional impacts to be minor, localized, and short-term.

Mitigation

Several mitigation options have been proposed that could minimize exposure of bristle-thighed curlew to bait containing the rodenticide during the proposed eradication campaign on Sand Island. These have been described above for other shorebirds but for the bristle-thighed curlew these would also include:

- Trapping as many individuals as possible and keeping them in captivity or clipping their flight feathers and moving them to Eastern Island until risk of exposure is eliminated or greatly reduced and the birds grow new feathers. Supplemental food and water would be supplied to ensure adequate carrying capacity on Eastern Island.

For the Palmyra Atoll rat eradication feasibility study (Howald et. al. 2004), the assessment team concluded that the most effective mitigation for this species was to conduct the eradication between early June and mid-July, when most adult bristle-thighed curlew are still on their breeding grounds in Alaska. Similarly, the lowest counts of bristle-thighed curlew on MANWR are in June. Timing during the summer period would also minimize the risk of short-term rodenticide exposure to the majority of curlew overwintering on MANWR. Any birds remaining on the atoll at this time of year are likely sub-adults (aged 1 to 3 years) that remain on the tropical Pacific islands until they mature. In addition, Pierce et. al. (2008) noted that it was easier for bristle-thighed curlew to ingest rodenticide bait after it had been softened by rainfall. However, the eradication on Sand Island will occur during the driest time of the year. In addition, the rodenticide bait used for Sand Island would be dyed a green color to reduce the likelihood of birds picking up the bait (Day and Matthews 1999, Oppel et al. 2016). The Palmyra Atoll eradication used blue-green dye, which was a color known to be least visible/preferred to non-target species including shorebirds (U.S. National Park Service 2000).

Live-trapping bristle-thighed curlew prior to the eradication of mice and holding the birds in captivity on Sand Island, or releasing birds with clipped wings on Eastern Island, would eliminate the risk of primary and secondary rodenticide exposure. Although feasible, it is unlikely that a significant portion of the summer population, the majority of which are likely sub-adult birds (1-3 years old), could be captured before the bait drop. Before the bait drop on Palmyra in 2011 for the rat eradication, biologists were able to trap 5-9% of the bristle-thighed curlew population present (USFWS 2011). If this same rate of capture were possible on MANWR, approximately 12 to 22 birds could be captured and held in captivity or released with clipped wings on eastern Island. However, there would also be additional risks associated with capturing birds, including physical injury and physiological stress that could result in the death of some individuals. Thirteen bristle-thighed curlew were caught and successfully held in captivity on Palmyra without any injuries or mortalities reported, but several different trapping methods would need to be employed on MANWR to maximize success, as bristle-thighed curlew tend to be extremely wary.

3.3.6.8 Laysan duck

3.3.6.8.1 Existing Conditions

The Laysan duck (*Anas laysanensis*) is currently on the Federal Endangered Species List due to its restricted distribution and small wild population. The Laysan duck was extirpated across the Hawaiian archipelago with one extant population persisting only on the island of Laysan. A second and third population were established via translocation of wild birds from Laysan Island to Midway and Kure Atolls, respectively (see Figure 3.8). The Laysan duck is largely nocturnal and sedentary. Body weight fluctuates significantly with season and reproductive status (Moulton and Weller 1984). In spring, females are heavier than males and can exceed 1.3 lbs. (600 g), while males are at less than optimum mass because of courtship activities. In summer, males are generally heavier than females. Females with young broods are lightest of all mature birds, often <0.88 lbs. (<400 g). Having evolved with avian rather than mammalian predators, Laysan ducks are more likely to walk than fly, and freeze rather than flush, when startled. Similar to other waterfowl, Laysan ducks molt all of their feathers at the same time, during which they become incapable of flight, and thus more vulnerable to predators at this time. On Laysan Island, molting typically occurs between July and August for males and between July and September for females. On MANWR, males start molting in June and the molt for females with brood may extend into October.

Figure 3.8 Laysan duck family

Source: USFWS (2017)

The Laysan duck feeds almost solely on macroinvertebrates, primarily insects (Moulton et al. 1996). These include Dipteran brine fly, adults, larvae, and pupae taken in and around lakes and ponds, along with brine shrimp (*Artemia spp*.) They also eat the larvae and pupae of noctuid moths (*Agrotis dislocate*) under low vegetation in upland areas.

Habitat requirements of the Laysan duck include vegetative cover, an invertebrate prey base, a source of fresh water, and protection from mammalian predators (USFWS 2009). On Laysan and Midway, ducks use all available habitats: upland vegetation, ephemeral wetlands, freshwater seeps, mudflats, the hyper-saline lake, and coastal areas. Nests are on the ground and well-concealed, usually within a base of vegetation, especially bunchgrass (*Eragrostis variabilis),* but sometimes in *Cyperus* or *Heliotropium*, on vegetated portions of the island (Moulton and Weller 1984). Egg-laying can begin as early as February and occur as late as November, but typically occurs from April to August; initiation and duration of egg-laying varies from year to year. Duckling activities are concentrated near sources of fresh water with nearby food and cover. Extirpation of the Laysan duck from the main Hawaiian Islands most likely was caused by a combination of predation by introduced mammals, especially rats, hunting by humans, and habitat destruction and degradation.

Current threats include alien species (e.g., mice, and invasive weeds) that can alter the Laysan duck's habitat. This was demonstrated on Laysan Island in the early 20th century, when introduced rabbits devegetated the island causing the accelerated filling of Laysan's freshwater seeps and saline lake. High duckling mortality from 1999 through 2004 suggests a lack of sufficient brood rearing habitat on Laysan.

Another threat to Laysan ducks is from on-going avian botulism outbreaks (Work et al. 2010). Dead mice and other dead non-target species could exacerbate the botulism issue by promoting a maggot cycle. Small population size and extremely limited distribution make the species highly vulnerable to demographic fluctuation and stochastic events, such as droughts, severe storms, epizootics, predators, and invasive species. Habitat degradation and loss within the Marine Monument may be intensified by increased storm severity and sea level rise associated with global climate change. The population at MANWR was founded with 42 wild birds from Laysan Island during 2004–2005 and grew to 661 adult and juvenile birds (95% CI 608–714) in 2010. A population decline of 38% was observed between 2010 and 2012 after the 2011 Tōhoku Japan earthquake-generated tsunami inundated 41% of the atoll and may have triggered an avian Botulism type C (*Clostridium botulinum*) outbreak. After another severe botulism outbreak during 2015, the population again experienced a 37% decline. Monitoring data indicate that the MANWR population, like the Laysan Island population, is susceptible to catastrophic population declines.

In 2015, Reynolds estimated there were between 314 and 435 Laysan ducks (95% CI for population estimate). The point estimate was 375 individuals (Reynolds et al. in press). This estimate of Laysan ducks at MANWR is approximately 50% of the global population. In comparison, the most recent estimate on Laysan Island in 2012 was 339 individuals (95% CI: 265–413). The model was then used to estimate the population of Laysan ducks on MANWR for 2017. Using a maximum count of 116 ducks counted at the end of August 2017, the model returns an estimated population of 491 ducks with a range (95% CI) of 387 to 596 individuals.

3.3.6.8.2 Probable Impacts: No Action Alternative

Under the No Action Alternative, rodenticides would not be used island-wide to eradicate mice on Sand Island, except for targeted control with the less toxic $AGRID_3$. Since the rodenticide $AGRID_3$ used under the no action alternate is not known to be harmful to birds, there would be no adverse effects to Laysan ducks under the no-action alternative from the use of this rodenticide. However, any adverse impacts of predatory mice to nesting Laysan ducks, eggs, and their young would continue. Mice could also be competing with ducks for invertebrate food resources and mice are known to be a seed predator on *Eragrastis spp.*, and important grass and plant cover for Laysan ducks. Therefore, any negative effects on Laysan ducks from the presence of the mice would continue under the no-action alternative.

3.3.6.8.3 Probable Impacts: Preferred Alternative

Primary and Secondary Exposure

Initial tests at sites on MANWR where non-toxic bait piles were put out and monitored, indicated that Laysan ducks would readily consume bait pellets. Thus, there is a clear primary route of exposure to the rodenticide as it is assumed they would consume bait. Since the ducks also consume invertebrates, there is a likely secondary exposure. The consequence of that exposure is presumed to be substantial and without mitigation, a large number of individual ducks present on the island during the eradication would very likely succumb to the toxic effects of the rodenticide. Therefore, reducing or eliminating the pathways of exposure would be a key mitigation strategy as described in the minimization and mitigation measures below.

A female Laysan duck's average weight during incubation is approximately 1.1 lbs. (500 g). The lethal dose (LD50) of brodifacoum for birds is 4.1 x 10^{-6} oz./lb. (0.26 mg/kg). This is the dose the dosage (D) of brodifacoum that is likely to be lethal (L) to 50% of birds ingesting the toxin. For primary exposure to the rodenticide, at an average weight of 1.1 lbs. (500 g), an individual duck would need to ingest only 5 bait pellets to receive a potential lethal dose of brodifacoum. For secondary exposure, an individual duck would need to ingest 1.5 oz. (42.6 g) of contaminated invertebrate prey, which would be 57.5% of a bird's daily food intake (Table 3.16). Therefore, based on Laysan duck feeding habits, primary and secondary exposure to the rodenticide are both likely sources of mortality. Thus, without mitigation, the impact could be very high to a significant proportion of the Laysan duck population. Without mitigation measures, the worst-case scenario is that the entire population on Sand Island could be at risk of mortality. However, birds that remain on Eastern Island would not be exposed to the bait and have little likelihood of being exposed to any contaminated invertebrate prey. Setting aside the worst-case scenario, using the maximum population estimate of 596 ducks for MANWR, it is possible that 20-80% (119-477 birds) of the population could be at risk from primary or secondary poisoning without mitigation. This range was derived from mortality data of shorebirds from the Palmyra rat eradication project (USFWS 2011, Pitt et al. 2015), other small mammal eradication projects documenting mortality to waterbirds (Pierce et al. 2008, Morton et al. 2002), and a worst-case mortality rate of 80% reported from a study of passerine mortality from an island rat eradication project using brodifacoum (McClelland 2002). Other instances of high avian mortality from rodent eradication projects include severe population impacts to ravens on Langara Island, British Columbia (Howald et al 1999), 80-90% mortality of Stewart Island weka, a flightless bird in New Zealand (Eason and Spurr 1995), and mortality to bald eagles on Rat Islands, Alaska, where forty six bald eagles died, which exceeded the known population of 22 bald eagles on the island (The Ornithological Council 2010).

With the mitigation strategy proposed below, these estimated mortality rates to Laysan ducks would be greatly reduced. However, even with the mitigation strategy outlined below, there is a possibility that birds will remain undetected and therefore not captured for protection. The worst-case scenario would be the rate of 33% (197 ducks) of the maximum population accessible for capture during the breeding and molting season from March through September (Reynolds et al. 2017) would not be captured. If all these 197 ducks ingested more than 5 pellets or consumed prey with enough brodifacoum to deliver a lethal dose, a loss of 33% of the maximum population of Laysan ducks at Midway could occur. However, due to the extended period of planned capture attempts, it is likely that individual birds would be detectable before or after breeding and molt in many cases, and capture rates would be higher than 33%.

Operational Hazard and Disturbance (Bird Strike and Noise/Human Disturbance)

Since Laysan ducks are more likely to walk than fly and freeze when disturbed rather than flush, they are at a very low risk for collision with the helicopter during bait drop operations. In addition, Laysan ducks molt all of their feathers at the same time and individuals are incapable of flight between July and August for males and between July and October for females. Therefore, many individuals would naturally be incapable of flight during the bait drop period in July and August. As part of the mitigation to protect this species, a significant number of birds would be captured and kept in captivity during the bait drop period, thus protecting them from possible helicopter collisions, disturbances from helicopter noise and humans distributing bait, and accidental trampling of eggs or chicks from distributing bait by hand broadcast methods. In addition, Laysan ducks are accustomed to human presence on MANWR and can be approached within a few feet before being disturbed.

We expect there to be some additional impact to Laysan ducks should the need arise to implement the rapid response portion of the refuge's biosecurity plan and during implementation of the project monitoring plan. A biosecurity plan has been in place on MANWR for many years and any additional bio-security measures would only occur if there was a new incursion of a non-native species. Biosecurity measures enacted would include rapid response to an incursion by non-native invasive species and implementing the monitoring plan would include follow-up observations (cameras on nests, radio-telemetry) and sample collecting (see Appendix A and B). Potential impacts such as flushing ducks off their nest and trampling of vegetative cover could occur with the additional human disturbance. Given the mitigation measures that will be in place to protect Laysan ducks, we expect any additional impacts to be minor and short-term. Implementing the biosecurity plan is only expected to have beneficial effects to Laysan ducks.

Mitigation

The Laysan duck presents a complex mitigation challenge for the Midway Seabird Protection Project. They are non-migratory, year-round resident species that are relatively abundant across MANWR, and regularly fly between Sand Island and Eastern Island. Thus, the only effective mitigation and minimization strategy is to prevent the exposure of the ducks to rodenticide either through live-capture and holding ducks on Sand Island or to capture and temporarily translocate the birds to another island such as Eastern Island, until the risk period passes. The population of Laysan ducks on MANWR is globally significant for the species, and a robust minimization strategy would need to be in place prior to implementation of the Midway Seabird Protection Project. The goal of the Laysan duck mitigation strategy is to ensure that Laysan ducks persist on MANWR after the mouse eradication. Thus, a robust and adaptive mitigation strategy with built in redundancy and monitoring to ensure that the mitigation is effective, and any uncertain or unexpected loss of ducks can be detected early, and before a significant portion of the population would be put at risk.

With either risk minimization option, the ducks would then be released in a step-wise progression when bait pellets are no longer available (degraded), which is anticipated to be approximately 30 days (Pitt et al. 2015, Alifano et al. 2012), when primary exposure risk is negligible. Duck release decisions would also be based on the testing of biological samples for rodenticide residues collected post-application when those residues are considered relatively non-toxic and low risk. A stepwise release would allow for an effective and adaptive approach to the mitigation and will not commit the entire population to inherent uncertainty with temporal secondary exposure risk – brodifacoum residues will persist well past the bait pellet degradation window and will likely enter the Laysan duck food web (invertebrates) leading to multiple and repeated exposures over time. The temporal exposure risk and consequence of exposure is difficult to quantify a priori but is likely to have high consequence to some individuals for a few to many months post-bait application. Thus, an adaptive mitigation strategy outlined here offers the highest probability of ensuring persistence of Laysan ducks on Midway. Effectively, each release group is a sentinel for the next group of released animals, and through monitoring for survivorship and other indicators, the mitigation team can either continue with the release of duck or halt the release and re-capture some individuals.

Release of ducks from captivity in a step-wise progression would increase the probability of successfully limiting the exposure of all captive held ducks to remaining bait pellets (primary) and to rodenticide residues (secondary). The longevity of bait pellets among habitats can be markedly different, with the rate of pellet degradation dependent on many factors including air temperature, light, humidity, rainfall, and the presence of scavengers, molds, and soil microbes that potentiate degradation. For example, the bait proposed in this EA is formulated for use in dryer sites, therefore any significant rainfall will cause it to dissolve. Based on the Midway bait trials, pellets were still found on the ground by the monitoring team seven days post-application (USFWS unpublished). The detection time of brodifacoum residues in biological samples post-application can vary; Pitt et al. (2015) detected residues at 30 days and Rueda et al. (2016) at 773 days. For the purposes of this EA, the variability of pellet and residue persistence, and the possibility that residues may have consequences for Laysan ducks well past what we anticipate, is acknowledged.

Mitigation measures discussed in this EA to minimize rodenticide exposure to Laysan ducks include avoiding aerial broadcast near wetlands and open water bodies by hand broadcasting in these areas. The proposed approach for minimizing, reducing, and avoiding exposure is to capture as many adults and ducklings as possible starting in March of 2019 to allow more time for capture during the period of laying, incubation, brood rearing, and molt when the birds are much more difficult to find (Reynolds et al. 2017). Incubation varies from December to July (Reynolds et al. 2007); the location of nests with eggs will be marked and monitored for capture-hold post-hatching. Mitigation measures include:

- Live capture and hold 50 male and 50 female ducks in captivity on Sand Island to insure a local population survival against worst case scenario. Prior to initiation of bait application, these birds would be transferred to Eastern Island and held until they molt their flight feathers. Once new primaries and secondaries are grown and clipped, the birds will be released on Eastern Island. The size and number of holding pens and aviaries used on Sand and Eastern Islands will be dictated by the number of ducks caught. A holding pen for a pair of adult ducks might consist of a shade cloth enclosure that measures 100 square feet (9.3 square meters) (Reynolds and Klavitter 2007).

- Once the aviary capacity of 100 ducks is reached all additional birds will be captured, marked with field readable bands, have their flight feathers clipped, and translocated to Eastern Island. Birds on Eastern Island would be monitored for flight feather regrowth and re-captured if their molt status indicates they will soon become flighted. Teams will also monitor behavior at the various artificial water sources and supplemental feeding stations necessary to support the free-range population.
- Eastern Island birds will have access to supplemental food, water, and cover resources, spread widely enough across the island to minimize agonistic behavior and to ensure all birds have access to food.
- Avicultural staff will camp on Eastern to care for the birds in the aviary and to monitor the free-living birds until all are released and flighted again and when it is safe for the birds to return to Sand Island based on monitoring of rodenticide pellet availability based on observations and biological samples collected post-application.
- Capture efforts will continue on Sand Island throughout the bait application period and any ducks not captured for hold-release, subsequently exposed to the rodenticide, and demonstrating signs of toxicosis, would be captured and treated with the antidote Vitamin K by a veterinary professional to offset the negative effects of the rodenticide. Ducks would be held in temporary holding pens under observation and any decision-making would occur based on the duck’s on-going health prognosis.
- Step-wise release of captive ducks after final bait application, whereby a few birds would be released back to Sand Island and observed for any signs of mortality or other signs of anticoagulant exposure (hunkered posture, puffed up wings, blood from nares, moribund). The first ducks would be released 30 days after the final bait application or when bait pellets are no longer available. Monitoring of released birds should include radio-tagging sentinels to aggressively track over time, using information gleaned for deciding when next batch of ducks should be released.
- Invertebrate prey species on Sand will be collected at intervals after the final bait application and brodifacoum residues will be measured to assess when those residues are relatively non-toxic. The LD50 of brodifacoum for mallards is 4.1 x 10-6 oz./lb. (0.26 mg/kg) (Ross et al. 1980, USEPA 1991). Residue levels considered relatively non-toxic to the Laysan duck are approximately <0.12 ppm (Daniels 2013).

An interdisciplinary team of scientist experienced with Laysan ducks has been formed to consult, test, and oversee the implementation of a robust minimization and mitigation plan. Based on capture success rates in 2017 on MANWR, it is likely that the majority of birds would be captured and held in captivity or released on Eastern island until risk of primary and secondary exposure to the rodenticide has passed, thus reducing the number of birds at risk on MANWR. Using a combination of captive care and wing clipping and release will increase the chances of survival for the greatest number of ducks. Laysan ducks are upland nesters, and subject to ground disturbance activities; if hand broadcasting of bait requires ground-based personnel to traverse across or apply bait in Laysan duck nesting habitat on Sand Island, they would be instructed to remain vigilant for Laysan duck nests and call in the capture team if one is detected. The location of nests with eggs will be marked and monitored for capture and hold post-hatching.

To implement any of these mitigation strategies would require USFWS-Refuges to consult under Section 7 of the Endangered Species Act. Any proposal must have no net negative impact to this species. The overall goal would be to maintain a healthy population of ducks on MANWR during and after the mouse eradication. Since the Laysan duck is also a ground nesting species, the removal of mice would likely contribute to maintaining Laysan ducks on MANWR. However, short-term adverse impacts are likely even with minimization and mitigation measures in place. However, the founding population of Laysan ducks on MANWR was small and this species can reproduce quickly. The initial introduced population on MANWR in 2004 was 42 birds and in 6 years this population grew more than 15-fold to 661 birds. In summary, with the implementation of the mitigation plan described above, there is likely to be short term adverse impacts to the population of ducks on Sand Island, but the population should recover quickly, and thus the action is not expected to have long-term adverse effects to the Pacific population. In addition, the populations on Laysan Island and Kure Atoll would not be affected.

3.3.6.9 Land Birds

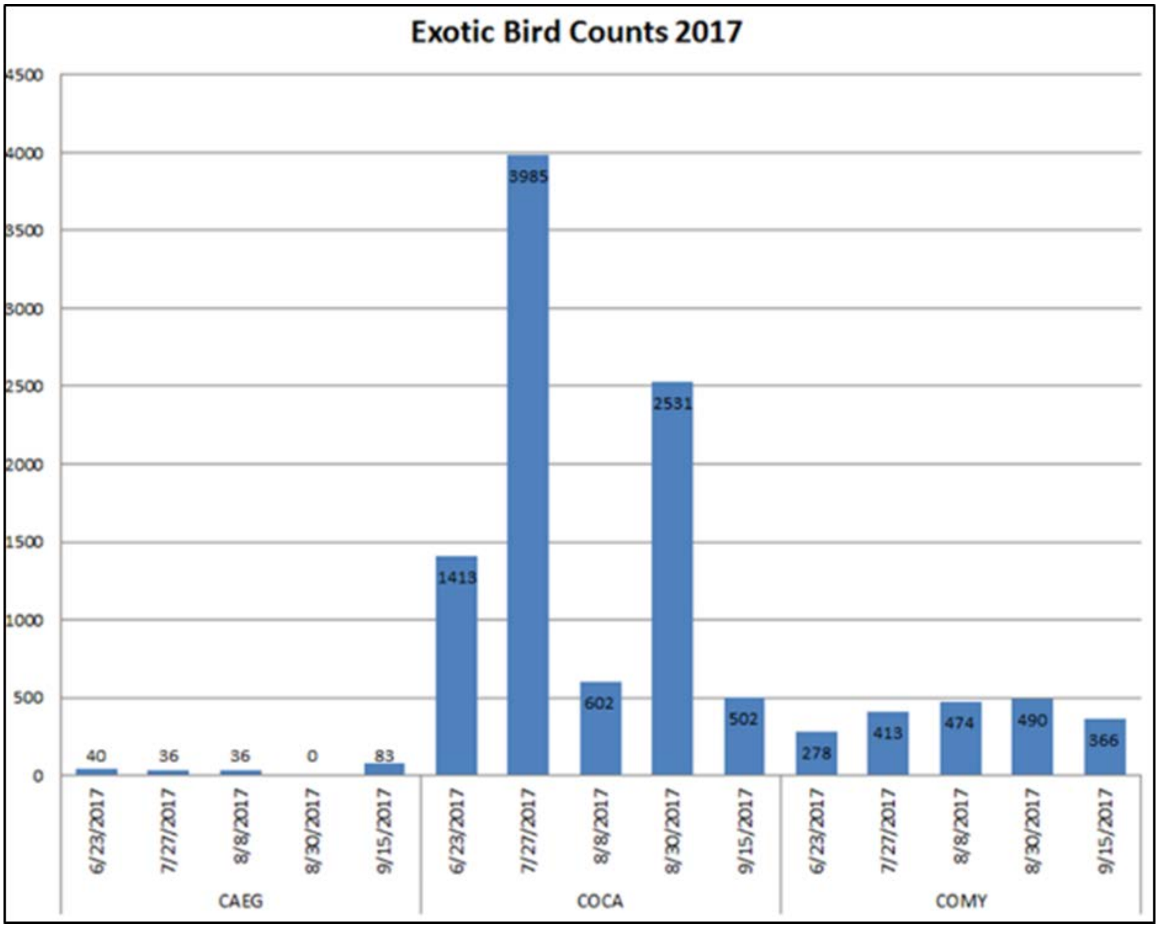
3.3.6.9.1 Existing Conditions

Three non-native landbird species are known to breed at MANWR: the Atlantic canary (*Serinus canaria*), the common myna (*Acridotheres tristis*), and the cattle egret (*Bubulcus ibis*) which is discussed in the next section. Both the Atlantic canary and the common myna are at risk of poisoning as they are present all year-round on Sand Island. Therefore, the timing of the rodenticide application is not a viable mitigation option.

The Atlantic canary is known worldwide simply as wild canary and is a small passerine bird in the finch family, Fringillidae. It is also called the island canary, canary or common canary. It is native to the Canary Islands, the Azores, and Madeira. Wild birds are mostly yellow-green, with brownish streaking on the back. The wild Atlantic canary can range from 3.9 to 4.7 in (10 to 12 cm) in length, with an average weight of around 0.53 oz. (15 g). The breeding population, which is confined to Europe, is estimated to number 1,500,000 to 2,520,000 pairs, which equates to 3,000,000-5,050,000 mature individuals (BirdLife International 2016b). This species is often kept as a pet and is referred to as the domestic canary. Selective breeding has produced many varieties which differ in color and shape. The species is widely kept in captivity in most areas of the world and is also widely used in scientific research. There are no known significant threats to this species (BirdLife International 2016b).

Island-wide monthly avian surveys, conducted from June through September 2017, counted 502 to 3,985 canaries on Sand Island (Figure 3.9). Using the maximum count of 3,985 birds from July 2017, the MANWR Atlantic canary population represents less than 0.078% of the global wild population.

