Biological Assessment
Midway Seabird Protection Project
Midway Atoll National Wildlife Refuge/
Battle of Midway National Memorial

U.S