Figure 3.9 Results of island-wide monthly avian surveys conducted from June through September 2017 for land birds



Source: USFWS (2017)

For the Atlantic canary, a cup-shaped nest is built 3 to 20 feet (1–6 m) above the ground in trees or bushes. Nests are made of twigs, grass, moss and other plant material and lined with soft material. Eggs are laid between January and July in the Canary Islands. A clutch contains 3 to 4, or occasionally 5, eggs, and 2-3 broods are raised each year. The Atlantic canary typically feeds in flocks, foraging on the ground or amongst low vegetation. It mainly feeds on seeds such as those of weeds, grasses and figs. It also feeds on other plant material and small insects (Snow and Perrins 1998).

In 1909, D. Morrison, superintendent in charge on Midway Island, purchased a mated pair of canaries from sailors on a ship in Honolulu Harbor. He brought them to Midway and kept them separate for 8 months until he put them in a breeding cage in January 1910. Soon after this, additional birds were brought from Hawaii and all birds were released on MANWR. By the end of 1910 they were breeding on Sand Island in the Casuarina trees and by 1922 there were approximately 1,000 canaries at Midway (Fisher 1949).

The common mynas native range covers a large swath of south and central Asia, from Turkmenistan eastward through all countries of the Indian subcontinent, including India, Pakistan, Nepal, Bangladesh, Bhutan, Sri Lanka, and Maldives. It also exists in much of southeast Asia south to Singapore. The species has been introduced and established in many other parts of the world (Kannan and James 2001). It is also abundant in urban areas of the Hawaiian Islands. It is one of the most common and most widespread avian species in all of the human-inhabited islands. Sexes alike, but male median weight of 4.5 oz. (126.5 g) is slightly larger than the female median weight of 4.0 oz. (113.5 g). Baker et al. (1999) estimated the population on MANWR in 1996 to be 750-850 individuals. Island-wide monthly avian surveys, conducted from June through September 2017, counted 278 to 490 birds for this species on Sand Island (see Figure 3.9). Using the maximum count of 490 birds from August 2017, the MANWR common myna population represents an insignificant proportion of the global population.

In the Hawaiian Islands, the common myna nests in palms and trees. They are also known to nest in any place that will hold a large pile of leaves and twigs, including, air-conditioners, drain pipes, open-ended steel rafters, traffic lights, and under eaves of buildings, etc. (Kannan and James 2001).

The common myna feeds while on ground and in trees and is omnivorous. The primary diet consists of fruits, grain, insects, and grubs. Its diet can also include kitchen scraps, tidbits from refuse dumps, bird eggs, small animals (young mice, frogs, lizards, crabs), and flower nectar. It has also been recorded to prey on seabird eggs including those of the wedge-tailed shearwaters in the Hawaiian Islands (Byrd 1979), terns (*Sterna* spp.) and noddies (*Anous* spp.) in Fiji and the Seychelles, and the eggs of gulls (*Larus* spp.) in New Zealand (Kannan and James 2001).

3.3.6.9.2 Probable Impacts: No Action Alternative

Under the No Action Alternative, limited mouse control would continue using the less toxic $AGRID_3$ rodenticide. Therefore, there would be no effects to the Atlantic canary or common myna under the no-action alternative since there are no known adverse effects to birds from the use of $AGRID_3$. Any potential predation of seabird eggs by the common myna would continue.

3.3.6.9.3 Probable Impacts: Preferred Alternative

<u>*Primary and Secondary Exposure.*</u>

The data in Table 3.17 indicate that both the Atlantic canary and the common myna would be at risk of primary and secondary poisoning from brodifacoum, since birds would only need to eat a fraction of their normal daily food intake of bait to receive a lethal dose. For a primary pathway, 1-2 pellets of bait (0.03 to 0.07 oz. [1 -2 g]) containing 0.025 mg of brodifacoum each, if ingested, would be enough to kill an individual canary or myna bird (Table 3.17). For secondary toxicity from consuming invertebrate prey, it would only take 18.1% and 36.5% of their daily food intake to reach a lowest lethal dose for the canary and myna bird respectively (Table 3.17). McClelland (2002) reported that 80% of fernbirds (*Bowdleria punctata wilsoni*), a warbler that forages on invertebrates, disappeared from a 74 ac (25ha) test plot that was used to assess risk of brodifacoum on non-target species prior to implementation of a rat eradication operation on Codfish Island, New Zealand.

In summary, brodifacoum would present a lethal risk to the Atlantic canary and common myna. Based on the above data, it would be possible that 996 to 3,188 (25-80% of the MANWR population) Atlantic canaries and 122 to 392 (25-80% of the population) common mynas could be killed by either primary or secondary poisoning from brodifacoum without mitigation. These numbers represent worst-case scenarios, based on maximum numbers of birds documented on Sand Island during the drop window and upper extremes of toxicity.

Table 3.17 Primary and secondary toxicity of Brodifacoum to Passerines on MANWR

Primary toxicity presented as grams of bait and secondary as grams of invertebrate prey. Active ingredient (mg) of brodifacoum is abbreviated as a.i. LD_{50} is that the dosage (D) of a toxin that is lethal (L) to 50% of animals of the species in laboratory tests.

Species	***Body Wt. (g)***	***Daily Food Intake (g)(1)***	***Brodifacoum***				
			LD_{50}(2) (mg/kg)	***LD_{50} (mg of a.i./bird)***	***LD_{50}(3) (g of bait)***	***LD_{50}2(4) (g of prey)***	***%(5) of Daily Food Intake***
Atlantic canary	15.0	7.1	0.26	0.0039	0.156	1.3	18.1
Common myna	126.5	29.5	0.26	0.0329	1.316	10.85	36.5

Notes:
1. Daily food intake calculated from allometric equation (Bird Feeding Rate = 0.059 x ($W^{0.67}$) (EPA 1995).
2. LD_{50} of brodifacoum based on mortality of mallard ducklings at the lowest dose, 0.26 mg/kg body weight = 0.026 mg/g (Ross et al. 1980, EPA 1991).
3. This is also the number of bait pellets that would need to be consumed to be lethal to 50% of the animals.4. Cockroach contamination based on highest reported value of 3.05 mg/kg = 0.00305 mg/g (Pitt et al 2015).
5. Calculated as LD_{50}2 grams of prey/daily food intake (g).

Operational Hazard (Bird Strike and Noise/Human Disturbance)

It would be unlikely ground operations associated with the Preferred Alternative would impact either the Atlantic canary and common myna. Both species either exclusively or preferentially nest in trees or shrubs, so trampling of nests would not be a concern. Helicopter operations have the potential to disturb passerines, but since planes land and take off from Sand Island regularly, this disturbance would be minor and might cause birds to temporarily flush from their locations. It would also be unlikely that helicopter operations would cause any collision hazard with these 2 species. During the helicopter operations for the Palmyra rat eradication, all helicopter collisions were with seabirds and shorebirds. One canary was recorded killed by aircraft at Henderson Field from 2004-2010.

The potential mortalities that would be expected to result from the Preferred Alternative represent insignificantly small numbers relative to overall global populations of both these species, but the Preferred Alternative would have a moderate negative affect for each of the Sand Island populations. Adverse effects would be readily detectable and localized with measurable consequences to the local population, but not readily detectable or measurable beyond the immediate area of impact. Mitigation measures would only be instituted for the Atlantic canary due to its cultural importance. Indirect effects from the Preferred Alternative would not be expected.

We expect there to be no additional impacts to the Atlantic canary and common myna should the need arise to implement the rapid response portion of the refuge's biosecurity plan and during implementation of the projects monitoring plan. A biosecurity plan has been in place on MANWR for many years and any additional bio-security measures would only occur if there was a new incursion of a non-native species. Biosecurity measures enacted would include rapid response to an incursion by non-native invasive species and implementing the monitoring plan would include follow-up observations and sample collecting (see Appendix A and B). We expect such additional ground-based human activities would not impact tree-dwelling species like the Atlantic canary and common myna.

Mitigation

Atlantic canaries on Sand Island would be caught and kept in aviaries during the bait drop period, and not released until post-monitoring of brodifacoum residues show decreased chance of primary or secondary exposure. A combination of mist-nets and walk in traps would be used to capture a subset of the resident flock adequate to protect the genetic variability of the population. However, this activity would receive a lower priority than protection of Laysan ducks or migratory shorebirds. In a capture test in 2017, 4 birds were caught in 2 morning hours of mist-netting. Walk-in traps have not been tested, but are known to be effective in trapping ground feeding passerines. The Atlantic canary is easy to hold in captivity, and any mortality of birds while being held should be minimal. After release, populations should grow quickly since this species can raise 2-3 broods each year, with the average nest containing 3 to 4 eggs.

3.3.6.10 Cattle Egrets

3.3.6.10.1 Existing Conditions

Invasive non-native cattle egrets (*Bubulcus ibis*) have colonized MANWR by island hopping through the Northwestern Hawaiian Islands. They have been documented breeding on Eastern Island, and the cattle egret regularly use both Eastern and Sand Island. Island-wide monthly avian surveys, conducted from June through September 2017, counted 0 to 83 birds for this species on MANWR (Figure 3.9). The European population is estimated at 76,100-92,300 pairs, which equates to 152,000-185,000 mature individuals (BirdLife International 2015). The global population is larger than this, although no estimate is available. Using the maximum count of 83 birds from September 2017, and the estimate of the minimum number of individuals in Europe, the cattle egret population on MANWR represents 0.05% of the European population.

The population of this species is actively managed on MANWR due to their predatory behavior on nesting seabirds. The USFWS has issued a federal migratory bird control order at 50 CFR 21.55 which allows for the take of Cattle Egrets (and Barn Owls) on the main Hawaiian Islands, the Northwestern Hawaiian Islands, and on Midway, which authorizes the Service and personnel from certain other agencies to lethally take cattle egrets to protect native species without a permit (50 CFR 21.55 [or 82 FR 34419]). Prior to this Control Order, control operations were authorized by permit, and from March to August in 2017, MANWR staff destroyed 80 egret nests, treated 303 eggs, and dispatched 10 chicks.

Since they only breed on Eastern Island, and a control program is already underway for this invasive species, helicopter disturbance or disturbance from ground personnel is not considered an issue.

3.3.6.10.2 Probable Impacts: No Action Alternative

Under the No Action Alternative, Sand Island's mouse population would not be the subject of an island-wide eradication project, but limited mouse control efforts would continue using the less toxic AGRID$_3$ to protect nesting seabirds and for human health and safety. Therefore, there would be no effects to the cattle egret under the no-action alternative.

3.3.6.10.3 Probable Impacts: Preferred Alternative

Primary and Secondary Exposure

The likelihood of primary exposure to rodenticides would be very low. However, the egret is a predator species. These birds would be expected to consume small mammals, birds, lizards, and invertebrates. They would also likely scavenge mice or other animals that succumbed to rodenticide. Because of their diets, secondary exposure to the rodenticide could be a risk to these birds. This species would need to eat 52.0% or more of their normal daily food intake to receive a potential lethal dose of brodifacoum by consuming invertebrates. For mammalian prey, only 0.52 oz. (14.9 g) of contaminated prey needs to be consumed for a potential lethal dose to an individual, which is only 24.6% of their estimated normal daily food intake (Table 3.16). Therefore, mortality from secondary exposure of this species could be high. However, although it was estimated that more than 20,000 rats were killed during the eradication project on Palmyra, only a few dozen rat carcasses were found during the project after the bait was applied because the animals often returned to their burrows before they died. (Pitt et. al. 2015). It is expected that this same result would occur on Sand Island, especially since mice are significantly smaller than rats and thus more difficult to detect. Thus, there may be few carcasses available for cattle egrets to find and consume.

Based on the above data, it is possible that 20-80% of the egret population (17-67 birds) would be killed or receive sub-lethal doses by consuming brodifacoum intoxicated prey. There would also be a potential that brodifacoum would persist in the environment for at least a year and have impacts beyond the proposed operational window (Rueda et al. 2016; Pitt et al. 2015), such that any returning egrets to Sand Island would be at risk from secondary poisoning.

Operational Hazard (Bird Strike and Noise/Human Disturbance)

It would be unlikely ground or air operations would impact cattle egrets. Egrets are not known to breed on Sand Island and this species does not nest on the ground. Air operations have the potential to disturb roosting egrets, but observations from field personnel during pre-project surveys indicate this disturbance would be minor and could cause birds to temporarily flush from their location. In addition, egrets do not fly very high, and thus have a negligible risk for collision potential with the helicopter. Calculations of mortality are based on the maximum number of birds observed in 2017. The potential mortalities that would be expected to result from Preferred Alternative represent insignificantly small numbers relative to overall populations of this species.

We expect there could be some additional impacts to cattle egrets should the need arise to implement the rapid response portion of the refuge's biosecurity plan and during implementation of the projects monitoring plan. A biosecurity plan has been in place on MANWR for many years and any additional bio-security measures would only occur if there was a new incursion of a non-native species. Biosecurity measures enacted would include rapid response to an incursion by non-native invasive species and implementing the monitoring plan would include follow-up observations and sample collecting (see Appendix A and B). Potential impacts such as causing birds to flush could occur from the additional human disturbance although this bird is a non-native invasive species. However, we expect any additional impacts to be minor, localized, and short-term.

Mitigation

No mitigation measures are planned for this species since a lethal control program is in place on MANWR.

3.3.6.11 Terrestrial Mammals

3.3.6.11.1 Existing Conditions

No native terrestrial mammals are known from MANWR. No domestic animals or livestock are present on the island. Rats were previously documented on the 3 islands but were successfully removed and the islands were declared rat free in 1997 (USFWS, Unpublished b). Personnel from Island Conservation were unable to confirm the presence of rats using remote cameras and bait on either Sand or Eastern Island. If somehow rats have been re-introduced to Sand Island and are present in low numbers at the time of the eradication, the design of the mouse eradication would eliminate rats as well. House mice are presently the only known non-native mammal on the island.

3.3.6.11.2 Probable Impacts: No Action Alternative

Under the No Action Alternative, Sand Island's mouse population would not be the subject of an island-wide eradication project, but limited mouse control efforts would continue using the less toxic $AGRID_3$ to protect nesting seabirds and for human health and safety. Therefore, impacts to the islands ecosystem, including negative impacts to vegetation and seabird populations, would continue.

3.3.6.11.3 Probable Impacts: Preferred Alternative

Under Preferred Alternative, every mouse on the island would receive a primary or secondary exposure to the rodenticide brodifacoum and the house mouse would be eradicated from Sand Island.

3.3.6.12 Herpetofauna

3.3.6.12.1 Existing Conditions

The only known terrestrial reptiles or amphibians present on Sand Island are non-native and include the House Gecko (*Hemidactylus frenatus*), Indo-Pacific Gecko (*Hemidactylus garnotii*), Mourning Gecko (*Lepidodactylus lugubris*), Penny Skink (*Lampropholis delicata*), and Blind Snake (*Ramphotyphlops braminus*).

3.3.6.12.2 Probable Impacts: No Action Alternative

Under the No Action Alternative, Sand Island's mouse population would not be the subject of an island-wide eradication project, but limited mouse control efforts would continue using the less toxic AGRID$_3$ to protect nesting seabirds and for human health and safety. Therefore, there would be minor effects to any herpetofauna under the no-action alternative. Any negative effects of mice on herpetofauna populations on Sand Island would continue.

3.3.6.12.3 Probable Impacts: Preferred Alternative

Primary Exposure

No mortality of herpetofauna associated with the use of brodificoum has been recorded to date, and one study indicates reptiles appear to be relatively insensitive to anticoagulant rodenticides (e.g., brodifacoum) compared to birds or mammals (Weir et al. 2015). This finding is supported by evidence from New Zealand, where brodifacoum has been extensively used in areas occupied by a wide range of herpetofauna, with no reports of reptiles or amphibians poisoned with brodifacoum (Eason and Spurr 1995). However, on Round Island Mauritius, Telfair's skinks (*Leiolopisma telfairii*) that ate rain-softened brodifacoum pellets broadcast in an eradication project were found dead (Merton 1987 in Eason and Spurr 1995). Telfairs's skinks are known to eat seeds and fruit. Analyses of the skink carcasses revealed brodifacoum concentrations in the liver of 9.6 x 10^{-6} oz./lb. (0.6 mg/kg). Neither the Penny skink nor the house gecko would be likely to consume pellets. Both species eat invertebrates and the gecko also consumes sap or nectar.

Because of the apparent relative insensitivity of reptiles to anticoagulants, it would be unlikely skinks, geckos or snakes would be killed by rodenticide poisoning. However, the situation with brodifacoum is less clear compared to diphacinone. However, when the above data are taken in total, the risk of killing skinks, geckos or snakes from brodifacoum poisoning would be low. If any mortality were to occur, population level effects are highly unlikely.

Secondary and Tertiary Exposure

While negative impacts to the skinks, geckos or snakes are unlikely, it is expected that these species would consume invertebrates that have fed on the pellets, which would then pose a tertiary poisoning risk to other animals that eat these animals as part of their diet. Because of reptiles' relative insensitivity to anticoagulant rodenticide, they may be able to accumulate relatively high sub-lethal residues. On Pinzón Island, native lava lizards (*Microlophus duncanensis*) were found to maintain brodifacoum residues in their liver more than 800 days after the last application of a rat eradication project (Rueda et al. 2016). This resulted in the deaths of several raptors.

The Preferred Alternative would be unlikely to affect the herpetofauna on the island, and there are no mitigation measures proposed to reduce this impact. Any impacts would likely be minor, localized, and of little consequence to the populations.

We expect there to be some additional impact to herpetofauna should the need arise to implement the rapid response portion of the refuge's biosecurity plan and during implementation of the projects monitoring plan. A biosecurity plan has been in place on MANWR for many years and any additional bio-security measures would only occur if there was a new incursion of a non-native species. Biosecurity measures enacted would include rapid response to an incursion by non-native invasive species and implementing the monitoring plan would include follow-up observations and sample collecting (see Appendix A and B). Potential impacts such as trampling vegetation or the crushing of animals underfoot could occur with the additional human activities along with collection of some animals to test for brodifacoum residues; although these species are non-native. However, we expect any additional impacts to be minor, localized, and short-term.

3.3.6.13 Terrestrial Invertebrates

3.3.6.13.1 Existing Conditions

Midway's terrestrial invertebrate fauna have been greatly altered by more than a century of human occupation. The majority of what we know about the terrestrial invertebrate community has focused on describing the species assemblage on Midway, and much of that assemblage work has focused on Arthropoda, and to a lesser extent Mollusca (Conant et al. 1983, Nishida and Beardsley 2002). Five hundred and fifty-two species of terrestrial invertebrates have been recorded thus far, of which 81% are introduced (Nishida and Beardsley 2002), and fill a wide range of habitat and functional niches in Midway's terrestrial ecosystem, as well as food resources for some of the avifauna.

The number of arthropod taxa observed on the atoll has grown rapidly over the past century and is speculated to have been aided by an increase in plant diversity and ease of migration (Nishida and Beardsley 2002). In the main Hawaiian Islands, Shiels et al. (2013) found that over half the diet of feral mice consisted of arthropods, with caterpillars making up the vast majority of the arthropod prey (~94%), followed by ants, fly larvae, burrowing bugs, and spiders. These results were in contrast with larger rodents (rats) at the same locations, which fed on a wider variety of arthropods, including cockroaches, Katydids, and honey bees (Shiels et al. 2013).

3.3.6.13.2 Probable Impacts: No Action Alternative

Under the No Action Alternative, Sand Island's mouse population would not be the subject of an island-wide eradication project, but limited mouse control efforts would continue using the less toxic $AGRID_3$ to protect nesting seabirds and for human health and safety. Therefore, there would be minor effects to terrestrial invertebrates under the no-action alternative. Any negative effects of mice on invertebrate populations on Sand Island would continue.

3.3.6.13.3 Probable Impacts: Preferred Alternative

Terrestrial invertebrates can accumulate anticoagulant rodenticide residues. It has been suggested that anticoagulant rodenticides, such as diphacinone and brodifacoum, are not likely to affect invertebrates, because their blood clotting mechanisms are different from those of vertebrates (Shirer 1992 in Eason and Spurr 1995). However, the toxicity of anticoagulants may differ across groups of invertebrates. Brodifacoum is highly toxic to *Daphnia magna*, an aquatic invertebrate, with an EC50 of 0.98 ppm after 48 hours (USEPA 1991). Most hard-bodied terrestrial invertebrates (e.g., crabs, cockroaches, beetles) appear to be relatively insensitive (Booth et al. 2003, references therein; Morgan et al. 1996; but see Pitt et al. 2015). There is evidence that brodifacoum may be more toxic to soft-bodied terrestrial invertebrates than hard-bodied species (Booth et al. 2003). In a laboratory study, 2 species of land snail (*Pachnodus silhouettanus*, *Achatina fulica*) died in 72 hours when exposed to doses ranging from 3.5 x 10^{-7} oz. to 1.1 x 10^{-6} oz. (0.01 to 0.04 mg) (Gerlach and Florens unpubl., Booth et al. 2003). In another lab study, brodifacoum equivalent to 8.0 x 10^{-5} to 1.6 x 10^{-4} oz./lb. (5 to 10 mg a.i./kg) was found to cause 100% mortality of earthworms (*Apporectodea calignosa*) (Booth et al. 2003).

However, causing this level of mortality required grinding pellets and mixing them with the soil, a scenario that would be unlikely to occur in the field. In general, most invertebrate species are not known to be susceptible to toxic effects from the use of brodifacoum in the field (Booth et al. 2003, Hoare and Hare 2006).

Preferred Alternative would be unlikely to directly affect any terrestrial invertebrates on the island and there are no mitigation measures planned to reduce impacts to invertebrates. Removal of mice from Sand Island would eliminate mice predation on invertebrates, and thus potentially could have a beneficial effect to these species.

We expect there to be some minor additional impacts to terrestrial invertebrates should the need arise to implement the rapid response portion of the refuge's biosecurity plan and during implementation of the projects monitoring plan. A biosecurity plan has been in place on MANWR for many years and any additional bio-security measures would only occur if there was a new incursion of a non-native species. Biosecurity measures enacted would include rapid response to an incursion by non-native invasive species and implementing the monitoring plan would include follow-up observations and sample collecting (see Appendix A and B). Potential impacts such trampling of vegetation and soil could occur from the additional human disturbance along with the collection of some animals to test for brodifacoum residues. However, over 80 percent of terrestrial invertebrates on MANWR are non-native. In summary, we expect any additional impacts to invertebrates to be minor, localized, and short-term.

3.3.6.14 <u>Marine Fish</u>

3.3.6.14.1 Existing Conditions

A total of 266 species of fish, including 7 pelagic species, have been recorded at Midway. Some of these species are rare or absent from the main Hawaiian Islands. Despite its low species diversity, Midway's reef fish biomass is higher than in the main Hawaiian Islands, largely due to lower fishing pressures. Midway and its neighboring atolls have the highest rates of endemic reef fishes within the archipelago, with up to 52% of all fish observed being endemic. Many Midway species grow to larger than average size. All trophic levels are well represented, including jacks and 4 species of sharks. Several species of fish found elsewhere only in deep waters are found at shallow diving depths at Midway, including the endemic Hawaiian black grouper (hapu‘upu‘u).

One alien algae, one alien fish, the blueline snapper (*Lutjanus kasmira*), and 4 alien marine invertebrate species are established at Midway as found in 2000- 2003 surveys. Incidental observations of 2 other introduced species, blacktail snapper (*Lutjanus fulvus*) and bluespotted grouper (*Cephalopholis argus*), have occurred at Midway in the last decade.

A total of 111 species of reef fish were observed during the 2008 surveys at Midway. Ten families represent the majority of the species of reef fish at Midway: *Acanthuridae, Kyphosidae, Scareidae, Mullidae, Pomacentridae, labridae, Carcharhinidae, lutjanidae, Holocentridae* and *Oplegnathidae*. The Kyphosids, or chubs, and the Acanthurids, or surgeon fish and tangs, are the most abundant and represent the highest biomass. Parrotfish (*Scaridae*) represented the third largest contributor to total fish biomass. Reef fish biomass density was higher in the forereef environment compared to the backreef and lagoon, and was slightly higher in the south and southeast quadrants of the atoll. Of the larger bodied reef fish greater than 50 cm in length, the parrot fishes (family *scaridae*) were the most abundant, composing 44% of the individual reef fish counted, and had the highest biomass density at 33%. Acanthurids represented the highest biomass in the backreef and lagoon habitats, and was third to sharks and chub, in the forereef habitat. Large jacks (*Caranx ignobilis*) are also known to frequent the forereef and reef crest environments.

3.3.6.14.2 Probable Impacts: No Action Alternative

Under the No Action Alternative, Sand Island's mouse population would not be the subject of an island-wide eradication project, but limited mouse control efforts would continue using the less toxic $AGRID_3$ to protect nesting seabirds and for human health and safety. No bait would be used in the vicinity of the marine environment; therefore, there would be no effects to marine fish or the marine ecosystem under the no-action alternative.

3.3.6.14.3 Probable Impacts: Preferred Alternative

Primary Exposure

The likely pathways for contamination of fish would be through primary and secondary exposure. A potential, but unlikely, pathway would be absorption through skin or gills (Empson and Miskelly 1999). Bait pellets dissolve quickly in the near shore environment, often within 15 to 30 minutes, and the concentration of rodenticide in sea water would be at undetectable levels and would pose very low, if any risk to fish. In a study on the Island of Lehua, Hawaiʻi, of the 48 species of fish documented to occur around the island, 29 were found to consume inert bait pellets; another 7 species made contact with the bait, but did not consume it (Mazurek 2015). In this trial with inert baits, pellets were applied at a rate equivalent to 653 lb./ac. (733 kg/ha), which is more than 10 times higher than the maximum rate proposed for this eradication project. In a similar trial, in New Zealand, 3 species of fish were seen to eat non-toxic baits (Empson and Miskelly 1999).

A recent laboratory study by the USGS showed that black triggerfish (*Rhinecanthus aculeatus*), smallmouth bass (*Micropterus dolomieu*) and fathead minnows (*Pimephales promelas*) refuse to eat bait pellets containing diphacinone (USGS Columbia Environmental Research Center). However, during the second 2017 Lehua rat eradication effort, fish were caught from shore by line and hook baited with shrimp on the day of each bait application; fish were euthanized, and gut contents examined for signs of bait material and the pyranine biomarker fluorescence. Bait material and/or the biomarker were observed in specimens of pinktail triggerfish (*Melichthys vidua*), black triggerfish, stocky hawkfish (*Cirrhitus pinnulatus*), and blue-lined snapper. No evidence of bait consumption was found in blacktail snapper or blotcheye soldierfish (*Myripristis berndti*) caught (S. Siers, personal communication, USDA NWRC 2016).

When diphacinone (bait or a.i.) is administered by gavage, the fish rapidly regurgitate the material (R. Riegerix, personal communication, USGS/University of Missouri-Columbia 2016), which indicates that some fish species can detect and avoid bait containing diphacinone. Results from aquarium trials associated with the Kapiti Island, New Zealand rat eradication found similar results using brodifacoum (Empson and Miskelly 1999). Three species of fish, variable triplefin (*Forsterygion varium*, 24 individuals), spotty (*Notolabrus celidotus*, 30), and blue cod (*Parapercis colias*, 6) were presented with bait pellets containing 0.002% brodifacoum. Of the 60 total fish, only 6 spotties were seen to eat the bait, with one dying from brodifacoum poisoning. Several fish died that did not eat the bait, and no brodifacoum residues were found in their livers. The authors speculated the fish may have absorbed the chemical through their skins or gills. When small quantities of brodifacoum bait entered the marine environment during aerial application operations on Anacapa Island and Isabel Island, Mexico, no marine organisms (fish or invertebrates) were observed to consume the bait (Howald et al. 2009, Samaniego-Herrera et al. 2014). However, in the Kapiti Island trials, 3 species of fish were seen to eat the non-toxic bait within 15 minutes of entering the marine environment (Empson and Miskelly 1999).

In summary, some species of fish may feed on pellets on the day of application. Whether the consumption is abundant or prolonged enough to cause illness or mortality to some fish remains unknown. The rapid dissolution of unconsumed pellets in water would prevent the prolonged feeding on pellets. Given the relatively small amount of bait that would be expected to enter the marine environment, the rapid dissolution of pellets, and the fact that some fish appear to avoid eating bait pellets with active rodenticide, it appears consumption of rodenticide baits for some species of fish would be minor and unlikely to have adverse affects on their populations.

Secondary Exposure

Secondary exposure of fish to brodifacoum around Sand Island would be a potential risk. However, on the Anacapa Island rat eradication project, 6 species of intertidal organisms (fish and invertebrates) were sampled 15, 30, and 90 days post-application, and all samples tested negative for brodifacoum residues (Howald et al. 2009). In addition, 2 studies conducted in conjunction with the 2008 Mōkapu and 2009 Lehua rat eradication projects using diphacinone indicate that the risk would be extremely low (Orazio et al. 2009, Gale et al. 2008). Within days of the last aerial broadcast of diphacinone pellets, samples were collected of fish, invertebrates, and seawater, and none of the species sampled showed detectable levels of diphacinone in their tissues. However, brodifacoum residues have been found in fish tissues after rat eradications. A review of rat eradication projects using brodifacoum found marine residue monitoring and analysis had been conducted in 10 applications between 1997 and 2011 (Masuda et al. 2015). Of the 10 applications, 1 detected brodifacoum residues in fish. Two of 65 fish sampled had residues, with concentrations 0.026 and 0.092 ppm in the liver, which exceeded the 96 hour LC50 for rainbow trout (*Oncorhynchus mykiss*) (0.015 ppm) and bluegill sunfish (*Lepomis macrochirus*) (0.026 ppm) (USEPA 1991). Following the rat eradication on Palmyra Atoll, rodenticide residues were detected in all fish samples collected from the lagoon which included mullet fishes (*Moolgarda engeli* and *Liza vaigiensis*) and one puffer fish. Fish were found dead and collected opportunistically for this study (Pitt et al. 2015). Mullet fish contamination ranged from 0.058–1.160 ppm (mean=0.337 ppm) and the single puffer fish (family *Tetraodontidae*) sample had 0.438 ppm of brodifacoum in homogenized tissue.

However, a number of factors will reduce the likelihood of marine secondary exposure around Sand Island relative to Palmyra including: (*i*) the shape of Sand Island has less coastline per acre of treated area; (*ii*) the much broader beaches with a lack of vegetaton on Sand Island and few coastal trees to block the view of the coastline by the helicopter pilot; (*iii*) the use of hand broadcast of bait in areas without beaches or with armouring on the shoreline and; (*iv*) greater lagoon flushing at MANWR because land doesn't protect the lagoon as it does on Palmyra.

The above examples demonstrate that marine fish can be contaminated during an aerial application of brodifacoum. However, it also demonstrates that this occurs only infrequently. It is also noteworthy that the very large amount of brodifacoum used on Palmyra Atoll at 75.6 lb./ac. (84.8 kg/ha) and 71.5 lb./ac. (80.1 kg/ha), for the first and second application respectively, was unprecedented, which likely influenced the available brodifacoum residues consumed by non-target species. The bait density used for Palmyra was 10-16% higher than that proposed for Sand Island. Following the accidental brodifacoum spill in New Zealand, fish samples were collected, and only one individual fish had detectable rodenticide residues (Primus et al. 2005). However, this site had a higher energy coastline with greater wave action than that on MANWR. In the above cases involving brodifacoum, it is unclear whether the fish exposure was primary or secondary.

In summary, the main secondary exposure risk from anticoagulant rodenticides would be from the consumption of fish that had died or had recently ingested toxicants, and therefore contained a high level of toxin, or from contaminated invertebrates. If any fish do die from primary exposure, those carcasses may pose secondary hazard to other species that may consume them. However, animals that survive direct ingestion would rapidly metabolize (24-48 hrs) the vast majority of the toxin, and residues in liver (and far lower in muscle tissue) are likely to be too low to be biologically significant.

Based on the above data, it would be unlikely that a sufficient quantity of brodifacoum would enter the water, or that the pellets would remain intact, in the environment, long enough to present an absorption or primary poisoning risk to any fish populations. In addition, the bulk of the reef around MANWR Island is not in close proximity to Sand Island. Therefore, although some reef fish near the island may be affected, the majority of the populations around the atoll would unlikely to be affected. Some individual fish may be at risk if they were to ingest pellets. The low levels of residues found are not likely to be biologically significant with respect to secondary exposure or bioaccumulation, especially in such a diffuse environment. It also would be unlikely that the rodenticide would contaminate sufficient prey of fish to pose a secondary poisoning risk to any fish populations. Therefore, it would be unlikely that Preferred Alternative would directly or indirectly impact any fish populations. Minor direct and indirect impacts may occur to some individual fish. Besides the multiple steps being taken to minimize bait pellets entering the marine environment (see below), there are no other mitigation measures proposed for marine fish.

We expect there to be no additional impact to marine fish from the implementation of the projects monitoring plan. Implementing the monitoring plan would include follow-up observations and sample collecting. Some game fish may be collected for the sampling of brodifacoum residues. Additional impacts to marine fish are not expected from implementation of the bio-security plan or monitoring plan since these activities will mostly occur in the terrestrial environment (see Appendix A and B). Therefore, we expect no potential impacts to marine fish from the additional terrestrial human disturbance and the number of fish collected will be small.

Mitigation

To minimize bait from entering the marine environment, prior to the application of bait pellets with rodenticide, the bait delivery system (bait bucket, controller, GPS units, and helicopter) would be tested and calibrated to ensure an accurate application rate. An onboard computer linked to a GPS and light bar would guide the pilot along pre-programmed flight lines over the island at a prescribed airspeed, which would facilitate application of bait over the terrestrial environment only. Aerial application of bait pellets would not occur during wind speeds in excess of 35 mph, or when heavy rains are forecast to occur within 72 hours. In addition, for areas near the shoreline, the bait hopper would be fitted with a deflector that spreads bait out to only one side (approx. 120° angle) to minimize bait application directly into the water. For shorelines where armoring is present and the shoreline is very narrow, spreading bait using hand-broadcast methods would be used to the maximum extent practicable. Every reasonable effort would be made to minimize the risk of bait drift into the water; however, it is expected that a small amount of bait will enter the ocean. The pilot and on-the-ground observers would visually monitor the application of bait, and if a malfunction were detected, operations would cease until the problem is corrected. Lastly, bait would be applied at the lowest rate possible to achieve eradication, and any bait spills above a defined threshold would be collected and disposed of according to label instructions.

3.3.6.15 Coral

3.3.6.15.1 Existing Conditions

MANWR is one of the northernmost coral atolls in the world, presenting a unique opportunity to study the effect of colder waters on the growth, development, and ecology of coral reefs. Its neighbor, Kure Atoll, is the northernmost atoll in the world. MANWR drops off steeply outside the barrier reefs, making it possible to observe in a relatively small area the different organisms and communities associated with pelagic, reef crest, ocean facing reef slope, deep reef, and lagoon habitats.

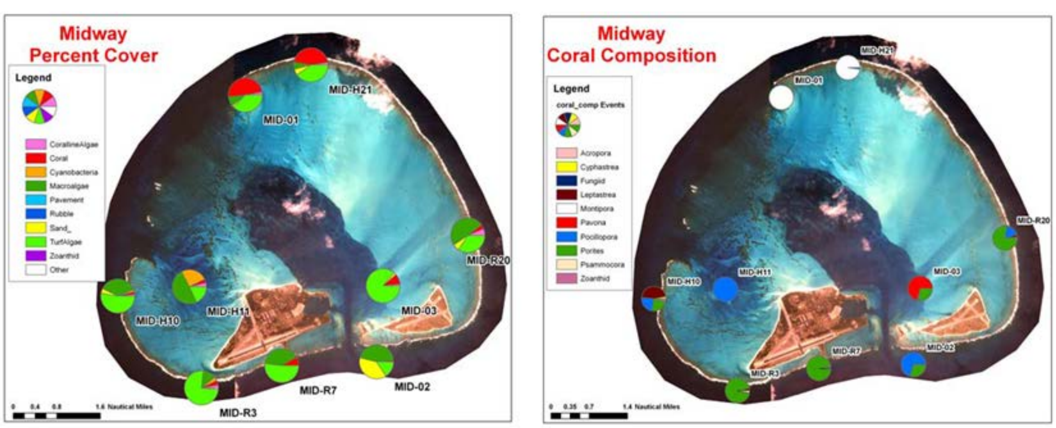
The lagoon is filled with dense networks of linear reticulated and circular reefs that trap sand washed over the northeastern reef rim. As in many atoll lagoons, sediments limit coral growth on Midway, except in the deeper central lagoon, where a modest amount of finger coral gardens still exists. Meadows of seagrass are common in the lagoon, as are rock-boring urchins, calcareous green algae, and brown turban algae. The deep southern ship channel between the ocean and lagoon was dredged during the World War II era and has substantially modified circulation and lowered lagoon water levels. Together with lagoon reefs, these changes reduced or blocked water circulation in much of the lagoon and created higher levels of turbidity. In 2000 and 2004, coral bleaching episodes were reported at Midway, as well as at the neighboring atolls of Kure, Pearl, and Hermes. Lagoon lobe and finger corals have declined during the past decade, although blue encrusting coral continues to thrive.

Massive spurs and grooves consisting mostly of coralline algae face the open ocean along the northwest to southwest perimeter reefs and protect the atoll from heavy wave action common during the winter months. These massive reefs offer evidence of the importance of coralline algae as a major reef builder in the far end of the Northwestern Hawaiian Islands. Corals on ocean-facing reef habitats are generally not as abundant compared to neighboring atolls to the southeast, but are common in a few sheltered reefs and especially on shallow back-reefs and lagoon pinnacles. High concentrations of the rock-boring urchin *Echinometra* are presently eroding much of the shallow perimeter reef crests dominated by coralline algae. Although not grazing corals directly, the sea urchins are hollowing out the dead interior skeletons of living lobe corals, and undermining other attached corals.

A total of 32 species of stony coral have been recorded at Midway, mostly *Pocillopora*, *Porites*, and *Montipora*, plus one zoanthid soft coral, *Palythoa*. Blue encrusting coral tentatively identified as *Montipora cf. turgecens* occurs in spectacular formations in the lagoon and back reef habitats, and may be endemic to the Northwestern Hawaiian Islands.

Coral cover around MANWR varies with both habitat and within region of the atoll. Hard coral cover was generally low island-wide, averaging around 2.45% and never exceeding 20%. The highest coral cover was generally located along several sections of the northern and eastern backreef, where coral assemblage was primarily composed of Montipora, Pocillopora, and Porites spp. Mean coral cover was low inside the lagoon (6.6 ± 3.0%) and on the forereef (4.0 ± 1.5%), while mean cover was moderately high in the backreef (32.3 ±14.2%) (NOAA CREP 2008). Coral community structure varied both between and within habitats. Two northern backreef sites consisted of large encrusting colonies of 3 Montipora species. The eastern backreef site was characterized by scattered Porites lobata and Pocillopora heads. On the forereef, the western area was scoured and corals were quite depauperate, most likely due to strong wave action. The southern forereef south of Sand Island is composed largely of Porites sp., while the forereef south of Eastern Island is composed of mostly Pocillopora sp. The coral communities at 2 lagoon patch reefs, one in the southeastern portion, and the other in the southwest (MID-03 and MID-H11, Figure 3.10), were quite different with one dominated by old Porites compressa mounds (MID-03, Figure 3.10) and the other (MID-H11, Figure 3.10) consisting of scarce Pocillopora heads.

Figure 3.10 Spatial Distribution of Benthic Cover and Coral Composition at NOAA CREP Rapid Ecological Assessment Sites at Midway in 2008



Source: NOAA (2008)

3.3.6.15.2 Probable Impacts: No Action Alternative

Under the No Action Alternative, Sand Island's mouse population would not be the subject of an island-wide eradication project, but limited mouse control efforts would continue using the less toxic AGRID$_3$ to protect nesting seabirds and for human health and safety. No bait would be used in the vicinity of the marine environment; therefore, there would be no effects to corals or the marine ecosystem under the no-action alternative.

3.3.6.15.3 Probable Impacts: Preferred Alternative

Primary and Secondary Exposure

As described above, a variety of corals inhabit the waters around MANWR, and there would be potential for these organisms to be exposed to rodenticide that inadvertently reached the marine environmental and dissolved in the water. However, the level of bait entering the nearshore environment would be very low, pellets would dissolve quickly in the nearshore environment, often within 15-30 minutes, and the rodenticide would be diluted rapidly, disperse and sink to the ocean bottom and start decomposing (see Section 3.3.2). In addition, as described below under essential fish habitat, the nearshore, directly adjacent to Sand Island and the project area, is depauperate of corals. The benthic substrate, adjacent to the mouse eradication project area is categorized as sand, hardbottom-uncolonized, pavement, pavement with sparse algae, and pavement-uncolonized (see Figure 3.10).

The only documented toxic effect of brodifacoum is that it prevents the production of vitamin K coagulating factors in mammals. These are "poisons" only due to the anticoagulant property and invertebrates do not have the same blood clotting system as mammals. There are no data to indicate corals have been impacted by anticoagulant rodenticides from previous eradication projects. On Palmyra Atoll, no impact to corals was documented after the application of bait containing brodifacoum applied using 2 applications at the rate of 75.6 and 71.5 lbs./ac. (84.8 and 80.1 kg/ha), which is 10-16% more than the application rate proposed for MANWR (65 lbs./ac. or 73 kg/ha).

Based on the above data, it would be unlikely that a sufficient quantity of brodifacoum would enter the water, or that the pellets would remain intact, to present an absorption or primary poisoning risk to any corals. In addition, no short- or long-term discharge of brodifacoum-impacted groundwater into the marine environment is anticipated (see Section 3.3.2). Therefore, it would be unlikely that the Preferred Alternative would impact any corals.

We expect there to be no additional impact to coral from the implementation of the projects monitoring plan. Implementing the monitoring plan would include follow-up observations and sample collecting. Additional impacts to coral are not expected from implementation of the bio-security plan or monitoring plan (see Appendix A and B) since these activities will mostly occur in the terrestrial environment.

Mitigation

The same minimization measures outlined under marine fish would also minimize the amount of rodenticide entering the marine environment.

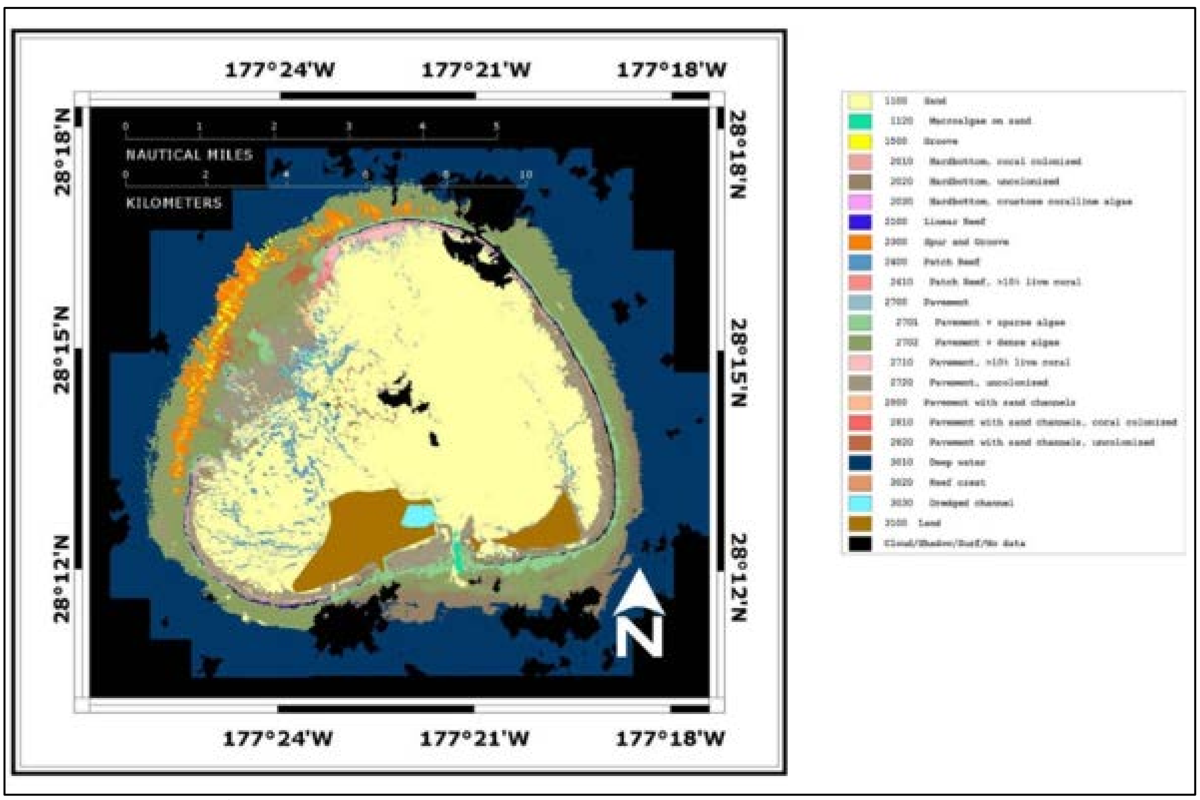
3.3.6.16 Essential Fish Habitat

3.3.6.16.1 Existing Conditions

The marine water column and seafloor of MANWR, adjacent to the proposed project area for the mouse eradication, is identified as Essential Fish Habitat (EFH). The EFH is said to support various life stages for Management Unit Species (MUS) identified under the Western Pacific Regional Fishery Management Council's Pelagic and Hawai'i Archipelago Fishery Ecosystem Plans. Of key relevance to this project is the designation of EFH for Coral Reef Ecosystems, including the water column and all bottom down to 328 ft. (100 m) depth from the shoreline out to the exclusive economic zone (EEZ) boundary (NOAA 2013).

The species composition, abundance and condition of the corals at MANWR vary depending on location within the atoll (see Figure 3.11). The nearshore, directly adjacent to Sand Island and the project area, is depauperate of corals. The benthic substrate, adjacent to the mouse eradication project area is categorized as sand, hardbottom-uncolonized, pavement, pavement with sparse algae, and pavement-uncolonized (see Figure 3.10). The benthic maps show only 2 small areas in the marine environment, close to the project area, that are categorized as pavement with >10% live coral (see Figure 3.11).

Figure 3.11 NOAA Midway Island Detailed Habitat Cover Image at 13m Resolution



Source: National Centers for Coastal and Ocean Science (2017)

Sand Island is located in the southern portion of the atoll and is nearest to the southern forereef. The high level of wave energy on the southern shore of Sand Island makes the area adjacent to the project area poor coral habitat. The seawall area of the island was added by the Navy during the Cold War (circa 1957-58) to lengthen the runway, and the nearshore environment was damaged by dredging and filling activities, and additional acres were added to the island (Figure 3.12). The majority of the nearshore habitat is categorized as reef flat (semi-exposed area between the shoreline intertidal zone and the reef crest of a fringing zone), though the boundary between land and reef flat has become less obvious as the sheet pile has eroded and vegetation and seabird nesting areas have appeared. Debris is present in the majority of the benthic habitat adjacent to the sheet pile seawall (USFWS PIFWO 2016). The hard substrate of the seawall sheet pile walls and areas where riprap has been placed to control erosion are artificial habitat, and have more abundant coral colonization than the sand, and pavement environments (USFWS PIFWO 2016).

A marine survey of the seawall portion of the adjacent marine environment was conducted by the Pacific Islands Fish and Wildlife Office and NOAA staff in February 2013, and again in April 2016, to determine presence and density of protected species and sensitive habitat for the seawall repair project (Figure 3.13) (Godwin 2013, Klavitter 2013, USFWS PIFWO 2016). The 2016 seawall survey covered nearshore areas, including the full length of seawall that may be included in future seawall repair efforts. Within the survey area, 97 reef fish, 9 coral, 32 non-coral macro-invertebrates, and 28 algae species were identified. The 9 coral species identified were from the families *Acroporidae*, *Faviidae*, *Pocilloporidae*, and *Poritidae*, with lobate, encrusting, and branching morphologies present. These species were found in low densities, with an average of 0.77 colonies per 10.8 $ft.^2$ ($0.77/m^2$) and had a maximum diameter of approximately 19.7 in. (50 cm). Corals were found on both benthic and artificial substrate. No ESA-listed coral species were found during this survey, and there are no reports of listed corals occurring at Midway or within the Hawaiian Archipelago.

During a seawall site visit in June 2017, sites seaward of the repair areas were scouted and assessed for suitability as coral translocation sites (Figure 3.14). These sites are representative of the patch reefs in the area. Transplant site Y had a total of 93 corals from 3 species, 2 from the genus *Pocillopora* and one Porites, within a 2,152 $ft.^2$ (200 m^2) area. Transplant site Z had a total of 79 corals from 2 species in the genus *Pocillopora* within a 1,076 $ft.^2$ (100 m^2) survey area. These sites are small areas of raised structure that are suitable for corals to persist. There is very little structure suitable to support live coral in the area, and what is colonized has a low abundance of live coral, as is represented by sites Y and Z. Sites Y and Z are over 500 ft. (157 m) away from the seawall, and well outside of the mouse eradication project area. The area inshore from sites Y and Z, along the length of the seawall, were scouted for coral transplant suitability, and were categorized as unfit, due to the lack of appropriate structure and live coral.

Figure 3.12 Augmentation of Sand Island during the Cold War

An airfield was added to Sand Island and the coastline along the southern and southeastern shore was hardened with a seawall.
Source: National Centers for Coastal and Ocean Science (2017)

Figure 3.13 Marine Survey Area for Seawall Repair Project

Areas of surveyed (orange) and interpolated (green) project area. "Target Area" identifies anticipated area of direct impact for the Seawall Repair Project.
(USFWS PIFWO 2016)

Figure 3.14 Possible Coral Translocation Site for the Seawall Repair Project

Possible coral translocation site for the seawall repair project, located on the southern shore of Sand Island over 500 ft. (157 m) from the seawall.
Source: USFWS (2017)

The back reef and reef crest habitat has a higher occurrence, abundance and species diversity of corals than the reef flat and lagoon habitats. On the southern shore of Sand Island, except for the area directly off of "Bulky Dump," the closest back reef and reef crest habitat is over 600 ft. (180 m) from shore. The area adjacent to the shoreline is sand or un-colonized pavement with few scattered coral heads. This area is subject to tidal exposure, further reducing the number of live coral present. The "Bulky Dump" area is categorized as pavement with sparse algae and is the closest point to the southern reef crest, at approximately 90 ft. (27 m). Excluding the seawall that has been addressed above, very few (if any) corals occur within a 30 ft. (10 m) zone along the southern shoreline of Sand Island.

The northern shoreline of Sand Island is predominately sand, and the environment immediately adjacent to the shore is sandy lagoon habitat devoid of coral. Very few (if any) corals grow within the 33 ft. (10 m) marine zone. The high coral cover areas of the lagoon occur out at the northern reef crest and back reef at site such as MID-01, MID-H21 and MID-156 (Figure 3.10). The high coral cover areas of the back reef and reef crest on the Northern and Northwestern sides of the island are over 5,000 ft. (1.5 km) from shore.

3.3.6.16.2 Probable Impacts: No Action Alternative

Under the No Action Alternative, Sand Island's mouse population would not be the subject of an island-wide eradication project, but limited mouse control efforts would continue using the less toxic AGRID$_3$ to protect nesting seabirds and for human health and safety. No bait would be used in the vicinity of the marine environment; therefore, there would be no effects to essential fish habitat under the no-action alternative.

3.3.6.16.3 Probable Impacts: Preferred Alternative

Primary Exposure

Based on the above data, it would be unlikely that a sufficient quantity of brodifacoum would enter the water, or that the pellets would remain intact, and in the environment, long enough to present a poisoning risk to essential fish habitat. Some dissolved particles of brodificoum would likely settle in the benthic marine environment and there is uncertainty how some organisms may be affected by trace amounts. However, since the toxic effect of brodifacoum is the prevention of the production of vitamin K coagulating factors in mammals, the effects would likely be negligible. Marine invertebrates do not have the same blood clotting systems as mammals and documented evidence show marine invertebrates such as crabs with no ill effects. As stated in the previous sections, the Preferred Alternative is unlikely to have any effects to coral, non-coral macro marine invertebrates (see Section 3.3.6.17), or algae (see Section 3.3.6.18) and only minor effects to individual reef fish.

Since broadifacoum can stay active to ~6 months, there is a possibility that there could be sufficient time for the toxin to percolate into the groundwater aquifer of Sand Island and possibly discharge active grains of ingrediant that settle on the benthic marine environment. However, as discussed in Section 3.3.2, should brodifacoum dissolved at low concentrations (it is nearly insoluble) enter the groundwater aquifer, it would be degraded by bacteria in the subsurface, be diluted, and take years or decades for that water to discharge into the marine environment. Due to saturation with percolating rainwater, groundwater flows down and outward towards the shore, where it eventually discharges into the ocean. However, the gradients and flux are small (GeoEngineers 2011). At Wake Island it was assessed that it would take 30 to 50 years for groundwater to migrate from the center of the island to either shore (a distance of approximately 1,000 ft. [305 m]) (AFCEE 2006). Residence times at Sand Island could be as much as 3 times longer because it is roughly 6,000 ft (1,828 m) across. Hydrogeological studies at Wake Island found that groundwater chemistry and temperature conducive to the biodegradation of organic compounds like brodifacoum, similar conditions are present at Sand Island. The Wake Island study also found that significant dilution, driven by vertical groundwater movement from tidal fluctuations, would occur (AFCEE 2006). Therefore, no short- or long-term discharge of brodifacoum-impacted groundwater into the marine environment is anticipated.

Therefore, it would be unlikely that the Preferred Alternative would directly or indirectly impact essential fish habitat. Multiple steps are being taken to minimize the number of bait pellets entering the marine environment. Any impacts would likely be minor and localized. In summary, the Preferred Alternative would likely have some adverse effects on essential fish habitat, but those effects would be minor and temporary.

We expect there to be no additional impact to essential fish habitat from the implementation of the projects monitoring plan. Implementing the monitoring plan would include follow-up observations and sample collecting. Additional impacts to essential fish habitat are not expected from implementation of the bio-security plan or monitoring plan since these activities will mostly occur in the terrestrial environment (see Appendix A and B).

Mitigation

The same minimization measures outlined under marine fish would also minimize the amount of rodenticide entering the marine environment.

3.3.6.17 Marine Invertebrates

3.3.6.17.1 Existing Conditions

The first systematic marine invertebrate survey was conducted at Midway in 1997. It documented 316 invertebrate species, 250 of which had not been previously recorded at Midway. Crustaceans were the dominant macroinvertebrates, composing 46% of the total species.

The sea urchin, *Echinostrephus aciculatus, Echinometra mathaei,* and *Heterocentrotus mammilatus,* are the most abundant benthic invertebrate in all 3 habitats (forereef, backreef, and lagoon.) The boring sea urchin (*Echinometra mathaei*) is the most abundant non-coral invertebrate present on the forereef, with over 73,000 individuals observed during towed diver surveys, and has its highest densities along the southern shore. Free urchins were relatively uncommon, with all records noted within the lagoon and backreef environments. Trapezid crabs and holothuroids or sea cucumbers, *Actinopyga obesa* and *Bohadaschia paradoxa*, are abundant within the lagoon at Midway. Sea cucumbers the second most abundant group of mobile invertebrate present on the forereef, with approximately 1,000 individuals counted during towed diver surveys, with the highest abundance present on the northern and southern backreefs.

3.3.6.17.2 Probable Impacts: No Action Alternative

Under the No Action Alternative, Sand Island's mouse population would not be the subject of an island-wide eradication project, but limited mouse control efforts would continue using the less toxic $AGRID_3$ to protect nesting seabirds and for human health and safety. No bait would be used in the vicinity of the marine environment; therefore, there would be no effects to marine invertebrates under the No Action Alternative. Any negative effects of mice on marine invertebrates or the intertidal and nearshore ecosystems would continue.

3.3.6.17.3 Probable Impacts: Preferred Alternative

Primary or Secondary Exposure

Based on the above data, it would be unlikely that a sufficient quantity brodifacoum would enter the water, or that the pellets would remain intact long enough, to present an absorption or primary poisoning risk to any marine invertebrates. As noted above (see Section 3.3.6.14), samples of fish, invertebrates (crabs and limpets), and seawater collected days after aerial application of diphacinone on Mōkapu and Lehua showed no detectable levels of diphacinone in their tissues (Orazio et al. 2009, Gale et al. 2008). Brodifacoum residues have been found in invertebrate tissues after rat eradications. A review of rat eradication projects using brodifacoum found marine residue monitoring and analysis had been conducted in 10 applications between 1997 and 2011 (Masuda et al. 2015). Of the 10 applications, 3 detected brodifacoum residues in invertebrates. Of the 196 invertebrates sampled, 11 had residues detected in their tissue, with concentrations ranging from 0.001 to 0.022 ppm (mean =0.008 ppm). After the rat eradication on Palmyra, brodifacoum residues were found in fiddler crabs (*Uca tetragonon*) (Pitt et al. 2015).

In general, invertebrates appear to be relatively insensitive to anticoagulant rodenticides (Pain et al. 2000, Hoare and Hare 2006). However, on Palmyra Atoll, some fiddler crabs may have died from brodifacoum poisoning in conjunction with the rat eradication (Pitt et al. 2015). This would likely be an extreme situation given the application rate on Palmyra was 32-40% higher than that proposed for Sand Island. In addition, the lagoon environment on Palmyra is not analogous to the conditions on Sand Island, which experiences a higher level of water exchange due to how the channel was dredged into the atoll lagoon by the Navy to facilitate boat access.

Primus et al. (2005) suggest mortality of marine invertebrates may have occurred as a result of a large spill of rodenticide containing brodifacoum. However, this situation would not be representative of how bait might enter and interact with the nearshore environment in the Preferred Alternative. Therefore, it would be unlikely that the Preferred Alternative would impact any marine invertebrates. The minimization measures outlined for marine fish are not a factor in this determination.

We expect there to be no additional impacts to marine invertebrates from the implementation of the projects monitoring plan. Implementing the monitoring plan would include follow-up observations and sample collecting. Some mollusks may be collected for the sampling of brodifacoum residues. Additional impacts to marine invertebrates are not expected from implementation of the bio-security plan or monitoring plan since these activities will mostly occur in the terrestrial environment (see Appendix A and B). In addition, the number of marine animals collected will be small.

Mitigation

The same minimization measures outlined under marine fish would also minimize the amount of rodenticide entering the marine environment. In addition, no short- or long-term discharge of brodifacoum-impacted groundwater into the marine environment is anticipated (see Section 3.3.2).

3.3.6.18 Algae

3.3.6.18.1 Existing Conditions

More than 100 species of algae are known to exist on Midway, including 35 previously unrecorded species at Midway and 1 seaweed species new to science, *Dudresnaya babbittiana*.

Algal communities contribute to the health of coral reef ecosystems, providing trophic resources for grazers and herbivorous fish (Gattuso et al. 1998), as well as contributing to coral reef productivity (Rowan 1998). The transfer of nutrients from algae to coral occurs when fish or invertebrates forage on primary producers and excrete on the coral reef (Birkeland and Grosenbaugh 1985).

The Algae Benthic communities around MANWR are composed primarily of turf and macroalgal functional groups with a combined total of 23 species of macroalgae observed (7 chlorophytes, 5 ochrophytes, 11 rhodophytes) from CREP sites surveyed (NOAA CREP 2008). Macroalgae cover averaged 21.1% island-wide and was generally highest along the eastern backreef areas (average 35.4%). In 2008, 2 towed-diver surveys approximately 5 mi (8 km) to the north of East Island encountered a *boodlea* algae bloom, with several segments recording 100% cover of the benthos in a layer up to 1.5 ft. (0.5 m) thick.

Coralline algae were generally low island-wide, recording 5.09% cover (range 0–40%). The highest coralline algae cover was generally noted along the northern forereef, reaching up to 50.1–62.5% cover. In 2008, 9 benthic sites were surveyed and showed that *Laurencia galtsoffii* is the most prevalent species encountered, with cover varying from 0% to 35.2% of the substrate across all survey sites in the lagoon, backreef and forereef (Table 3.18). *Dictyota ceylanica, Lobophora variegata, Stypopodium flabelliforme* and a species of *Padina* are present on the atoll and can often be among the most dominant algal species. Overall, turf algae is abundant and was the dominant algal functional group at 6 of the 9 sites surveyed in 2009, with a % cover range of 15.6% to 84.8% (NOAA CREP 2008). The lagoon habitat was characterized by high % cover of both turf and macroalgal communities, and very low presence and % cover (3.6 to 1.6%) of crustose coralline algae (CCA). *Microdictyon setchellianum* has been the most prevalent species documented at some lagoon sites, with 25.2% to 31.6% algal cover. The backreef habitat was characterized by high % cover of turf algae (34-40%) and a low presence of macroalgae (9%) at most sites, and little CCA cover. The forereef habitat was dominated by turf algae (50-84%) and also hade high cover of macro algae (36-44%). CCA cover on the forereef was less than 3%.

Table 3.18 Additional species recorded at each site at MANWR during roving diver survey

Site	***Chlorophyta***
MID-R20	*Boodlea composita*
MID-H11	*Codium edule*
MID-R7, MID-H10, MID-H11, MID-H21	*Dictyosphaeria versluysii*
MID-H11	*Halimeda discoidea*
MID-01, MID-02, MID-R3, MID-H21	*Halimeda velasquezii*
MID-H21	*Microdictyon setchellianum*
MID-01, MID-02, MID-H21	*Neomeris sp.*
	Ochrophyta
MID-R20	*Dictyota ceylanica*
MID-02	*Distromium flabellatum*
MID-R20	*Sargassum sp.*
MID-H21	*Stypopodium flabelliforme*
MID-H21	*Turbinaria ornate*
	Rhodophyta
MID-H11	*Chondrophycus parvipapillatus*
MID-H10, MID-H11	*Galaxaura filamentosa*
MID-02	*Galaxaura sp.*
MID-01	*Halichrysis coalescens*
MID-H11	*Halymenia sp.*
MID-02, MID-H10, MID-H11	*Jania sp.*
MID-02	*Laurencia galtsoffii*
MID-H11	*Liagora sp.*
MID-H10	*Martensia sp.*
MID-01	*Peyssonnelia sp.*
MID-R20	*Portieria hornemannii*

3.3.6.18.2 Probable Impacts: No Action Alternative

Under the No Action Alternative, Sand Island's mouse population would not be the subject of an island-wide eradication project, but limited mouse control efforts would continue using the less toxic $AGRID_3$ to protect nesting seabirds and for human health and safety. No bait would be used in the vicinity of the marine environment; therefore, there would be no effects to marine algae or the marine ecosystem under the no-action alternative.

3.3.6.18.3 Probable Impacts: Preferred Alternative

<u>Primary or Secondary Exposure</u>

There are no known effects (or pathways) of anticoagulant rodenticides on marine algae and operations would not extend into the marine environment. Therefore, the Preferred Alternative would be unlikely to directly or indirectly impact marine algae.

We expect there to be no additional impacts to algae from the implementation of this projects monitoring plan. Implementing the monitoring plan would include follow-up observations and sample collecting. Additional impacts to algae are not expected from implementation of the bio-security plan or monitoring plan since these activities will mostly occur in the terrestrial environment (see Appendix A and B).

Mitigation

The same minimization measures outlined under marine fish would also minimize the amount of rodenticide entering the marine environment. In addition, no short- or long-term discharge of brodifacoum-impacted groundwater into the marine environment is anticipated (see Section 3.3.2).

3.3.6.19 Sea Turtles

3.3.6.19.1 Existing Conditions

The ranges of 5 species of marine turtles (all listed under the ESA) encompass the waters of Midway, including the loggerhead turtle (*Caretta caretta*), the olive ridley (*Lepidochelys olivacea*), and the leatherback (*Dermochelys coriacea*).

Worldwide populations of the green turtle (*Chelonia mydas*) have seriously declined as a direct result of overharvesting of turtles and eggs over the last centuries (Parsons 1962). In 1978, the Hawaiian subpopulation of the green turtle was listed as threatened under the Endangered Species Act of 1973. Additional protective regulations are enforced throughout all areas within U.S. jurisdiction, in an effort to conserve and restore marine turtle populations to their former levels of abundance. Inclusion of green turtles into the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), also known as the Washington Convention, made it illegal to trade any products made from this species in the U.S. and 130 other countries.

Threatened Hawaiian green turtles are frequently seen inside the MANWR lagoon and basking on beaches. They are present year round. No turtle nesting had been documented until successfully hatched eggs were discovered on Spit Islet in July 2006. High surf uncovered the eggs, which probably hatched in 2005. In 2007, a successful sea turtle nest was documented on Sand Island and in June 2017 several crawls and possible nests were observed but not confirmed on the beach to the west of Bulky Dump and North Beach. Adult green sea turtles are herbivores, feeding on seaweeds, seagrasses, and algae (NMFS and USFWS 1998). Juveniles are omnivores, eating a range of insects, crustaceans, worms, and seagrasses. Sea turtles are also reported to feed on marine debris (Schuyler et al. 2014). Green turtles of nearshore habitats in the Hawaiian Islands feed on benthic algae of the following genera: *Codium*, *Amansia*, *Pterocladia*, *Ulva*, *Gelidium*, and *Caulerpa* (NMFS 1998). Green turtles often nest on wide sandy beaches, and nesting has been documented at least once at Midway.

Endangered hawksbill sea turtles (*Eretmochelys imbricata*) are infrequently seen in the lagoon, and other species of turtles have been observed foraging at MANWR. Hawksbill turtles are specialist sponge carnivores, selecting just a few genera of sponges for their principal diet (Vicente 1994). This feeding strategy is unique, as few vertebrates are capable of digesting sponges without being injured by the sponges' silicate spicules (i.e., needles).

3.3.6.19.2 Probable Impacts: No Action Alternative

Under the No Action Alternative, Sand Island’s mouse population would not be the subject of an island-wide eradication project, but limited mouse control efforts would continue using the less toxic $AGRID_3$ to protect nesting seabirds and for human health and safety. Therefore, there would be no effects to sea turtles under the no-action alternative.

3.3.6.19.3 Probable Impacts: Preferred Alternative

Primary Exposure

Little is known about the effect that brodifacoum may have on turtles. Rodenticide toxicity experiments have not been conducted in many turtle species and therefore the LD_{50} values are unknown for the Green sea turtles or other species of turtles present in the waters surrounding MANWR. However, an initial assessment from preliminary findings of a USDA National Wildlife Research Center (NWRC) turtle-anticoagulant hazards study indicates ornate wood turtles (*Rhinoclemmys pulcherrima*) were not negatively affected by brodifacoum consumption. Turtles that were fed high brodifacoum doses received 2.5 x 10^{-5} oz./lb. (1.6 mg/kg) of turtle body weight of brodifacoum, and none died or showed signs of ill health prior to being euthanized one week later. The turtle with the highest liver residue level (2.02 ppm) weighed 0.7 lbs. (319 g), which means that it received about 500 ppm (0.5 mg) of brodifacoum. Since a Brodifacoum-25D pellet contains 25 ppm, the turtle essentially received the equivalent of 20 pellets (USFWS 2011). Adult green sea turtles weigh on average 325 lbs. (147 kg) (NOAA Fisheries Service 2011a), thus, using similar metrics, one adult green turtle would have to consume approximately 9,200 pellets or 40.5 lbs. (18.4 kg) of pellets to receive a comparable exposure to that the ornate wood turtle received which showed no ill effects. Adult hawksbill turtles weigh on average 125 lbs. (57 kg) (NOAA Fisheries Service 2011b), thus one hawksbill turtle would have to consume approximately 3,500 pellets or 15.4 lbs. (7.0 kg) of pellets to receive a comparable exposure to that the ornate wood turtle received.

Green sea turtles could potentially eat baits that drift into the water. However, it would be very unlikely this would occur given the low probability of bait entering the water and the rapid decomposition of bait in water. Therefore, there would likely be no effect on sea turtles as a result of implementation of the Preferred Alternative. Secondary exposure or other indirect effects to sea turtles also would be very unlikely due to their diet.

Operational Hazard (Noise/Human Disturbance)

Turtles may be disturbed when loafing on the beach, but this occurs predominantly later in the day and thus disturbance should be minimal during the early morning and afternoon when the operation would take place. With a helicopter speed ranging from 29–58 mph (46-93 km/hr) during each bait drop, even at the slowest airspeed the helicopter would take only 16 seconds to travel 656 ft. (200 m). Thus, disturbance would only last a few seconds. The level of disturbance for individuals is likely to be low since the disturbance would only occur at each site once or twice during each baiting application. Therefore, these noise impacts would be short-lived and negligible.

We expect there could be some additional impacts to sea turtles from the implementation of the projects monitoring plan (Appendix B). Implementing the monitoring plan would include follow-up observations and sample collecting. Potential impacts such as disturbing beach-basking turtles could occur from the additional human disturbances. Additional impacts to sea turtles are not expected from implementation of the bio-security plan since this will occur in the terrestrial environment. Given the minimization measures that will be in place to protect the Hawaiian green sea turtle, we expect any additional impacts from disturbance to be minor, localized, and short-term.

<u>*Mitigation*</u>

The same minimization measures outlined under marine fish would reduce the likelihood that any rodenticide would enter the marine environment. In addition, all project personnel on the ground would maintain a 100 ft. (30.5 m) buffer from sea turtles during operations. During aerial bait broadcast, helicopters would avoid hovering near turtle basking areas and would avoid distributing pellets over turtles on the beaches to the extent possible without sacrificing the chance of project success. These mitigation measures would reduce any potential impacts on sea turtles.

Figure 3.15 Hawaiian monk seal

Source: USFWS (2017)

The USFWS will consult with the Protected Species Division of NOAA, under Section 7 of the Endangered Species Act, to identify the best course of action to ensure protection of sea turtles. This process will address monitoring protocols; bait application around turtles; and a response plan in the unlikely event of finding a turtle sick or dead during or following the operation.

3.3.6.20 <u>*Marine mammals*</u>

3.3.6.20.1 Existing Conditions

Marine mammals of 2 orders, Cetacea and Pinnipedia, have been observed in the pelagic waters surrounding Midway. The most commonly sighted cetaceans are bottlenose dolphins (*Tursiops truncatus*) and spinner dolphins (*Stenella longirostris*). Although protected under the Marine Mammal Protection Act (MMPA) of 1972, none of the cetaceans mentioned here are listed under the ESA or otherwise considered threatened. Approximately 200-300 Hawaiian spinner dolphins rest within Midway's lagoon and forage outside the atoll. Bottlenose, striped (*Stenella coeruleoalba*), spotted (*Stenella attenuate*), and rough-toothed dolphins (*Steno bredanensis*) may occasionally be seen in the open ocean, as well as beaked (family; *Ziphiidae***)**, pilot (*Globicephala macrorhynchus*), and the endangered humpback whales (*Megaptera novaeangliae*).

Spinner dolphins frequently use inshore island and atoll habitat for day-time rest and social interactions, and forage over deep waters at night. The groups of spinner dolphins associated with Kure and Midway Atolls have been the subject of long-term research since 1998. Depth contours are used as vectors of movement within the atoll's lagoon, while areas of extreme local depth and shallows are generally avoided. Socially important behaviors, such as resting and socializing, occur over spatially restricted areas, contrary to behaviors such as travel and play that might occur over a considerably larger portion of the lagoon.

Potential measurable impacts from mice eradication activities to cetaceans in the waters surrounding MANWR would be negligible, since all of the activities described in the proposed action are terrestrial and these marine mammals forage outside of the lagoon.

The Hawaiian monk seal (*Neomonachus schauinslandi*) is one of the most endangered marine mammals in the world and the rarest pinniped in US waters (see Figure 3.15). Following decades of decline, Hawaiian monk seal abundance increased 3% annually from 2013-2016 and is estimated at about 1,400 individuals. This positive trend is largely due to multiple years of increased juvenile survival in the Northwestern Hawaiian Islands (NWHI). Weighing between 400-600 lbs. (180-270 kg) and about 7-7.5 ft. (2.1-2.3 m) in length, females are slightly larger than males. Pups are approximately 24-33 pounds (11-15 kg) at birth and about 3 ft. (1 m) long.

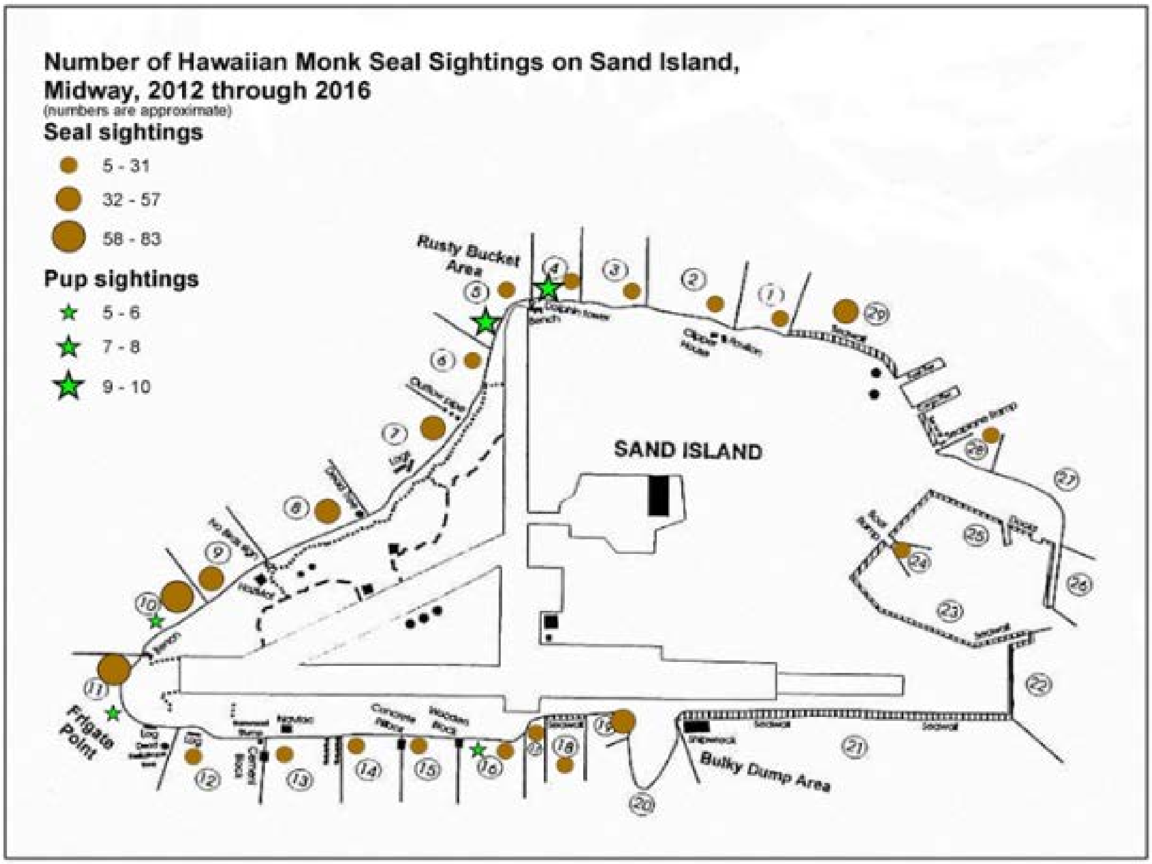
The Hawaiian monk seal's entire range is within U.S. waters and the majority of seals reside in the NWHI within the Papahānaumokuākea Marine National Monument at 8 breeding subpopulations. These islands include; (*i*) Kure Atoll; (*ii*) Midway Islands; (*iii*) Pearl and Hermes Reef; (*iv*) Lisianski Island; (*v*) Laysan Island and; (*vi*) French Frigate Shoals, (*vii*) Mokumanamana (Necker) Island and (*viii*) Nihoa Island. A sub-population of about 300 seals is now also found on the main Hawaiian Islands where births have occurred on all major islands.

Hawaiian monk seals live in warm subtropical waters and spend two-thirds of their time at sea. They use waters surrounding atolls, islands, and areas farther offshore on reefs and submerged banks. Hawaiian monk seals have also been found using deepwater coral beds as foraging habitat. Hawaiian monk seals sometimes spend days at sea before returning to the islands where they sleep and digest their food. Hawaiian monk seals are primarily benthic foragers, feeding on a variety of prey including fish, cephalopods, and crustaceans. Hawaiian monk seals generally hunt for food outside of the immediate shoreline areas in waters 60-300 ft. (18-90 m) deep and at depths of up to 1,600 ft. (500 m) where they prey on eels and other benthic organisms (NMFS and NOAA 2007). Hawaiian monk seals come ashore to rest, give birth and rear their pups, and during the molting period. They haul-out on sand, corals, volcanic rock, and other substrates. Sandy, protected beaches surrounded by shallow waters are preferred when pupping. Hawaiian monk seals are often seen resting on beaches on Sand Island (see Figure 3.16).

Females generally mature at age 7-10, the gestation period is believed to be about 10-11 months, and most births occur between February and July, with a peak in April to May. However, birthing has been recorded year-round. Nursing occurs for about 39 days, during which time the mother fasts and remains on land. After this period, the mother abandons her pup and returns to sea.

The information below summarizes Hawaiian monk seal beach counts conducted on Sand Island, Midway from 2012 through 2016 (Johanos 2017). Data were collected on each hauled out seal during systematic whole-island beach surveys which began around 1300. In total, observers conducted 41 standardized beach surveys and recorded 486 Hawaiian monk seal sightings over this 5-year period. For the purpose of seal data collection, the perimeter of Sand Island is divided into 29 areas, or sectors, to describe the spatial properties of seal habitat use (Figure 3.16) (Table 3.19 and Table 3.20).

Figure 3.16 Sand Island Hawaiian Monk Seal Sightings: 2012-2016



Source: NOAA (2017)

Beach count data are summarized below by sector location (Table 3.19) and month (Table 3.20).

In 2016, the total number of endangered Hawaiian monk seals present at Midway was estimated to be 74 seals (12 pups and 62 non-pups). Pupping levels have increased significantly since 1996, with a record number of 17 in 2004. These seals are present at all times of the year, generally hauling ashore to rest. The pupping season on Midway is predominantly February to July with only 3-4 animals typically having pups on Sand Island. However, as is common throughout the Hawaiian Islands, survivorship of juveniles is low and contributes to the endangered status of the species. In an effort to increase survivorship, NOAA-Fisheries established a captive care program on Sand Island in 2006. Six females were released in March 2007.

Table 3.19 Hawaiian Monk Seal Beach Count Data Summarized by Sector

Average number of seals hauled out on Sand Island, MANWR, by sector, per standardized beach count, conducted during 2012 through 2016. This is the number of seals you would expect to encounter, on average, on one beach count.						
	Non-Pup Size Classes			***Totals***		
Sector	***Adult***	***Sub-Adult***	***Juvenile***	***Non-Pup***	***Pup***	***All Seals***
1	0.3	0.1	0.1	0.5	0.0	0.5
2	0.4	0.0	0.0	0.5	0.0	0.5
3	0.2	0.2	0.1	0.4	0.0	0.4
4	0.2	0.0	0.0	0.2	0.2	0.4
5	0.1	0.0	0.0	0.4	0.2	0.6
6	0.2	0.1	0.0	0.3	0.0	0.3
7	0.5	0.2	0.0	0.7	0.0	0.7
8	0.7	0.3	0.0	1.0	0.0	1.0
9	0.7	0.3	0.2	1.1	0.0	1.1
10	0.9	0.2	0.1	1.2	0.1	1.3
11	0.5	0.7	0.3	1.5	0.1	1.7
12	0.0	0.2	0.1	0.3	0.0	0.3
13	0.0	0.0	0.0	0.1	0.0	0.1
14	0.0	0.1	0.0	0.2	0.0	0.2
15	0.1	0.0	0.0	0.1	0.0	0.1
16	0.0	0.0	0.0	0.0	0.1	0.1
17	0.0	0.0	0.0	0.0	0.0	0.1
18	0.1	0.0	0.0	0.1	0.0	0.1
19	0.6	0.1	0.0	0.7	0.0	0.7
20	0.0	0.0	0.0	0.0	0.0	0.0
21	0.0	0.0	0.0	0.0	0.0	0.0
22	0.0	0.0	0.0	0.0	0.0	0.0
23	0.0	0.0	0.0	0.0	0.0	0.0
24	0.1	0.0	0.0	0.2	0.0	0.2
25	0.0	0.0	0.0	0.0	0.0	0.0
26	0.0	0.0	0.0	0.0	0.0	0.0
27	0.0	0.0	0.0	0.0	0.0	0.0
28	0.1	0.1	0.0	0.1	0.0	0.1
29	0.6	0.1	0.0	0.6	0.0	0.7
Source: PIFSC 17-021 (Johanos2017)						

Table 3.20 Hawaiian Monk Seal Beach Count Data Summarized by Month

Average number of seals hauled out on Sand Island, MANWR, by month, during standardized beach counts conducted during 2012 through 2016.

Month	No. of Surveys	Non-Pup Size Classes			Totals			
		Adult	Sub-Adult	Juvenile	Non-Pup	Pup	All Seals	Std.
March	1	5.0	3.0	6.0	14.0	0.0	14.0	-
April	2	5.0	2.5	3.0	10.5	0.5	11.0	1.41
May	2	5.5	2.0	3.5	11.0	1.0	12.0	4.24
June	11	7.1	4.4	1.1	12.6	2.6	15.1	5.82
July	9	6.6	3.6	0.1	10.2	0.8	11.0	3.12
August	6	6.2	1.7	0.8	8.7	0.5	9.2	2.64
September	7	7.9	1.9	0.9	10.6	0.6	11.1	1.68
October	2	6.0	2.0	1.5	9.5	0.0	9.5	3.54
November	1	5.0	1.0	3.0	9.0	0.0	9.0	-

Source: PIFSC17-021 (Johanos 2017)

3.3.6.20.2 Probable Impacts: No Action Alternative

Under the No Action Alternative, Sand Island's mouse population would not be the subject of an island-wide eradication project, but limited mouse control efforts would continue using the less toxic AGRID3 to protect nesting seabirds and for human health and safety. No bait would be used in the vicinity of the marine environment; therefore, there would be no effects to marine mammals under the no-action alternative.

3.3.6.20.3 Probable Impacts: Preferred Alternative

<u>Primary Exposure</u>

As many as 74 Hawaiian monk seals could be present on or around Sand Island during the proposed operation. Because they do not forage on land, direct consumption of bait pellets from the ground would not be a risk. Bait pellets that might drift into the water would fall close to the shoreline far from the typical offshore foraging areas of monk seals, however weaned pups often mouth and may consume sea cucumbers and other prey items in the wave wash and nearshore environment (NMFS unpublished data). Older Hawaiian monk seals were found not to interact with bait pellets during a placebo trial on the island of Lehua in 2015 for a rat eradication study (Mazurek 2015).

Moreover, bait pellets degrade quickly in water and fragments sink to the bottom, and so would only be available to monk seals for a very short period of time. However, fish have been demonstrated to be intoxicated with anticoagulant rodenticide that has entered the ocean directly or indirectly from spills and eradication projects (Primus et al. 2005, Pitt et al. 2015). In a 2015 placebo trial on the island of Lehua, 19 species of fish in the near shore environment consumed the baits (Mazurek 2015). However, post-application sampling of the near shore marine environment from 2 eradication projects in Hawaiʻi found no detectable levels of rodenticide in fish, invertebrates, or seawater (Orazio et al. 2009, Gale et al. 2008). Furthermore, because older Hawaiian monk seals typically forage in offshore areas, it would be unlikely they would prey on any fish or invertebrates that may have consumed rodenticide pellets. In the unlikely event a non-pup seal did forage in the near shore environment there would be a low probability that it would encounter a prey item that had consumed rodenticide.

Secondary Exposure

Hawaiian monk seals would only be at risk of secondary exposure to brodifacoum in the unlikely event that a very large quantity of bait was accidently dropped into the ocean, and fish or other prey items were able to consume it before ocean currents dissipated the spilled bait. However, a 220 lbs. (100 kg) juvenile seal would have to eat 22-88 lbs. (10-40 kg) of intoxicated fish to receive the calculated lethal doses. Hawaiian monk seals normally consume 5.8 to 12.9% of their body weight per day. For a 220 lbs. (100 kg) juvenile, that would correspond to around 13-28 lbs./day (6 to 13 kg/day). It is not likely that a seal would consume more than their daily food intake of contaminated fish. Because nursing and newly weaned pups remain near shore for extended periods, there is some risk of exposure for this age class.

Based on the above data, it would be unlikely that the Preferred Alternative would primarily or secondarily expose non-pup Hawaiian monk seals to a sufficient quantity of rodenticide to have any negative effects. There have been no documented cases of impacts to seals or sea lions after aerial bait application, including the 2009 rodenticide application on Lehua Island.

Operational Hazard (Noise/Human Disturbance)

Air and ground-based operations have the potential to cause Hawaiian monk seals to move or flush into the ocean. However, with a helicopter speed ranging from 29–58 mph (46-93 km/hr.) during each bait drop, even at the slowest airspeed the helicopter would take only 16 seconds to travel 656 ft. (200 m). Thus, disturbance would only last a few seconds. Therefore, these noise impacts would be short-lived and negligible, and have been determined as not likely to adversely affect. The level of disturbance for individuals is likely to be low since the disturbance would only occur at each site once or twice during each baiting application, which is believed not to pose a significant risk. The exception is during the pupping season. Although pups can be born at any month of the year, most pups are born between February and July, which is predominantly earlier than the proposed bait drop. There is little that can be done to mitigate this disturbance, but as only 3-4 animals pup on Sand Island each year, and most pupping would be completed before the baiting period, the disturbance would be short lived and minor.

We expect there will be no additional impacts to bottlenose and spinner dolphins but some possible additional impacts to Hawaiian monk seals should the need arise to implement the rapid response portion of the refuge's biosecurity plan and during implementation of this projects monitoring plan (see Appendix A and B). Biosecurity measures enacted would include rapid response to an incursion by non-native invasive terrestrial species and implementing the monitoring plan would include follow-up observations and sample collecting. Additional impacts to dolphins are not expected from implementation of the bio-security plan or from the additional human disturbance, since these will almost all occur in the terrestrial environment. However, some additional impacts such as disturbing basking seals and pupping activities could occur from these activities. Given the minimization measures that will be in place to protect the Hawaiian monk seal, we expect any additional impacts to be minor, localized, and short-term.

Mitigation

The same minimization measures outlined under marine fish would also minimize the amount of rodenticide entering the marine environment. In addition, all project personnel on the ground would maintain a 100 ft. (30.5 m) buffer from seals during operations. During aerial bait broadcast, helicopters would avoid hovering near Hawaiian monk seals and would avoid distributing pellets over seals on the shore. These mitigation measures would reduce impacts on Hawaiian monk seals. Indirect effects from the Preferred Alternative, particularly for non-pups, would be fairly unlikely.

The USFWS will consult with the Protected Species Division of NOAA, under Section 7 of the Endangered Species Act, to identify the best course of action to ensure protection of Hawaiian monk seals. This process will address monitoring protocols; bait application around seals; and a response plan in the unlikely event of finding a monk seal sick or dead during or following the operation.

3.3.6.21 Human Health and Safety

3.3.6.21.1 Existing Environment

A safe environment is one in which there is little or no potential for death or serious bodily injury or illness, or property damage. Human health and safety addresses: (*i*) workers' health and safety during project operations, and (*ii*) public safety during project operations. Project safety is managed via adherence to regulatory requirements imposed for the benefit of worker and public safety, and implementation of operational practices that reduce the potential for illness, injury, death, and property damage.

The health and safety of MANWR and PMNM workers are safeguarded by the numerous regulations designed to comply with standards promulgated by OSHA and the EPA. These standards specify the amount and type of training required for industrial workers, the use of protective equipment and clothing, engineering controls, and maximum exposure limits for workplace stressors. Compliance with OSHA and other applicable laws and regulations for the protection of employees is exclusively the obligation of the commercial contractor.

On Sand Island, MANWR, the various agencies and contractors have health and safety managers, and all personnel are reminded to focus on workers safety on an ongoing basis. This focus on health and safety is particularly important given the Atoll's remote and inaccessible location. There is a doctor and/or nurse practitioner on the Atoll at all times and that individual is on call 24-hours a day and 7 days a week in case of injury or illness.

All fuel deliveries operate in compliance with USFWS regulations and the *Midway Atoll Spill Prevention Control and Countermeasure Plan*.

Safety and accident hazards can often be anticipated, identified, and either reduced or eliminated. Necessary elements for an accident-prone situation or environment include:

- The presence of one or more hazards;
- The presence of an exposed population; and

- The absence of appropriately-observed safety procedures.

The degree of hazard is largely dependent on the proximity of the hazard to the exposed population. Activities that are innately hazardous include: (*i*) transportation; (*ii*) construction; (*iii*) maintenance and repair activities; (*iv*) training; and (*v*) noisy operations or environments. The proper operation, maintenance, and repair of vehicles and equipment are vital to creating a safe work environment. Extremely noisy environments can damage hearing and can also mask verbal or mechanical warning signals such as sirens, bells, or horns.

3.3.6.21.2 Aerial Operations Safety

Aircraft safety is based on the physical risks associated with aircraft flight, as well as operational procedures related to aircraft and aircraft maintenance safety. Weather conditions at MANWR are generally clear, with light trade winds for most of the year, interrupted by periodic rainstorms. Adverse weather conditions of concern during the time of year proposed for the Midway Seabird Protection Project include: (*i*) thunderstorms, (*ii*) hail, (*iii*) severe turbulence, (*iv*) wind shear, and (*v*) hurricanes. There are no obstructions, such as towers or electrical transmission lines and poles, which would cause a safety concern for helicopter operations on Sand Island, MANWR.

The extreme concentration of birds is also a concern for aircraft operations and would be taken into account in planning the exact timing of the eradication operation. In order to address this, MANWR has adopted a BASH Program that includes methods to reduce the risk of BASH using harassment techniques (such as pyrotechnics) under the terms of a USFWS permit. Per the terms of that permit, the airfield is inspected and the taxiway/runway area is cleared of birds prior to aircraft operations, which occur approximately twice per month. When needed based on the result of these inspections, a sweeper vehicle is used to prevent the accumulation of Foreign Object Debris (FOD) on the runway and taxiway.

3.3.6.21.3 Ground Operations Safety

Ground safety conditions on Sand Island, MANWR are subject to existing safety plans which incorporate and adhere to the requirements of OSHA and USFWS standards. All personnel working on Sand Island have attended a Basic Safety Course as part of their orientation when arriving on island, which includes lecture, discussion, and video materials intended to familiarize new arrivals with basic safety procedures and protocols. Periodically, a USFWS-designated Safety Officer will electronically disseminate messages, lessons, or other safety topics to all supervisors to be posted in work areas.

Safety signs, instructions, and safety bulletin boards with required OSHA material are posted throughout the work spaces on the Atoll. Many accidents occur as a result of improper tool usage, foot injuries from rough coral present on the Atoll, and the typical lacerations and contusions resulting from construction and demolition work. Safety information and materials are available onsite for all hazardous materials used on Sand Island, MANWR, and there is an active industrial hygiene program.

Emergency services such as police, fire, and emergency medical services are available on Sand Island, MANWR to allow for prompt response to emergencies, 24-hours per day. The Sand

Island Fire Station is located at Henderson Field Airport and is staffed by refuge workers qualified in firefighting. All firefighters are certified with 40-hour Hazardous Waste Operations and Emergency Response Standard training and serve as the MANWR Hazardous Materials Team. Available firefighting and emergency equipment include 2 crash trucks, a structure fire truck, a water tanker, a mini-pumper, a service truck, and an ambulance. One fire truck equipped with foam is on standby at the airfield. Fire hydrants are distributed across Sand Island to provide a firefighting water supply.

Sand Island, MANWR has a Physician's Assistant (PA) and a small clinic. The PA provides medical care to all personnel on the Atoll. In addition, the PA serves as the food inspector. In the event of a serious emergency, the patient would have to be airlifted off the island to Honolulu. Emergency medical evacuation services are provided by the U.S. Coast Guard.

3.3.6.21.4 Probable Impacts

If the implementation of the proposed action or alternatives were to substantially increase risks associated with the safety of personnel, contractors, or the contractor residences, or would substantially hinder the ability to respond to an emergency, it would represent a significant impact to safety on Sand Island, MANWR.

Under the proposed action, short-term minor safety risks are anticipated as a result of: (*i*) conducting aerial broadcast operations; (*ii*) conducting hand broadcast operations in compromised structures; and (*iii*) broadcasting a toxicant, in this case brodifacoum. Specific risks could include handling the brodifacoum, loading the bait hopper, and flying the helicopter. To address this, a USFWS contractor would be required to establish and maintain safety programs and comply with all guidelines for handling bait pellets and operating or maintaining aircraft. In addition, the Contractor would comply with all existing aviation, airfield, and installation safety procedures and standards.

Because the project involves the broadcast of a toxin, a potential short-term impact on safety on Sand Island, MANWR is the potential for accidental poisoning of staff and contractors. For the proposed action only USFWS and its Contractor would come in contact with brodifacoum. This contact with brodifacoum may occur in several ways, including:

- Direct consumption of bait by personnel unfamiliar with its appearance.
- Incidental consumption of bait through inadvertent contamination of food stocks with the toxin, whether through direct contact with bait or secondary transmission via rodent feces or urine.
- Secondary ingestion of the toxin through consumption of animals that were primary consumers of the bait.

While inadvertent consumption of brodifacoum by humans is unlikely, a small risk remains. The ingestion of 3.5 x 10-5 oz. (1 mg) of brodifacoum was reported to result in bleeding that persisted for more than 2 months. The average fatal dose for an adult man weighing 132 lbs. (60 kg) is estimated to be approximately 5.3 x 10-4 oz. (15 mg) of brodifacoum, or approximately 10.5 oz. (300 g) of bait (WHO, 1995). The brodifacoum concentration on the bait being proposed for use under the conservation label 0.0025 %, which would require that an adult ingest 1.3 lbs.

(600 g) of bait to achieve an average fatal dose; this would be equivalent to ingesting 600 bait pellets.

Symptoms of acute intoxication may be an increased tendency to bleed in less severe poisonings, to massive hemorrhages in more severe cases. The signs of poisoning develop with a delay of 1 to several days after ingestion. Both intentional and unintentional poisonings have been reported. To reach the toxic or lethal does, the nontarget animals must consume comparatively large amounts of bait with a concentration of 0.0025% of the active ingredient (i.e., brodifacoum). Treatment of brodifacoum poisoning includes the use of Vitamin K_1 to counter the effects. Physician-controlled Vitamin K_1 supplements would be available for all Sand Island, MANWR residents during and after the eradication operation.

Installation staff would be educated on the entire program and how to deal with operation mishaps, accidental release or poisoning, and transport of brodifacoum into non-target areas such as food stocks or drinking water. In addition, certain restrictions would be placed on residents during the proposed action, such as limiting the number of individuals authorized to come into contact with the bait to further mitigate the potential for inadvertent safety risks. Personnel would be advised to limit their outdoor activities on those days where bait is aerially applied along recommendations to wear long sleeves and long pants.

Procedures would also be implemented to protect potable water supplies (see Section 3.3.2).

Over the longer-term, the proposed action would have a beneficial effect on safety by eliminating an invasive pest species that can act as a disease vector, contaminate food supplies, and damage MANWR infrastructure.

CHAPTER 4: CUMULATIVE IMPACTS

4.1 CUMULATIVE IMPACTS

Federal agencies like the USFWS are required by NEPA to consider direct and indirect impacts of any actions taken, but also must consider the cumulative impacts of their actions. Cumulative impacts on environmental resources result from incremental effects of a proposed action, when combined with other past, present, and reasonably foreseeable future actions. Such impacts result from individually minor, but collectively substantial, actions undertaken over a period of time. Informed decision-making is elicited by consideration of cumulative impacts resulting from projects that are proposed, under construction, recently completed, or anticipated to be implemented.

There are no future actions on Sand Island that are likely to negatively impact the environment because the atoll is managed in perpetuity as a National Wildlife Refuge. Additionally, it should be noted that many species of MANWR may be experiencing unrelated impacts elsewhere in their extensive ranges, or they may still be recovering from severe past impacts. In addition, the potential numbers of individuals of a species that could be killed from either rodenticide poisoning or aircraft collisions are not cumulative, since if an individual is killed by a collision it is taken out of the population and would not be exposed to the rodenticide.

The following is a breakdown of the past, present, and foreseeable future actions that would likely contribute to the cumulative impacts associated with the 3 identified alternatives. Direct and indirect impacts from each alternative would be analyzed with the following list of activities to determine the cumulative impacts for a given alternative.

4.2 PAST ACTIONS

Past actions are actions that occurred in the past but have lasting impacts that could contribute to the impacts associated with the proposed action.

In the mid-1990s, the USFWS successfully eradicated black rats (*Rattus rattus*) from MANWR using bait stations with brodificoum and snap traps. In a study on brodifacoum bait residues before a rat eradication project on the island of Palmyra in 2011, residue concentrations decreased with time, and the toxicant was not detected in most of the 28, 36, and 50-day samples tested; and only trace amounts (≤0.2 ppm for brodifacoum) of the toxicant were detected in a few samples from these groupings. The results from the study show that following a broadcast of rodenticide across Palmyra’s emergent land area, only small amounts of brodifacoum remained in the islands topsoil for a short period of time. Given the short half-life of brodifacoum in soil, no cumulative effects from the previous attempt on MANWR are expected. Therefore, cumulative effects from this previous eradication are not expected and would not negatively contribute to the impacts from the proposed action.

In addition, other small mammal eradications that have already been conducted on islands throughout the world to conserve and protect nesting birds will likely have a cumulative beneficial effect on global seabird populations (Brooke at al. 2017), including some of the seabird species present at MANWR.

4.3 CURRENT ACTIONS

Current actions are actions that are occurring within the same timeframe as the proposed action, or within the planning and compliance phase of the proposed action and could contribute to the impacts from the proposed action.

4.3.1 PLANT RESTORATION AND INVASIVE WEED CONTROL

The USFWS is conducting a project to restore native plants to MANWR, along with eradicating invasive plants, including the ironwood tree and invasive plant *verbesina spp*. These 2 actions could positively contribute to the cumulative impacts of the proposed action by improving habitat for native species and contributing to the overall restoration of the atoll.

4.3.2 LEAD ABATEMENT

Studies conducted by USFWS and others at Sand Island between the late 1980s and 2009 have shown that Laysan albatross chicks exhibited symptoms of lead toxicity, and that their exposure is likely related to ingestion of lead-based paint (LBP) chips and soil contaminated with LBP chips. Buildings and structures on Sand Island, some of which date back to the early 1900s, are the primary source of the paint chips that contaminate the soil where the albatross nest. From 2005 to present, the USFWS has remediated all of the 95 buildings with LBP, with the total removal of all LBP from the interior, and the encapsulation of all lead-based paint on the exterior. This action contributes positively to the cumulative impacts of the proposed action by improving habitat for native species, decreasing mortality to seabirds, and contributing to the overall restoration of the atoll.

4.3.3 MARINE DEBRIS REMOVAL

On a continuing basis, NOAA Coral Reef Ecosystem Program has sent their marine debris team to remove tens of thousands of pounds of debris from MANWR. Funded by the NOAA Marine Debris Program and the NOAA Papahānaumokuākea Marine National Monument, the mission of the NOAA Marine Debris Program is to investigate and prevent the adverse impacts of marine debris. In 2016, crews collected 15,206 lbs. (6,897 kg) of debris from Midway beaches. This action would positively contribute to the cumulative impacts of the proposed action by improving habitat for native species, decreasing mortality to seabirds, and contributing to the overall restoration of the atoll.

4.3.4 MOUSE CONTROL/MANAGEMENT EFFORTS

MANWR currently implements several ongoing measures on Sand Island to control/manage the spread and impact of invasive house mice. These efforts are in commensal areas to maintain human health standards and are around the nests of breeding albatross to prevent predation and mortality of adults and chicks. Control measures in commensal areas include bait stations and multi-catch live-traps deployed around habitations, food stores, and at the dining hall, and in areas near buildings, man-made structures, at the airport, and on shipping docks receiving conveyances. To protect albatross, control measures are used in the winter months during the nesting season (November to February); these measures include bait stations and multi-catch live traps, as well as hand applications of rodenticide in areas where mouse attacks to albatross are documented. The Preferred Alternative of targeted mouse eradication on Sand Island would have a positive effect in that it would eliminate the need for these ongoing mouse control efforts.

4.4 FUTURE ACTIONS

Future actions include actions that are reasonably foreseeable in the future, and that could contribute to the cumulative impacts from the proposed action.

The U.S. Fish and Wildlife Service and the Federal Aviation Administration (FAA) propose to conduct repairs as needed over a ten year period (2018-2027) along a 5,720-foot-long seawall located on Midway Atoll's Sand Island in order to protect Henderson Field and to control erosion of wildlife habitat along the southeast side of Sand Island. The proposed seawall repair project which is currently being planned would not contribute to additional, cumulative impacts when considered in combination with the proposed Midway Seabird Protection Project. There is not expected to be any persisting effects of the Midway Seabird Protection Project at the time that the seawall project is implemented and whatever impacts result from the seawall project will not "accumulate" with any impacts of the Midway Seabird Protection Project.

Areas of impact linked to future global climate change, which may have the potential to affect MANWR, include warmer air temperatures and declines in rainfall (University of Hawai'i 2014).

In addition, other small mammal eradications being planned on islands throughout the world to conserve and protect nesting birds will likely have a cumulative beneficial effect on global seabird populations as has been shown by Brooke at al. (2017).

4.5 PROBABLE CUMULATIVE IMPACTS

4.5.1 NO ACTION ALTERNATIVE

Under the no-action alternative, the current negative impacts of mice on MANWR's seabird populations and terrestrial ecosystem would continue in perpetuity. These impacts could be additive to other, unrelated future impacts on the resources of MANWR. The minor impacts that ongoing projects (primarily conservation-related) would have on the biological, physical, and cultural resources of MANWR are not likely to contribute to mice-related impacts. If mice persist on Sand Island, the biological resources of the island would continue to be negatively affected.

Under the No Action Alternative, Sand Island's mouse population would not be the subject of a targeted eradication project, but mouse control efforts to protect breeding albatross, which were started in 2016, would continue and expand as deemed appropriate. Mouse management on Sand Island currently consists of (*i*) trapping and rodenticide bait stations containing AGRID3 (active ingredient cholecalciferol) for human health and safety in commensal areas such as food storage and preparation areas, as well as in areas near buildings, man-made structures, at the airport, and on shipping docks receiving conveyances; and (*ii*) multi-catch live trapping, and rodenticide bait stations and hand broadcasting of AGRID3 for seabird and listed candidate plant protection in areas where mouse predation of seabirds and mouse damage to listed or candidate plants are detected. Trapping (*i*) includes multi-catch live traps and mechanical traps (snap-traps and glue boards) used in the commensal environment as deemed appropriate per the terms of each structure's SMP (see Section 2.3.1). Hand broadcasting (*ii*), which is extremely labor and time intensive, involves 2 separate hand-broadcast applications of AGRID3 pellets approved for restricted use at MANWR under a supplemental label for mouse control. Per label instructions, a 17 lbs./ac. (20 kg/ha) application rate is used over 27.2 ac. (11 ha) where evidence of mouse attacks occurred in 2016. The second application (same rate, same area) occurs in the month of November prior to the albatross's main egg laying season, and then only as needed if and where there were mouse attacks throughout the incubation period, up until the following February. There were no observations of any non-target organism, such as shorebirds or Laysan ducks, interacting with bait pellets in the field, or being found sick or dead in the colony as a result of the baiting process (USFWS, Unpublished b). Both control measures, (*i*) and (*ii*), are ongoing. The proposed action of targeted mouse eradication on Sand Island would have a positive effect in that it would eliminate the need for these ongoing control efforts.

4.5.2 PREFERRED ALTERNATIVE

There would be no major adverse impacts to the biological, physical, or cultural resources of Sand Island under the Preferred Alternative. The minor negative impacts to biological, physical, and cultural resources as a result of the Preferred Alternative would not contribute to the impacts related to any separate, current, or future projects. Similarly, the expected positive impacts of the Preferred Alternative to Sand Island's biological resources could contribute to the cumulative, positive impacts from separate, current, or future projects.

CHAPTER 5: LIST OF PREPARERS AND CONTRIBUTORS

5.1 PREPARERS

Table 5.1 below identifies the principal agencies, organizations, and individuals that participated in the preparation of this report.

Table 5.1 Principal Prepares of this Environmental Assessment

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Source: Compiled by Hamer Environmental (2017)	

5.2 CONTRIBUTORS

Table 5.2 below identifies the agencies, organizations, and individuals that contributed critical information for the development of this report.

Table 5.2 Contributors to this Environmental Assessment

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CHAPTER 6: REFERENCES

ACAP. 2012a. Black-footed Albatross *(Phoebastria nigripes)*. Agreement on the Conservation of Albatrosses and Petrels [cited September 2017]. Available from http://www.acap.aq/en/acap-species.

---. 2012b. Laysan Albatross *(Phoebastria immutabilis)*. Agreement on the Conservation of Albatrosses and Petrels [cited September 2017]. Available from http://www.acap.aq/en/acap-species.

Alifano, A., A. Wegmann, B. Puschner, and G. Howald. 2012. "Migration of Brodifacoum and Diphacinone from Bait Pellets into Topsoil at Palymyra Atoll National Wildlife Refuge. *In* Proc. 25th Vertebrate Pest Conference, edited by R.M. Timm: University of California, Davis. Pp. 139-143.

Amarasekare, P. 1994. "Ecology of Introduced Small Mammals on Western Mauna Kea, Hawai'i." J. Mammal. 75:24-38.

Amerson, A.B., Jr., R.B. Clapp, and Wirtz. W.O. 1974. "The natural history of Pearl and Hermes Reef, Northwestern Hawaiian Islands." Atoll Res Bull 174:1-306.

Andrews, C. 1909. "On the fauna of Christmas Island." *Proceedings of the Zoological Society of London*:101-103.

Angel, A., R.M. Wanless, and J. Cooper. 2009. "Review of impacts of the introduced house mouse on islands in the Southern Ocean: are mice equivalent to rats." *Biological Invasions* 11:1743-1754.

Apfelbaum, S.I., J.P. Ludwig, and C.E. Ludwig. 1983. Ecological problems associated with disruption of dune vegetation dynamics by *Casuarina equisetifolia L.* at Sand Island, Midway Atoll. Washington DC: Smithsonian Institution.

Arata, J. A., Sievert P.R., and M.B. Naughton. 2009. Status assessment of Laysan and black-footed albatrosses, North Pacific Ocean, 1923-2005. http://www.iucnredlist.org/details/biblio/22698365/0.

Ashmole, N.P., and M.J. Ashmole. 1967. Comparative feeding ecology of seabirds of a tropical oceanic island. Peabody Museum Bulletin 24: 1-131.

Atkinson, I. 1985. "The spread of commensal species of Rattus to oceanic islands and their effects on island avifaunas." In *Conservation of Island Birds*, edited by P. J. Moors, pp 35-81. International Council for Bird Preservation: Cambridge, UK.

Avenant, N.L., and V.R. Smith. 2003. "The microenvironment of house mice on Marion Island (sub-Antarctic)." Polar Biology 26:129-141.

Baker, H., P.E. Baker, and N. Seto. 1999. "Common Myna on Midway Atoll NWR, 1996." 'Elepaio 59:17-19.

Bamford, M., D. Watkins, W. Bancroft, G. Tischler, and J. Wahl. 2008. Migratory Shorebirds of the East Asian - Australasian Flyway; Population Estimates and Internationally Important Sites. Canberra, Australia: Wetlands International - Oceania.

BirdLife International. 2015. *Bubulcus ibis*. The IUCN Red List of Threatened Species [cited 06 October 2017].

---. 2016a. *Numenius tahitiensis*. The IUCN Red List of Threatened Species [cited 07 Oct 2017]. Available from http://dx.doi.org/10.2305/IUCN.UK.2016-3.RLTS.T22693182A95218288.en.

---. 2016b. *Serinus canaria*. The IUCN Red List of Threatened Species [cited 08 October 2017]. Available from http://dx.doi.org/10.2305/IUCN.UK.2016-3.RLTS.T22720056A88429138.en.

Birkeland, C., and D. Grosenbaugh. 1985. Ecological interactions between tropical coastal ecosystems. United Nations Environmental Program.

Blackburn, T.M., P. Cassey, R.P. Duncan, K.L. Evans, and Gaston. K.J. 2004. "Avian extinction and mammalian introductions on oceanic islands." *Science* 305:1955-1958.

Booth, L.H., F. Fisher, V. Heppelthwaite, and C.T. Eason. 2003. Toxicity and residues of brodifacoum in snails and earthworms. In Doc Science Internal Series Wellington, New Zealand: Department of Conservation.

Bremner, A., C. Butcher, and G. Patterson. 1984. "The density of indigenous invertebrates on three islands in Breaksea Sound, Fiordland, in relation to the distribution of introduced mammals." *Journal of the Royal Society of New Zealand* 14:379-386.

Brooke, M. de L. 2004. *Albatrosses and petrels across the world*. New York, N.Y.: Oxford University Press. 499 pp.

Brooke, M., E. Bonnaud, B.J. Dilley, E.N. Flint, N.D. Holmes, H.P. Jones, P. Provost, G. Rocamora, P.G. Ryan, C. Surman, and R.T. Buxton. 2017. "Seabird population changes following mammal eradications on islands." Animal Conservation. doi: 10.1111/acv.12344.

Broome, K.G., A. Cox, C. Golding, P. Cromarty, P. Bell, and P. McClelland. 2014. Rat eradication using aerial baiting: Current agreed best practice used in New Zealand (Version 3.0). New Zealand Department of Conservation internal document: Wellington, New Zealand.

Brown, P.R., and G.R. Singleton. 1999. "Rate of increase as a function of rainfall for house mouse Mus domesticus populations in a cereal-growing region in southern Australia." Journal of Applied Ecology 36 (4):484-493. doi: 10.1046/j.1365-2664.1999.00422.x.

Bruegmann, M. 1998. Report on a botanical survey of Midway Atoll, April 1-7, 1995. Honolulu, HI: U.S. Fish and Wildlife Service Report.

Bryan, W.A. 1905. "Notes on the American birds collected in the Hawaiian Islands by Mr. Gerrit Wilder." Occas. Pap. B. P. Bishop Mus. 2:245-248.

Buckelew, S., Howald G.R., Wegmann A., Sheppard J., Curl J., McClelland P., Tershy B., Swift K., Campbell E., and Flint B. 2005. Progress in Palmyra Atoll restoration: rat eradication trial, 2005. Island Conservation unpublished report: Santa Cruz, CA. 50 pp.

Bullock, D. 1986. "The ecology and conservation of reptiles on Round Island and Gunner's Quoin, Mauritius." *Biological Conservation* 37:135-156.

Buckle, A.P., and R. Smith. 2015. *Rodent pests and their control*. 2nd ed. CAB International: Oxfordshire, UK.

Byrd, G.V. 1979. “Common Myna predation on Wedge-tailed Shearwater eggs.” *`Elepaio* 39:69-70.

Campbell, D., and I. Atkinson. 2002. “Depression of tree recruitment by the Pacific rat (*Rattus exulans peale*) on New Zealand's northern offshore islands.” *Biological Conservation* 107 (19-35).

Campbell, D., H. Moller, G.W. Ramsay, and J. Watt. 1984. “Observations on food of kiore (*Rattus exulans*) found in husking stations on northern offshore islands of New Zealand.” *New Zealand Journal of Ecology* 7:131-138.

Campbell, E. 1991. “The effects of introduced roof rats on bird diversity of Antillean Cays.” *Journal of Field Ornithology* 62:343-348.

Chardine, J.W., and R.D. Morris. 1996. Brown Noddy (*Anous stolidus*), version 2.0. In *The Birds of North America*, edited by P. G. Rodewald. Cornell Lab of Ornithology: Ithaca, New York, USA. https://doi.org/10.2173/bna.220.

Christophersen, E., and E.L. Caum. 1931. "Vascular plants of the Leeward Islands, Hawai'i." Bernice P. Bishop Museum Bul 81:41.

Clapp, R.B., and W.O. Wirtz, II. 1975. "The natural history of Lisianski Island, Northwestern Hawaiian Islands." Atoll Res. Bull. 186:1-196.

Collar, N.J., L.P. Gonzaga, N. Krabbe, A.M. Nieto, L.G. Naranjo, T. A. P. III, and D.C. Wege. 1992. *Threatened Birds of the Americas*, *The ICBP/IUCN Red Data Book, Part 2. Third edition*. Smithsonian Institution Press: Washington, DC.

Conant, S., C.C. Christiansen, P. Conant, W.C. Gagne, and M.L. Goff. 1983. The Unique Terrestrial Biota of the Northwestern Hawaiian Islands. Proceedings of the Second Symposium on Resource Investigations in the Northwestern Hawaiian Islands, at Honolulu, HI. pp 491.

Cree, A., C. Daughtery, and J.M. Hay. 1995. “Reproduction of a rare New Zealand reptile, the tuatara Sphenodon punctatus on rat-free and rat-inhabited islands.” *Conservation Biology* 9:373-383.

Cromarty, P. L., K.G. Broome, A. Cox, R.A. Empson, W.M. Hutchinson, and I. McFadden. 2002. “Eradication planning for invasive alien animal species on islands - the approach developed by the New Zealand Department of Conservation.” In *Turning the Tide: The Eradication of Invasive Species*, edited by C. R. Veitch and M. N. Clout, pp 85-91. IUCN SSC Invasive Species Specialist Group, Gland: Switzerland and Cambridge, UK.

Daniel, M., and G. Williams. 1984. “A survey of the distribution, seasonal activity and roost sites of New Zealand bats.” *New Zealand Journal of Ecology* 7:9-25.

Day, T.R., and L.R. Matthews. 1999. "Do colours that deter birds affect cereal bait acceptance by possums (*Trichosurus vulpecula*)." *New Zealand Journal of Ecology* 23.

de Bruyn, P.J.N., A.D.S. Bastos, C. Eadie, C.A. Tosh, and M.N. Bester. 2008. "Mass Mortality of Adult Male Subantarctic Fur Seals: Are Alien Mice the Culprits." *PLoS ONE* 3 (11):e3757. doi: 10.1371/journal.pone.0003757.

Delany, S., and D. Scott. 2006. *Waterbird population estimates*. Wetlands International. Wageningen, The Netherlands.

DIISE. 2016. *Database of Island Invasive Species Eradications*. Available from http://diise.islandconservation.org.

Donlan, C.J., G. Howald, B. Tershy, and D. Croll. 2003. "Evaluating alternative rodenticides for island conservation: roof rat eradication from the San Jorge Islands, Mexico." *Biological Conservation* 114:29-34.

Drost, C.A., and G.M. Fellers. 1991. "Density Cycles in an Island Population of Deer Mice, *Peromyscus maniculatus*." Oikos 60 (3):351-364. doi: 10.2307/3545078.

Duncan, R., and T. Blackburn. 2007. "Causes of extinction in island birds." *Animal Conservation Biology* 10:149-150.

DuhrSchultz, M., B. Flanders, G. Howald, E.N. Flint, D. Norwood, R. Taylor, S.A. Hunter. In Press. Interim Control of House Mice Preying on Adult Albatrosses at Midway Atoll Prior to an Eradication Attempt.

Eason, C., and E. Spurr. 1995. "Review of the toxicity and impacts of Brodifacoum on nontarget wildlife in New Zealand." *New Zealand Journal of Zoology* 22:371-379.

Eason, C., and M. Wickstrom. 2001. *Vertebrate Pesticide Toxicology Manual (Poisons), Technical Series 23*. Wellington, New Zealand. 120pp.

Eason, C.T., M. Wickstrom, R. Henederson, L. Milne, and D. Arthur. 2000. "Non-target and secondary poisoning risks associated with cholecalciferol." *New Zealand Plant Protection* 53:299-304.

Eijzenga, H. 2011. Vegetation change following rabbit eradication on Lehua Island, Hawaiian Islands. Island invasives: eradication and management, at IUCN, Gland, Switzerland. pp 290-294.

Eisemann, J.D., and C.E. Swift. 2006. "Ecological and human health hazards from broadcast application of 0.005% diphacinone rodenticide baits in native Hawaiian ecosytems." *Proceedings of the Vertebrate Pest Conference* 22:413-433.

Ely, C.A., and R.B. Clapp. 1973. "The natural history of Laysan Island, Northwestern Hawaiian Islands.". Atoll Res. Bull. 171:1-361.

Empson, R.A., and C.M. Miskelly. 1999. "The risks, costs and benefits of using Brodifacoum to eradicate rats from Kapiti Island, New Zealand." *New Zealand Journal of Ecology* 23:241-254.

Engilis, Jr., A., and M.B. Naughton. 2004. U.S Pacific Islands Regional Shorebird Conservation Plan. In *U.S. Shorebird Conservation Plan*. Portland, OR: U.S. Department of the Interior, Fish and Wildlife Service.

Engeman, R., W.C. Pitt, A.R. Berentsen, and J.D. Eisemann. 2013. Assessing spatial variation and overall density of aerially broadcast toxic bait during a rat eradication on Palmyra Atoll. USDA National Wildlife Research Center Staff Publications 2013. Available from http://digitalcommons.unl.edu/icwdm_usdanwrc/1131.

Erickson, W., and D. Urban. 2004. Potential risks of nine rodenticides to birds and nontarget mammals: a comparative approach. Edited by Pesticides Programs U.S. Environmental Protection Agency. Environmental Fate and Effects Division: Washington, DC.

European Parliament and Council. 2010. Brodifacoum (PT 14) Assessment report. Standing Committee on Biocidal Products. Directive 98/8/EC concerning the placing of biocidal products on the market. 365 pp.

Fisher, H.I. 1949. "Populations of birds on Midway and the man-made factors affecting them." Pacific Science 3:103-110.

Fisher, H.I., and M.L. Fisher. 1969. "The visits of Laysan Albatrosses to the breeding colony." *Micronesia* 5 (1):173-221.

Fisher, P., C. O'Connor, G. Wright, and C. Eason. 2003. Persistence of four anticoagulant rodenticides in the livers of laboratory rats. DOC Science Internal Series 139. New Zealand Department of Conservation: Wellington, NZ.

Fleet, R.R. 1974. "The Red-Tailed Tropicbird on Kure Atoll." *Ornithological Monographs*. 16:1-64.

Fukami, T., D. Wardle, P. Bellingham, C. Mulder, D. Towns, G. Yeates, K. Bonner, M. Durrett, M. Grant-Hoffman, and W. Williamson. 2006. "Above- and below-ground impacts of introduced predators in seabird-dominated island ecosystems." *Ecology Letters* 9 (1299-1307).

Gale, R.W., M. Tanner, and C.E. Orazio. 2008. Determination of Diphacinone in Sea Water, Vertebrates, Invertebrates, and Bait Pellet Formulations Following Aerial Broadcast on Mokapu Island, Molokai, Hawai'i. edited by U.S. Geological Survey Open-File Report 2008-1285.

Gattuso, J.P., M. Frankignoulle, I. Bourge, S. Romaine, and R.W. Buddemeier. 1998. "Effect of calcium carbonate saturation of seawater on coral calcification." *Global and Planetary Change* 18:37-46.

Gauger Metz, V.H., and E.A. Schreiber. 2002. Great Frigatebird (*Fregata minor*). In *The Birds of North America*, edited by P. G. Rodewald. Cornell Lab of Ornithology: Ithaca, New York, USA. https://doi.org/10.2173/bna.681.

Gauger, V.H. 1999. Black Noddy (Anous minutus). Version 2.0. Available from https://doi.org/10.2173/bna.412.

GeoEngineers, Inc. 2011. Engineering Evaluation/Cost Analysis, Midway Atoll National Wildlife Refuge, Midway Island. In RG for U.S. Fish and Wildlife Service. Prepared by Joey F. Hickey, Neil F. Morton, and John H. Biggane: January 18, 2011.

Gill, R., R. Lanctot, J. Mason, and C. Handel. 1990. "Observations on habitat use, breeding chronology, and parental care in bristle-thighed curlews on the Seward Peninsula, Alaska." *Wader Study Group Bulletin* 61:28-36.

Gill, R.E., B.J. McCaffery, and P.S. Tomkovich. 2002. Wandering Tattler (*Tringa incana*). version 2.0. Cornell Lab of Ornithology. Available from https://doi.org/10.2173/bna.642.

Godwin, S. 2013. Inventory of shoreline and shallow subtidal marine invertebrates at proposed seawall repair site - Midway Atoll runway. Prepared for: Midway Atoll National Wildlife Refuge: U.S. Fish and Wildlife Service: NOAA-NOS-ONMS. Resource Protection Program, Papahānaumokuākea Marine National Monument. 12 pp.

Goodale, K. 2017. Shorebird survey methodology, Midway Atoll. USFWS. Honolulu, HI. Unpublished data.

Gross, A.O., J.M. Moulton, and C.E. Huntington. 1963. Notes on the Wedge-tailed Shearwater at Heron Island, Great Barrier Reef, Australia. In *Atoll Research Bulletin*, No. 99. Washington, D.C.: The Pacific Science Board, National Academy of Sciences - Natural Research Council.

HDLNR. 2015. Hawaiʻi's State Wildlife Action Plan. Prepared by H. T. Harvey and Associates, Honolulu, HI: Hawaiʻi Department of Land and Natural Resources.

Hoare, J., and K. Hare. 2006. "The impact of Brodifacoum on non-target wildlife: gaps in knowledge." *New Zealand Journal of Ecology* 30:157-167.

Holway, D.A., L. Lach, A.V. Suarez, N.D. Tsutsui, and T.J. Case. 2002. "The Causes and Consequences of Ant Invasions." *Annu. Rev. Ecol. Syst.* 33:181-233.

Howald, G., A. Samaniego, S. Buckelew, P. McClelland, B. Keitt, A. Wegmann, W. Pitt, D. Vice, E. Campbell, K. Swift, and S. Barclay. 2004. Palmyra Atoll rat eradication assessment trip report August 2004. Island Conservation: Santa Cruz, CA.

Howald, G., C.J. Donlan, J.P. Galván, J. Russell, J. Parkes, A. Samaniego, Y. Wang, D. Veitch, P. Genovesi, M. Pascal, A. Saunders, and B. Tershy. 2007. "Invasive rodent eradication on islands." *Conservation Biology* 21:1258-1268.

Howald, G., C.J. Donlan, K.R. Faukner, S. Ortega, H. Gellerman, D.A. Croll, and B.R. Tershy. 2009. "Eradication of black rats Rattus rattus from Anacapa Island." *Oryx* 44:30-40.

Howald, G.R., K. Faulkner, B.R. Tershy, B.S. Keitt, H. Gellerman, E.M. Creel, M. Grinnell, S. Ortega, and D.A. Croll. 2005. Eradication of Black Rats from Anacapa Island: Biological and Social Considerations. Proceedings of the Sixth California Islands Symposium, at Ventura, CA, December 1-3, 2003. pp 299-312.

Howald, G.R., P. Mineau, J.E. Elliot, and K.M Cheng. 1999. "Brodifacoum Poisoning of Avian Scavengers During Rat Control on a Seabird Colony." *Ecotoxicology* 8:431-447.

Howell, T.R. 1978. "Ecology and reproductive behavior of the White, or Fairy, Tern." In *Ecology and reproductive behaviour of the Gray Gull and of the Red-tailed Tropicbird and the White Tern on Midway Island*, pp 274-284. Natl. Geogr. Soc. Res. Rep.

Hutton, J.C., M. Pershavaria, and K.W. Brocklehurst. 1984. Biochem. J. 224:483-490.

IUCN. 2017*a*. *The IUCN Red List of Threatened Species* (Version 2017-1) [cited 27 Sept 2017].

---. 2017*b*. *Phoebastria immutabilis (amended version published in 2016)* [cited 05 Oct 2017].

Island Conservation. 2017. Feasibility Report: House Mouse Eradication on Midway Atoll National Wildlife Refuge. Report prepared for the U.S. Fish and Wildlife Service. 69 pp.

Johnsgard, P.A. 1981. Bustards, Hemipodes, and Sandgrouse; birds of dry places. Oxford University Press: London.

Johnson, O.W., and P.G. Connors. 2010. Pacific Golden-Plover *(Pluvialis fulva), version 2.0.* Cornell Lab of Ornithology. Available from https://doi.org/10.2173/bna.202.

Jouventin, P., J. Bried, and T. Micol. 2003. “Insular bird populations can be saved from rats: a long-term experimental study of White-chinned Petrels *Procellaria aequinoctialis* on Ile de la Possession (Crozet archipelago).” *Polar Biology* 26:371-378.

Kannan, R., and D.A. James. 2001. "Common Myna." Birds N. Am. 58:1-20.

Kaukeinen, D.E. 1993. Nontarget Organism Evaluations for Rodenticides. In Pesticides in Urban Environments. American Chemical Society. Pp 352-363.

Keitt, B., R. Griffiths, S. Boudjelas, K. Broome, S. Cranwell, J. Millett, W. Pitt, and A. Samaniego-Herrera. 2015. “Best practice guidelines for rat eradication on tropical islands.” *Biological Conservation* 185:17-26. doi:10.1016/j.biocon.2014.10.014.

Kepler, A., and C. Kepler. 1994. “Natural history of Caroline Island. Part I: History, physiography, botany, and isle description.” *Atoll Research Bulletin* 397:1-225.

Kessel, B. 1989. Birds of the Seward Peninsula, Alaska. University of Alaska: Fairbanks, AK.

Klavitter, J.L. 2004. Midway Atoll National Wildlife Refuge Wildlife Assessment for Henderson Field Airport Operations. Honolulu, HI: USFWS Midway Atoll National Wildlife Refuge.

---. 2103. Supplemental marine shallow subtidal observations at the proposed seawall repair site - Midway Atoll National Wildlife Refuge Henderson Field Runway. Midway Atoll National Wildlife Refuge, U.S. Fish and Wildlife Service.

Kurle, C.M., D.A. Croll, and B.R. Tershy. 2008. “Introduced rats indirectly change marine rocky intertidal communities from algae- to invertebrate-dominated.” *PNAS* 105:3800-3804.

Lindsey, G.D., and S.M. Mosher. 1994. "Tests indicate minimal hazard to 'io from diphacinone baiting." *Hawaii's Forests and Wildlife* 9 (4).

Mackay, J.W.B. 2011. *Improving the success of mouse eradication attempts on islands*, PhD diss., The University of Auckland, Auckland, New Zealand.

Macwhirter, R.B., P. Austin-Smith Jr., and D.E. Kroodsma. 2002. Sanderling *(Calidris alba), version 2.0.* Cornell Lab of Ornithology. Available from https://doi.org/10.2173/bna.653.

Marks, J.S. 1993. “Molt of Bristle-thighed Curlews in the northwestern Hawaiian Islands.” *Auk* 110:573-587.

Marks, J.S., and R. Redmond. 1994. "Conservation problems and research needs for Bristle-thighed Curlews Numenious tahitiensis on their wintering grounds." Bird Conserv. Int. 4:329-341.

---. 1996. “Demography of bristle-thighed curlews, *Numensius tahitiensis*, wintering on Laysan Island.” *Ibis* 138:438-447.

Marks, J.S., R.L. Redmond, P. Hendricks, R.B. Clapp, and R.E. Jr. Gill. 1990. “Notes on longevity and flightlessness in Bristle-thighed Curlews.” *Auk* 107:779-781.

Marks, J.S., R. Tibbitts, R.E. Gill Jr., and B.J. McCaffrey. 2002. Bristle-thighed curlew *(Numensius tahitiensis).* Cornell Lab of Ornithology [cited September 2017]. Available from http://bna.birds.cornell.edu/bna/species/705.

Marshall, E.F. 1984. Cholecalciferol: a Unique Toxicant for Rodent Control. Vertebrate Pest Conference Proceedings collection.

Masuda, B.M., P. Fisher, and B. Beaven. 2015. "Residue profiles of brodifacoum in coastal marine species following an island rodent eradication." Ecotoxicol. Environ. Saf. 113:1-8. doi: 10.1016/j.ecoenv.2014.11.013.

Mazurek, M. 2015. Lehua Island Inert Bait Study September 2015 Final Report. Honolulu, HI: Island Conservation.

McCaffery, B., and G. Pelota Jr. 1986. "The status of the bristle-thighed curlew on the Yukon Delta National Wildlife Refuge, Alaska." *Wader Study Group Bulletin* 47:22-25.

McClelland, P. 2002. Eradication of Pacific rats (*Rattus exulans*) from Whenua Hou Nature Reserve (Codfish Island), Putauhinu and Rarotoka Islands, New Zealand. Turning the tide: the eradication of invasive species. IUCN SSC Invasive Species Specialist Group, at Gland, Switzerland and Cambridge, UK, IUCN. Pp 173-181.

Megyesi, J.L., and C.R Griffin. 1996. "Brown Noddy Chick Predation by Great Frigatebirds in the Northwestern Hawaiian Islands." *Condor* 98 (2):322-327. doi: 10.2307/1369150.

Merton, D. 1987. "Eradication of rabbits from Round Island, Mauritius, a conservation success story." Dodo. Journal of Jersey Wildlife Preservation Trust 24.

Merton, D., G. Climo, V. Laboudallon, S. Robert, and C. Mander. 2002 of Conference. Alien mammal eradication and quarantine on inhabited islands in the Seychelles. Pgs. 182-198 *in* Turning the tide: The eradication of invasive species. Proceedings of the International Conference on Eradication of Island Invasives. Occ. Paper of the IUCN Species Survival Commission, No. 27, Report, at Gland, Switzerland and Cambridge, UK.

Mitchell, C., C. Ogura, D. W. Meadows, A. Kane, L. Strommer, S. Fretz, D. Leonard, and A. McClung. 2005. Hawai‘i's comprehensive wildlife conservation strategy. Honolulu, HI: Department of Land and Natural Resources. 722 pp.

Morrell, T.E., and S.M. Aquilani. 2000. "Nest-site characteristics of Red-tailed Tropicbirds on Rose Atoll, American Samoa." *Journal of Field Ornithology* 71 (3):455-459.

Moulton, D.W., and A.P. Marshall. 1996. Laysan Duck (*Anas laysanensis*), version 2.0. In *The Birds of North America*, edited by P. G. Rodewald. Cornell Lab of Ornithology: Ithaca, New York, USA. https://doi.org/10.2173/bna.705.

Moulton, D.W., and M.W. Weller. 1984. "Biology and conservation of the Laysan Duck (*Anas laysanensis*)." Condor 86:105-117.

NMFS. 1998. Recovery plan for the US Pacific populations of green turtles (*Chelonia mydas*). Edited by National Marine Fisheries Service. U.S. Fish and Wildlife Service: Silver Spring, MD.

NMFS and NOAA. 2007. Recovery Plan for the Hawaiian Monk Seal (*Monachus schauinslandi*). National Marine Fisheries Service, National Oceanic and Atmospheric Administration: Honolulu, HI. 165 pp.

NMFS and USFWS. 1998. Recovery plan for the US Pacific populations of green turtles (*Chelonia mydas*). National Marine Fisheries Service, U.S. Fish and Wildlife Service: Silver Spring, MD.

NOAA CREP. 2008. Coral Reef Ecosystem Program. NOAA Fisheries, Pacific Islands Fisheries Science Center [cited October 2017]. Available from https://www.pifsc.noaa.gov/cred/.

NOAA Fisheries Service. 2011a. Green Turtle (*Chelonia mydas*). Office of Protected Fisheries: Silver Spring, MD.

---. 2011b. Hawksbill Turtle (*Eretmochelys imbricata*). Office of Protected Fisheries: Silver Spring, MD.

Naughton, M.B, M.D. Romano, and T.S. Zimmerman. 2007. A Conservation Action Plan for Black-footed Albatross (*Phoebastria nigripes*) and Laysan Albatross (*P. immutabilis*). http://www.iucnredlist.org/details/biblio/22698350/0.

Navarrete, S.A., and J.C. Castilla. 1993. "Predation by Norway rats in the intertidal zone of Central Chile." Mar. Ecol. Prog. Ser. 92:187-199. doi: 10.3354/meps092187.

Neff, J.A., and P.A. DuMont. 1995. "A partial list of the plants of the Midway Islands." Atoll Research Bulletin. The Smithsonian Institution, Washington D.C. 45 (12):12.

Nettleship, D.N. 2000. Ruddy Turnstone *(Arenaria interpres), version 2.0.* Cornell Lab of Ornithology. Available from https://doi.org/10.2173/bna.537.

Niering, W.A. 1963. "Atoll Geography and Ecology." Ecology 44 (2). doi: 10.2307/1932200.

Niethammer, K.R., and L.B. Patrick. 1998. White Tern *(Gygis alba), version 2.0.* Cornell Lab of Ornithology. Available from https://doi.org/10.2173/bna.371.

Nishida, G.M., and J.W. Beardsley. 2002. "A Review of the Insects and Related Arthropods of Midway Atoll." *Bish. Mus. Occas. Pap.* 68:25-69.

Ogden. 1994. Report on lead based paint (LBP) and asbestos survey of all structures on Eastern and Sand Islands. Ogden Environmental and Energy Service.

---. 1996. NAF Midway Island Abbreviated RI Report (Draft) for the Active and Abandoned Housing Areas. Ogden Environmental and Energy Service.

---. 1997. Base Realignment and Closure (BRAC) Cleanup Plan: Environmental status of NAF Midway Atoll as of 1996. Ogden Environmental and Energy Service.

Oppel, S., J.L. Lavers, A.L. Bond, and G. Harrison. 2016. "Reducing the primary exposure risk of Henderson crakes (*Zapornia atra*) during aerial broadcast eradication by selecting appropriate bait colour." *Wildlife Research*.

Orazio, C.E., M.J. Tanner, C. Swenson, J. Herod, P. Dunlevy, and Gale G.W. 2009. Results of Laboratory Testing for Diphacinone in Seawater, Fish, Invertebrates, and Soil Following Aerial Application of Rodenticide on Lehua Island, Kauai County, Hawai'i. U.S. Geological Survey Open-File Report 2009-1142.

Pain, D.J., D.de L. Brooke, J.K. Finnie, and A. Jackson. 2000. "Effects of brodifacoum on the land crab of Ascension Island." Journal of Wildlife Management 64 (2).

Parkes, J., P. Fisher, and G. Forrester. 2011. "Diagnosing the cause of failure to eradicate introduced rodents on islands: brodifacoum versus diphacinone and method of bait delivery." *Cons. Evidence* 8:100-106.

Parkes, J. 2014. "Eradication of house mice *Mus musculus* from Marion Island: a review of feasibility, constraints and risks." In *BirdLife South Africa Ocassional Report Series No. 1*. Edited by R.M. Wanles, pp 27. Birdlife South Africa: Johannesburg, South Africa.

Parsons, J. 1962. The Green Turtle and Man. University of Florida Press: Gainesville, FL.

Pierce, R., N. Anterea, U. Anterea, K. Broome, D. Brown, L. Cooper, H. Edmonds, F. Muckle, B. Nagle, G. Oakes, M. Thorsen, and G. Wragg. 2008. Operational work undertaken to eradicate rats and rabbits in the Phoenix Islands, Republic of Kiribati, May-June 2008. Pacific Expeditions Ltd.

Pitt, W. C., A. R. Berentsen, S. F. Volker, and J. D. Eisemann. 2012. Palmyra Atoll Rainforest Restoration Project: Monitoring Results for the Application of Broadcast of Brodifacoum 25W: Conservation to Eradicate Rats. QA-1875 Final Report. USDA, APHIS, W, NWRC. Hilo, HI. 85 pp.

Pitt, W. C., A.R. Berentsen, A. B. Shiels, S. F. Volker, J.D. Eisemann, A.S. Wegmann, and G.R. Howald. 2015. "Non-Target Species Mortality and the Measurement of Brodifacoum Rodenticide Residues after a Rat (*Rattus rattus*) Eradication on Palmyra Atoll, Tropical Pacific." *Biological Conservation* 185:36-46.

Pitt, W., A. Wegmann, J. Eisemann, and G. Howald. 2011. Palmyra Atoll Rainforest Restoration Project: rat eradication monitoring plan for all aerial broadcast alternatives. Island Conservation: Santa Cruz, CA.

Pratt, H.D., P.L. Bruner, and D.G. Berrett. 1987. *A Field Guide to the Birds of Hawai'i and the Tropical Pacific*. Princeton University Press: Princeton, NJ.

Primus, T.M., G. Wright, and P. Fisher. 2005. "Accidental discharge of brodifacoum baits in a tidal marine environment: a case study." Bull. Environ. Contam. Toxicol. 74:913-919.

Pye, T., R. Swain, and R. Seppelt. 1999. "Distribution and habitat use of the feral black rat (*Rattus rattus*) on subantarctic Macquarie Island." *Journal of Zoology* 247:429-438.

Pyle, R.L, and P. Pyle. 2017. *The Birds of the Hawaiian Islands: Occurrence, History, Distribution, and Status* (Version 2 (1 January 2017)). Honolulu, HI, U.S.A. Available from http://hbs.bishopmuseum.org/birds/rlp-monograph/. (downloaded 14 November 2017).

Reynolds, M., P. Berkowitz, J.L. Klavitter, and K.N. Courtot. 2017. "Lessons from the Tōhoku tsunami: A model for island avifauna conservation prioritization." *Wiley Ecology and Evolution* 7:5873–5890. doi: 10.1002/ece3.3092.

Reynolds, M. H.; Crampton, L. H.; Vekasy, M. S. 2007. Laysan Teal *Anas laysanensis* nesting phenology and site characteristics on Laysan Island. *Wildfowl* 57: 54-67

Reynolds, M., K. Courtot, and J. Hatfield. In press. How many Laysan Teal (*Anas laysanensis*) are on Midway Atoll? Methods for monitoring abundance after reintroduction. US Geological Survey, Pacific Island Ecosystems Research Center, Kīlauea Field Station: Hawai'i Volcanoes National Park, HI.

Ross, D.B., N.L. Roberts, and C. Fairley. 1980. Brodifacoum: The acute oral toxicity (LD50) of Brodifacoum to the Mallard duck. Huntingdon Research Centre, Huntingdon, Cambridgeshire, UK. Submitted by ICI Americas, Inc. Agricultural Products, Wilmington, Delaware 19897. ICI's Study No. ICI308WL/791275. EPA MRID 415633-03.

Rowan, R. 1998. "Diversity and ecology of zooxanthellae on coral reefs." *Journal of Phychology* 34:407-417.

Rueda, D.K., K.J. Campbell, P. Fisher, F. Cunninghame, and J.B. Ponder. 2016. "Biologically significant residual persistence of brodifacoum in reptiles following invasive rodent eradication, Galapagos Islands, Ecuador." Conservation Evidence 13:38.

Russell, J. C., and N.D. Holmes. 2015. "Tropical island conservation: rat eradication for species recovery." *Biological Conservation* 185:1-7.

Samaniego, A. 2016. Mouse eradication on Midway Atoll: a review of the record. In *Pacific Invasives Initiative (PII)*.

Samaniego-Herrera, A., J. Russell, D. Choquenot, A. Aguirre-Munoz, and M. Clout. 2014. Invasive Rodents on Tropical Islands: Eradication Recommendations from Mexico. 26th Vertebrate Pest Conference, at Davis University, CA.

Samaniego-Herrera, A. 2016 Mouse eradication on Midway Atoll: a review of the record. In *Pacific Invasives Initiative (PII)*.

Schreiber, E.A. and R.W. Schreiber. 1993. Red-tailed tropicbird (Phaethon rubricauda). The Birds of North America, Number 43. The American Ornithologists' Union, Washington, D.C., USA, and The Academy of Natural Sciences, Philadelphia, Pennsylvania, USA.

Schreiber, B.A., and R.W. Schreiber. 2009. *Red-tailed Tropicbird (Phaethon rubricauda), version 2.0.* Cornell Lab of Ornithology. Available from https://doi.org/10.2173/bna.43.

Schreiber, E.A., P.F. Doherty, Jr., and G.A. Schenk. 2001. Effects of a Chemical Weapons Incineration Plant on Red-Tailed Tropicbirds. *The Journal of Wildlife Management*, (65)4: 685-695.

Schreiber, E.A., and R.L. Norton. 2002. *Brown Booby (Sula leucogaster), version 2.0.* Cornell Lab of Ornithology. Available from https://doi.org/10.2173/bna.649.

Schuyler, Q., B.D. Hardesty, C. Wilcox, and K. Townsend. 2014. "Global Analysis of Anthropogenic Debris Ingestion by Sea Turtles." Conserv Biol 28 (1):129-139. doi: 10.1111/cobi.12126.

Seto, N. 1994. The effects of rat (*Rattus rattus*) predation on the reproductive success of the Bonin Petrel (*Pterodroma hypoleuca*), Master's Thesis, University of Hawaiʻi, Honolulu, HI.

Seto, N.W., and D.L. O'Daniel. 1999. Bonin Petrel *(Pterodroma hypoleuca), version 2.0.*

Shiels, A.B., C.A. Flores, A. Khamsing, P.D. Krushelnycky, S.M. Mosher, and D.R. Drake. 2013. "Dietary niche differentiation among three species of invasive rodents (*Rattus rattus, R. exulans, Mus musculus*)." *Biolological Invasions* 15:1037-1048.

Snow, D.W., and C.M. Perrins. 1998. The Birds of the Western Palearctic Concise Edition: Volume 1 Non-Passerines, Volume 2 Passerines Oxford University Press, Oxford.

Starr, F., and K. Martz. 1999. Botanical survey of Midway Atoll 1999 update. *In* U.S. Fish and Wildlife Service Report. Honolulu, HI.

Starr, F., and K. Starr. 2008. Botanical Survey of Midway Atoll. *In* Report prepared for the United States Fish and Wildlife Service. Honolulu, HI.

---. 2015. Botanical survey of Midway Atoll. Report prepared for the U.S. Fish and Wildlife Service. Honolulu, HI.

The Ornithological Council. 2010. The Rat Island Rat Eradication Project: A Critical Evaluation of Non-target Mortality. *Prepared for* Island Conservation, The Nature Conservancy, U.S. Fish and Wildlife Service, Alaska Maritime National Wildlife Refuge. *Reviewed by* T.P. Salmon, Sheffield, S.R. and Paul, E. 85 pp.

Thibault, J.C. 1995. "Effect of predation by the black rat *Rattus rattus* on the breeding success of Cory's Shearwater *Calonectris diomedea* in Corsica." *Marine Ornithology* 23:1-10.

Tobin, M., and M. Fall. 2005. Pest control: Rodents Agricultural Sciences. *In Encyclopedia of Life Support Systems (EOLSS)*. Oxford, UK: EOLSS Publishers under the auspices of the United Nations Educational, Scientific, and Cultural Organization.

Tomich, P. 1986. *Mammals in Hawai'i. 2nd edition*. Bishop Museum Press: Honolulu, HI.

Towns, D. 1991. "Response of lizard assemblages in the Mercury Islands, New Zealand, to removal of an introduced rodent, the kiore (*Rattus exulans*)." *Journal of The Royal Society of New Zealand* 21:119-136.

UK University of Hertfordshire *Pesticide Properties Database*, Available from http://sitem.herts.ac.uk/aeru/ppdb/en/Reports/87.htm.

U.S. Army Space and Missile Defense Command. 2003. Ground-Based Midcourse Defense (GMD) Extended Test Range (ETR): Environmental Impact Statement. Volume 1. Huntsville, AL.

USEPA. 1991. Reregistration Eligibility Decision (RED) Rodenticide Cluster. U.S. Environmental Protection Agency, Pesticides Programs: Washington, D.C.

USEPA. 1995. "Great Lakes Water Quality Initiative. Methodology for Development of Wildlife Criteria." 40 CFR Ch. App D. US EPA.

U.S. National Park Service. 2000. Anacapa Island Restoration Projects. Final Environmental Impact Statement. Ventura, CA. 139 pp.

USFWS. 1983. Atlas of Hawaiian Seabird Colonies. In *Catalog of Hawaiian Seabird Colonies*. Edited by S.I. Fefer, et al. Refuges and Wildlife, Pacific Islands Office: Honolulu, HI. 236 pp.

---. 2005. Regional Seabird Conservation Plan, Pacific Region. U.S. Fish and Wildlife Service, Migratory Bird and Habitat Programs, Pacific Region. Portland, Oregon.

---. 2008a. Birds of conservation concern 2008. Edited by U.S. Fish and Wildlife Service. Division of Migratory Bird Management: Arlington, VA.

---. 2008b. Short-tailed Albatross Recovery Plan. Anchorage, AK.

---. 2009. *Cenchrus agrimonioides* (Kāmanomano): 5-Year Review Summary and Evaluation. Pacific Islands Fish and Wildlife Office Honolulu, Hawai'i. 14 pp.

---. 2011. Final Environmental Impact Statement: Palmyra Atoll National Wildlife Refuge Rat Eradication Project. Pacific Region: Portland, OR. 659 pp.

---. 2014. Fighting weeds to save seabirds, 6 March 2014 [cited 20 Oct 2017]. Available from https://www.fws.gov/refuges/news/FightingWeedsToSaveSeabirds.html.

---. 2015. *Fact Sheet: Wedge-tailed Shearwater (Puffinus pacificus)* [cited 10-5-17].

---. 2016. *Fact Sheet: Red-tailed Tropicbird (Phaethon rubricauda rothschildi)*.

---. Unpublished *a*. "Midway Atoll National Wildlife Refuge 2002-2006."

---. Unpublished b. "Regarding seabirds and shorebirds of Midway Atoll National Wildlife Refuge."

USFWS and HDLNR. 2017. Final Environmental Assessment Lehua Island Ecosystem Restoration Project. Co-Lead Agencies: U.S. Fish and Wildlife Service and Hawai'i Department of Land and Natural Resources, Division of Forestry and Wildlife.

USFWS, and PIFWO. 2016. DRAFT Fish and Wildlife Coordination Act Planning Aid Report. Seawall Long Term Maintenance Project. Midway Atoll National Wildlife Refuge/Battle of Midway National Memorial. Prepared by Nadiera Sukhraj and Gordon Smith. May 2016. U.S. Fish and Wildlife Service, Pacific Islands Fish and Wildlife Office, Region 1, Honolulu, HI.

University of Hawaii. 2014. "Climate Change Impacts in Hawai'i - A Summary of Climate Change and Its Impacts to Hawai'i's Ecosystems and Communities."

Van Gils, J., and P. Wiersma. 1996. Family Scolopacidae (sandpipers, snipes and phalaropes). Edited by A. Elliott and J. Sargatal J. del Hoyo, Handbook of the birds of the world. Barcelona: Lynx Ediciones.

Veitch, C., and M. Clout. 2002. Turning the Tide: the Eradication of Invasive Species. SSC Invasive Species Specialist Group: Gland, Switzerland and Cambridge, UK.

Veitch, C.R., and M.N. Clout. 2011. "Island invasives: eradication and management." In *International Union for the Conservation of Nature*, edited by D.R. Towns. Gland, Switzerland.

Vicente, V.P. 1994 of Conference. Spongivory in Caribbean hawksbill turtles, *Eretmochelys imbricata*: Data from stranded specimens. Pgs. 185-188 *in* Thirteenth Annual Symposium on Sea Turtle Biology and Conservation, Report, at NOAA Tech Memo. NMFS-SEFSC-341, Jekyll Island, GA.

WHO. 1995. Brodifacoum Health and Safety Guide No. 93, Section 2.3 Environmental Transport, Distribution, and Transformation. International Programme on Chemical Safety, World Health Organization. Geneva, Switzerland. [Downloaded 16 November 2017]. Available at http://www.inchem.org/documents/hsg/hsg/hsg093.htm.

Wanless, R.M, A. Angel, R.J. Cuthbert, G.M. Hilton, and P.G. Ryan. 2007. "Can predation by invasive mice drive seabird extinctions?" *Biology Letters* 3 (3):241-244. doi: 10.1098/rsbl.2007.0120.

Weatherbase.com. 2017. Average temperature and rainfall at Henderson Field Airport, Sand Island, Midway Atoll, NW Hawaiian Islands. Available from https://www.weatherbase.com.

Wegmann, A.S. 2009. Limitations to tree seedling recruitment at Palmyra Atoll. University of Hawaiʻi: Honolulu, HI.

Weir, S.M., S. Yu, A. Knox, L.G. Talent, J.M. Monk, and C.J. Salice. 2016. "Acute toxicity and risk to lizards of rodenticides and herbicides commonly used in New Zealand." New Zealand Journal of Ecology 40 (3):342-350. doi: 10.20417/nzjecol.40.43.

Whitaker, A.H. 1973. "Lizard populations on islands with and without Polynesian rats *Rattus exulans* (Peale)." *Proceedings of the New Zealand Ecological Society* 20:121-130.

Whittow, G.C. 1993a. "Black-footed Albatross (*Diomedea nigripes*)." In *The Birds of North America*, edited by A. Poole and F. Gill. Washington, D.C: The American Ornithologists' Union: Philadelphia: The Academy of Natural Sciences.

---. 1993b. "Laysan Albatross (*Phoebastria immutabilis*)." In *The Birds of North America*, edited by A. Poole and F. Gill. Washington, D.C.: The American Ornithologists' Union: Philadelphia: The Academy of Natural Sciences.

Woodward, P.W. 1972. "The natural history of Kure Atoll, Northwestern Hawaiian Islands." Atoll Res. Bull. 164:1-318.

Work, T.M., and M.R. Smith. 1996. "Lead exposure in Laysan albatross adults and chicks in Hawaii: prevalence, risk factors, and biochemical effects." *Archives of Environmental contamination and Toxicology* 31:115-119.

Work, T. M., Klavitter, J. L., Reynolds, M. H. & Blehert, D. (2010). "Avian botulism: a case study in translocated endangered Laysan Ducks (Anas laysanensis) on midway atoll." J. Wildl. Dis. 46: 499–506.

Young, H., D. McCauley, R. Dunbar, and R. Dirzo. 2010. "Plants cause ecosystem nutrient depletion via the interruption of bird derived spatial subsidies." Proceedings of the National Academy of Science. 107:2072-2077.

CHAPTER 7: CONSULTATION & DISTRIBUTION

7.1 PRE-DRAFT SCOPING PROCESS

The proposed mouse eradication action involves the aerial broadcast of bait pellets containing rodenticide into all potential mouse territories on Sand Island, MANWR. Mouse eradication would occur in the summer dry season (July to August) to maximize the probability of success, targeting the mice when their food resources are lowest and their abundance is declining. Conducting the operation during this period would also minimize the risk of exposure to both seabirds and shorebirds, as well as the risk of rain washing rodenticide pellets into the ocean.

A Public Scoping effort by the USFWS was conducted to solicit input from the public, state and Federal regulatory agencies, and non-governmental organizations regarding the proposed Midway Seabird Protection Project on Sand Island, MANWR, and the Northwestern Hawaiian Islands. Prior to the preparation of the Draft Environmental Assessment for the proposed action, on August 7, 2017, a scoping letter describing the proposed action and interview questions were emailed to the individuals listed in Table 7.1:

Table 7.1 Scoping Letter Recipients

No.	***Recipient***	***Agency or Role***
1	Karen Vitulano	Environmental Protection Agency
2	Thierry Work	United States Geological Service, National Wildlife Health Center
3	Richard Hall	National Oceanic and Atmospheric Administration, National Marine Fisheries Service
4	Thea Johanos-Kam	National Oceanic and Atmospheric Administration, National Marine Fisheries Service
5	Gabrielle Fenix Grange	Hawaii Department of Health, Hazard Evaluation and Emergency Response Office
6	Maggie Sergio	Island Watch Conservation Science
7	Sydney Ross Singer	Good Shepherd Foundation
8	Joshua Atwood	Hawaiʻi Department of Land and Natural Resources, Division of Forestry and Wildlife
9	Mark Rauzon	Pacific Seabird Group/Laney College
10	Richard and Jenny Johnson	former Midway resident and Midway volunteer
11	Jill McIntire	Midway volunteer
Source: Hamer Environmental (2017)		

These individuals, organizations, and agencies were contacted because they had previously expressed interest in similar island eradication projects or may have oversight or regulatory concerns about the project. All eleven responded to the interview questions either via email or by phone.

7.2 INTERVIEW PROCESS

A series of interview questions were prepared by Hamer Environmental, Inc., and Planning Solutions. Scoping participants were informed of the proposed project's purpose, need, method, schedule, background and alternatives. The 16 questions were categorized into 4 parts as shown in Table 7.2:

Table 7.2 Summary of Scoping Interview

Part I: Contact Information	
No.	*Question*
1	Please state your full name, preferred contact number, and email.
2	What is your occupation and/or affiliation?
3	How many people are in your organization?
4	How many days, week, months, or years have you spent on Midway?
5	When was your most recent trip to Midway?
6	What do you consider your particular areas of expertise related to the project purpose or location?
Part II: Survey	
7	Do you have input on the purpose and need?
8	Do you believe that conservation of the native environment (seabirds, wildlife, and botanical resources) adequately justify the eradication of invasive mice?
Part III: Historical and Cultural Information	
9	Is there anything you would like to say about the general history of the area, or past and present land use?
Questions only for people who have visited or lived on Midway:	
10	Have you participated in or observed any cultural events or practices on Midway?
11	Do you know anything about the canaries and their potential historic or cultural significance?
Part IV: General Considerations	
12	Have you encountered or are you aware of any facilities, areas, or resources on Midway that you believe require special consideration, either in terms of project implementation or potential project impacts?
13	What concerns would you have regarding the use of following rodenticide distribution methods on Midway: (a) aerial broadcast; (b) band broadcast; (c) bait stations?
14	Are you aware of any human activities on Midway that may be impacted by or affect the efficacy of an eradication effort?
15	What factors, such as structures, topography, or human habits, do you feel represent the biggest challenges to the eradication effort? How would you approach them?
16	What impacts do you foresee (water or marine environment or others) from the action and how would you (a) avoid, (b) minimize, or (c) mitigation for them?
Source: Hamer Environmental (2017)	

The USFWS compiled responses from the public scoping process, and prepared a list of environmental issues that warranted specific consideration in the EA analysis. The concerns that were identified are: (*i*) damage to seabird populations; (*ii*) secondary poisoning; (*iii*) poisoning of rodents and non-target species; (*iv*) disturbance; (*v*) cultural issues; (*vi*) project effectiveness; and (*vii*) the EA process and Alternatives.

CHAPTER 8: STATEMENT OF COMPLIANCE FOR IMPLEMENTATION OF THE PROPOSED ACTION AT MANWR

The following Regulatory and Policy Compliance Requirements and Permit processes are currently underway and would be completed prior to implementing the proposed action.

8.1 NATIONAL ENVIRONMENTAL POLICY ACT (1969)

The Environmental Assessment development process has been conducted in accordance with NEPA Implementing Procedures, Department of the Interior and Service procedures, and has been performed in coordination with the affected public.

8.2 NATIONAL HISTORIC PRESERVATION ACT (1966)

The implementation of the proposed action is currently under review for its impacts on cultural resources. The proposed action does not meet the criteria of an effect or adverse effect as an undertaking defined in 36 CFR 800.9 and 614 FW 2. The Service would comply with the National Historic Preservation Act if any management actions have the potential to affect any historic properties which may be present.

8.3 EO 12372 INTERGOVERNMENTAL REVIEW

Coordination and consultation with affected State governments, and other Federal agencies has been completed through personal contact by Service planners, refuge managers, and supervisors.

8.4 ENDANGERED SPECIES ACT OF 1973

The Service has initiated consultation with the NOAA/National Marine Fishery Service and the U. S. Fish and Wildlife Service under Section 7 of the Endangered Species Act for all listed species at MANWR. A Biological Assessment will be written and used with this EA in the consultation process to identify mitigation actions to minimize impacts to all listed species.

8.5 MAGNUSON-STEVENS ACT ESSENTIAL FISH HABITAT

The Service has initiated consultation with NOAA/National Marine Fishery Service for effects to Essential Fish Habitat from the Proposed Action. The Draft Environmental Assessment is serving as the primary document for the consultation process.

8.6 MIGRATORY BIRD TREATY ACT AND EO 13186 FEDERAL PROTECTION OF MIGRATORY BIRDS

The Draft NEPA analysis evaluates the effects of proposed action on migratory birds and outlines avoidance and minimization measures that will be implemented to reduce or eliminate incidental take of migratory birds.

8.7 EO 13112 RESPONSIBILITIES OF FEDERAL AGENCIES PERTAINING TO INVASIVE SPECIES

EO 13112 requires Federal agencies to prevent the introduction of invasive species and provide for their control and to minimize the economic, ecological, and human health impacts that invasive species cause.

8.8 INTEGRATED PEST MANAGEMENT, 517 DM 1 AND 569 FW 1

In accordance with 517 DM 1, and 569 FW1, an integrated pest management (IPM) approach has been adopted to eradicate, control, or contain pest and invasive species on the Refuge. In accordance with 517 DM 1, only pesticides registered with the Environmental Protection Agency (EPA) in full compliance with the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), and as provided in regulations, orders, or permits issued by EPA, may be applied on lands and waters under Refuge jurisdiction. Consistent with agency policy, a Pesticide Use Plan (PUP) would be prepared prior to implementing the proposed action.

8.9 EPA-APPROVED RODENTICIDE LABEL

The proposed action would be implemented using the product Brodifacoum-25D: Conservation (EPA Reg. No. 56228-37). A Supplemental label would be obtained prior to transporting the rodenticide, to account for the particularities of the mice eradication operation on Midway Atoll NWR. Field applications of the rodenticide would be made in full compliance with the EPA supplemental label. Alternate bait products of Brodifacoum 25ppm may be considered. Given that the concentration of the active ingredient, brodifacoum would be the same, this would not alter the environmental risk profile of the operation and all potential consequences discussed for Brodifacoum-25D: Conservation would apply.

8.10 EPA – NATIONAL POLLUTION DISCHARGE ELIMINATION (NPDES) SYSTEM GENERAL PERMIT

The proposed action requires a Pesticide General Permit under the NPDES Program. Once the application is submitted, there is a 30-day period for EPA to respond. No response means the Permit is approved. Permit application will be completed online at: epa.gov/NPDES/pesticide-permitting prior to implementing the proposed action.

8.11 PAPAHĀNAUMOKUĀKEA MARINE NATIONAL MONUMENT (PMNM) PERMIT

The PMNM permitting program is designed to manage and minimize human impact, while increasing conservation protection for Papahānaumokuākea’s natural, cultural and historic resources. In accordance with Presidential Proclamation 8031 and codifying regulations in 50 CFR Part 404, all activities in the Monument, with limited exceptions, require a permit. A Marine Monument permit would be obtained prior to implementation of the proposed action at Midway. Permit application deadline is February 1, 2018.

8.12 EO 12898. FEDERAL ACTIONS TO ADDRESS ENVIRONMENTAL JUSTICE IN MINORITY AND LOW-INCOME POPULATIONS

All Federal actions must address and identify, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations, low-income populations, and Indian Tribes in the United States. The proposed action was evaluated and no adverse human health or environmental effects were identified for minority or low-income populations, Indian Tribes, or anyone else.

8.13 PESTICIDE APPLICATOR CERTIFICATION

USFWS and Regional policy requires Pesticide Applicator certification for employees or volunteers who frequently apply pesticides or who supervise the application of pesticides by others (*relevant policies include:* Integrated Pest Management Policy 569 FW 1: and Pesticide Users Safety 242 FW 7:)

CHAPTER 9: GLOSSARY OF TERMS

Anticoagulant - a class of drugs that work to prevent blood clotting.

Atoll - a ring-shaped reef, island, or chain of islands formed of coral.

Behaviorally plastic - change in an organism's behaviors or habits that results from change in the environmental conditions, such as a shift to a new primary food source due to changes in food abundance.

Biological Control - the control of a pest by the introduction of a natural enemy or predator.

Broadcast – (of pesticide) the uniform treatment to a broad area using various procedures of application, such as hand and aerial broadcast methods.

Brodifacoum - a second-generation rodenticide that requires only one feeding for a rodent to receive a lethal dose.

Climate - how the atmosphere "behaves" over relatively long periods of time.

Colony (of seabirds) - a large group of birds from one or more species that nest or roost (sleep) close to each other at a particular location. Most seabirds are social nesters and display extraordinary site fidelity.

Colonization - the process in biology by which a species successfully spreads to a new area.

Commensal - (pertaining to humans) eating together at the same table; (in ecology, of an animal, plant, fungus, etc.) living with, on, or in another, without injury to either.

Coumarin-based - (pertaining to anticoagulants) a class of vitamin K antagonist (VKA) anticoagulant drug molecules derived from coumarin (4-hydroxycoumarin).

Diphacinone - a first-generation rodenticide which requires multiple feedings over several days for a rodent to receive a lethal dose.

EC_{50} - Half Maximal Effective Concentration; the concentration of a toxicant that gives half-maximal response; measured in ppm.

Endemic - a species that is native to just one place.

Ephemeral (plants) - those which sprout, reproduce, and die back very quickly as an evolutionary adaptation to take advantage of brief wet periods in an otherwise dry climate.

Eradication - the complete removal of a damaging species from a specific location to enable ecosystem recovery.

Executive Order - presidential directives issued by United States presidents; generally directed towards officers and agencies of the Federal government.

Extinction - when the last of a species dies and that species ceases to exist anywhere in the world.

Extirpation - the complete removal of an organism from a specific location but which continues to exist in other places; also known as local extinction.

Federal Mandate - orders that induce "responsibility, action, procedure or anything else that is imposed by constitutional, administrative, executive, or judicial action" for state and local governments and/or the private sector.

Federal Acts - laws, also known as statutes, passed by a legislature.

Granivore - seed predators that feed on the seeds of plants as a main or exclusive food source, leaving seeds damaged and not viable.

Groundwater - water held underground in the soil or in pores and crevices in rock.

Half-life - the time it takes for a certain amount of a pesticide to be reduced by half as it dissipates or breaks down in the environment; a pesticide will break down to 50% of the original amount after a single half-life.

Hemorrhaging - the flow of blood out from a blood vessel; bleeding.

Herpetofauna - amphibians (frogs, toads, salamanders and newts) and reptiles (snakes, lizards, turtles, tortoises and crocodilians).

Hopper - a piece of equipment used in many types of industry to discharge products at a steady rate.

Immigration - the movement of an organism to a new area from elsewhere, assisted or unassisted.

Insectivorous - an animal that eats insects as a primary or exclusive food source.

Invasive - a non-native species whose introduction causes or is likely to cause economic or environmental harm, or harm to human health.

Ionic strength (of seawater) - a measure of the concentration of ions in a solution which affects important properties such as the dissociation or solubility of different salts.

Island Biosecurity - The policies and protocols put in place to protect island ecosystems from non-native species by preventing, detecting and responding to introductions.

Lambda - Rate of growth (lambda) is the ratio of population size at the end of one interval to population size at the end of the previous interval. When lambda = 1.0 the population density is stable while values >1.0 indicate increasing populations.

LC_{50} - the concentration of the chemical in feed that kills 50% of test samples; usually administered over a multi-day period (e.g. 5 to 7 days).

LD_{50} - the amount of an ingested substance that kills 50% of test samples; usually administered as a single dose.

LOAEL - the lowest dose or exposure level of a toxicant that produces a measurable toxic effect on the test group of animals.

Mitigation - steps taken to reduce or avoid negative environmental impacts.

Native - a species that occurs naturally (without human agency) in an area.

NOAEL - a dose or exposure level of a toxicant that produces no measurable toxic effects on the test group of animals.

Non-native (introduced, alien) - an organism that is not native to the place in which it occurs, having been accidentally or deliberately transported to the new location by human activity.

pp_ - parts per thousand (**ppt**), parts per million (**ppm**), parts per billion (**ppb**) are units of concentration for extremely dilute solutions; for example, a concentration of 1 ppm means 1 mg of solute in 1,000,000 mg of solution, or 1 mg of solute in 1000 g of solution, or 1 mg of solute in 1 kg of solution.

Palatability - having an agreeable or pleasant taste that is accepted by the target consumer.

Pesticide - any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any pest.

Pica - displaying an indiscriminate preference for eating non-food items; such as chicks pecking and eating rocks, sticks and other foreign objects.

Pinnipeds - seals; a diverse group of carnivorous semi-aquatic marine mammals.

Potable - safe to drink; drinkable.

Predation - the act of one organism killing and eating other organisms; can refer to both animals and plants.

Pyranine - a fluorescent dye commonly found in highlighters and used as a biological stain to show ingestion pathways.

Recruitment - the ability of juvenile organisms to survive and add to the population of that species.

Refuge - (pertaining to wildlife) a naturally occurring sanctuary, such as an island, that provides protection for species from hunting, predation, or competition; it is a protected area, a geographic territory within which wildlife is protected.

Rodenticide – a pesticide formulated to kill rodents.

Sublethal - having an effect less than lethal.

Threshold - the magnitude or intensity that must be exceeded for a certain reaction, phenomenon, result, or condition to occur or be manifested.

Weather - conditions of the atmosphere over a short period.

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APPENDIX A. MIDWAY ATOLL NATIONAL WILDLIFE REFUGE BIO-SECURITY PLAN

Island biosecurity results from policies and protocols put in place to protect island ecosystems from non-native species by preventing, detecting and responding to introductions Non-native species (sometimes referred to as non-indigenous, alien, or exotic species) are plants, animals, and micro-organisms (PAMs) transported or established outside of their natural range due to the activities of humans, regardless of whether these actions are intentional or not. Non-native invasive species (NISs) have the potential to establish populations and cause unacceptable harm.

The main points found within the Midway Atoll Wildlife Refuge Biosecurity Plan are briefly summarized in this appendix. They address prevention measures, reporting protocol, education, and rapid response. Preventing the introduction of NISs is the most time- and cost-effective way to protect island ecosystems. The focus of this summary is rodents, particularly mice and rats.

I. Prevention Measures

Use a rodent-proof facility to hold supplies and equipment prior to shipping. Pack consumable goods in rodent-proof containers, and check non-food items carefully. Do not leave cargo outside over-night. On-island preparation includes setting traps/bait stations in key areas like the dock, airport, and cargo staging/storage areas, elevating them to avoid interference with crabs. Check all detection devices regularly and maintain them; have spare traps/bait on hand and replace as needed. Train personnel handling cargo to identify rodent signs, e.g., feces in containers, holes chewed in packaging, etc.

a. Boat Arrival

All docking vessels must: (*i*) have rodent inspections prior to off-loading, (*ii*) deploy collared rat-guards to all dock lines, and (*iii*) have pest detection and control devices in use on board, e.g., snap-traps and glue-traps. Carry out rodent control measures 2 weeks before departure, 2 weeks prior to estimated arrival, and for the duration of stay.

b. Plane Arrival

All planes must have rodent traps/bait stations deployed near the wheels. Those planes stored inside (e.g., hangers) must additionally deploy control devices around the edges of each structure.

II. Reporting Protocol

Report any detections or suspicions of NIS presence immediately to the Refuge Manager who will coordinate appropriate follow-up.

III. Education

Update residents and educate visitors on refuge biosecurity measures. Provide guidelines, signs, and brochures containing the basic protocols and procedures, e.g., how to detect, identify, and report NISs.

IV. Rapid Response if Animals Are Detected

a. Rodents

i. Use a variety and combination of removal methods, e.g., snap traps, bait stations, flavored sticky traps, rodenticides, and cage traps. Exact types of devices and methods will be determined by target rodent.

ii. Bait station grid should cover all habitat types across the island. Bait stations and traps should be placed at a higher density around key habitat and detection sites.

iii. All trap and bait station locations should be numbered, visibly marked, and mapped. Any member of the response team should be able to easily locate every location.

iv. Place traps in locations with plenty of natural cover, and where animals are likely to be active. Place additional traps near any footprints or scat.

v. Traps should be covered and/or placed in locations (e.g. attached to tree limbs) that reduce the chance of interference by non-targets.

vi. Bait traps with known attractants. Check all traps daily and bait stations daily or every other day. Peanut butter mixed with rolled oats makes good rodent bait.

vii. Keep detailed records. Any sign should be recorded and analyzed.

viii. Any specimens caught are to be aged, sexed, breeding status obtained and have samples collected for DNA. DNA analysis may help determine source population. The specimen is then to be frozen (well labeled) in case required for later analysis.

ix. Staff should continually search for signs and new trap locations.

b. Mammalian Predators

i. A variety of trap types should be used. Possibilities include snares, foothold traps, conibear traps, and box traps. Exact size and trapping techniques will be dictated by the target animal.

ii. Bait traps with known attractants. Check all traps daily and bait stations daily or every other day. Peanut butter mixed with rolled oats makes good rodent bait.

c. Reptiles and Amphibians

i. Active search and capture of individuals by hand, with sniffer dogs, or using nets or nooses.

ii. Drift fences with funnel traps

d. Post-Animal Review

i. Monitor island-wide to verify that all individuals have been removed and a population was not established. During and after an introduction, review the current biosecurity practices and identify how the animal arrived on island. Any failures identified in the biosecurity protocols must be re-evaluated to prevent similar situations from occurring.

APPENDIX B. SUMMARY OF PROPOSED MONITORING

Documentation of the best operational approach, the efficacy of the operation, the environmental and ecological effects of the proposed action requires monitoring of a number of parameters before, during, and after the implementation of an eradication operation will be undertaken by the Restoration partners.

I. Eradication Planning

To inform eradication planning efforts where possible (e.g., baiting methods, evaluation of methods to reduce non-target impacts of the eradication procedure) we will evaluate bait uptake rates and persistence in representative habitats and use DNA Metabarcoding to provide direct evidence for mice diet components. We will collect mouse diet samples via stomach contents and mouse feces in stratified habitat types; collect samples of diet items if DNA hasn't been previously characterized. These data can directly inform eradication planning and baiting strategy. We will monitor phenology of plants suspected of being important in mouse diets.

II. Conservation Measures

To measure recovery of target conservation species and ecosystems and the unintended consequences of the removal of a ubiquitous species, a number of ecosystem components will be characterized prior to and at 1, 3, 5 and 10 years post-eradication. Good monitoring will enable land managers to predict and prepare for positive and negative impacts of the eradication action (pre-eradication) and clearly document conservation gains (post-eradication).

Taxa identified for monitoring, parameters to be measured, and methods include:

1. **Seabirds**, especially those burrow nesters and ground-nesters particularly vulnerable torodent predation such as Laysan Albatross, Tristram's Storm-petrel, Bulwer's Petrel, and Bonin Petrel for which we will measure breeding population size using counts and acoustic activity and reproductive performance and impacts of mice to Bonin petrels by using camera traps and tracking cards to document mouse-seabird interactions. We will deploy 10-13 Songmeters across Sand and Eastern (control) at known and potential breeding locations to record call activity to record population densities of cryptic burrow nesting species such as Tristram's Storm-petrels and Bulwer's Petrels. We will observe and quantify impacts of mice on Laysan and Black-footed Albatross mice and chicks within and outside of mouse control treatment areas by monitoring albatross nest density and reproductive success within a subset of existing albatross demography 20 x 20m plots as well as additional plots (e.g., zones where no baiting is being conducted as well as Eastern Island as a control).
2. **Laysan Duck,** for which we will monitor population size, reproductive performance, and behavior. We will quantify direct and indirect impacts of mice on duck population by the use of camera traps on nests and conducting measures of reproductive performance and foraging behavior before and after implementation. After live-capture and holding ducks on Sand or Eastern Island, birds will be released in a step-wise progression beginning 30 days after the final bait application or until bait pellets are no longer available to be consumed or biological samples collected

post-application indicate low risk. Monitoring will also include recapture of ducks demonstrating signs of toxicosis, radio-tagging and aggressive tracking of sentinel ducks released post-bait application.

3. **Arthropod community,** for which we will document changes in population densities of land crabs, insects, and spiders. We will confirm extant land crab species for Midway Atoll and document density and demography of land crab population by conducting opportunistic searches and observations of crabs and potential crab holes that are not obviously the known species, *Ocypode pallidul*, and surveying quadrats across potential crab habitat, counting burrows and measuring width of burrows. We will monitor arthropod abundance and richness by deploying pitfall traps in stratified habitats and count sample and identify them to families.

4. **Plant community and seed production,** especially species known to provide important forage for native species in order to understand the extent of competition between introduced house mouse and native birds and insects. We will quantify native seed availability (potential food resource for both mice and ducks) before and after mouse removal by counting seeds and looking at plant recruitment rates for selected species. DNA Metabarcoding will help to predict where land managers can expect to see changes in flora and fauna and identify areas of focus for pre-eradication monitoring efforts.

III. Efficacy Monitoring

Documentation of bait persistence and availability during the implementation period over all habitat types will inform practitioners of appropriateness of application rates. Telemetry of radio-tagged mice during the implementation will allow us to track fates of a sample of individuals. Post eradication detection methods including chew blocks, trail cameras, and other techniques will evaluate successful removal of all mice from Sand Island.

IV. Environmental Impact and Residue Monitoring

1. Brodifacoum residue monitoring: Environmental brodifacoum residues will be evaluated by testing of soil and seawater samples before and after baiting operations. Brodifacoum residues in living tissues (e.g., food web compartments) will be assessed by collection and euthanasia of appropriate invertebrates, lizards, fishes and birds, with liver tissues (site of greatest accumulation) harvested and submitted for chemistry (whole-body samples will be shipped for processing, with tissue harvest occurring under residue-sanitary conditions). Any tissues representative of items for human food consumption (mollusks, game fish) will have whole-body or muscle tissues analyzed as well. Cockroaches, which are demonstrated to be a significant consumer of rodenticide baits and in turn are heavily consumed by Laysan Ducks, will be a particular focus of sampling, with diminishment of brodifacoum levels to be confirmed before ducks are returned to Midway Island.

2. Mortality of all non-target organisms associated with the baiting operations will be assessed by active searching for non-target carcasses on terrestrial and near-shore marine environments (including recording of data on search effort), and by opportunistic sampling during other aspects of operational activities. Carcasses that appear to be within approximately three days of time of death, for which cause of

death is not obvious (e.g., aircraft strike), will be collected and submitted for brodifacoum residue testing.

3. Sampling of prey species important to terrestrial vertebrates vulnerable to brodifacoum will continue periodically until residue levels become undetectable or until the levels are deemed not harmful to Laysan ducks and other migratory bird species foraging in the terrestrial environment on Sand Island.

Chemical analyses (assay and quantification by liquid chromatography and tandem mass spectrometry, “LC-MS/MS”) will be conducted by the USDA NWRC Chemistry Lab Unit in Fort Collins, Colorado. Detection and quantitation limits for each sample type will be established during analysis. Remaining tissues or homogenates may be made available for confirmatory testing by external agencies.

Given that brodifacoum has higher toxicity and a longer half-life (compared to first-generation anticoagulants), and therefore an increased risk of bioaccumulation in the food web, sampling will continue over a long enough timeframe to ensure that appropriate environmental thresholds have been met for actions such as the release of Laysan Ducks from protective captivity.

V. Mitigation Measures and Effectiveness Monitoring

Mitigation measures and actions identified for multiple species in Chapter 3 would be carried out and monitored for their effectiveness. Effectiveness monitoring tracks the success in achieving desired outcomes and evaluating environmental effects. Mitigation includes specific measures or practices that would reduce, avoid or eliminate the effect of the proposed action on non-target species. In this EA, the identified mitigation measures are part of the proposed action (project) and necessary to support a FONSI. Examples of mitigation measures in Chapter 3 include: training ground-based staff to identify endangered plants and how to avoid stepping on seabird burrows; capturing and moving vulnerable species to avoid rodenticide exposure; measures to minimize bait entering the marine environment; and measures to reduce impacts to sea turtles and monk seals. For detailed descriptions see the mitigation section for each species in Chapter 3.

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Front cover: Wisdom's mate and their chick
Kiah Walker/USFWS Volunteer

Back cover: Albatross nesting at Midway Atoll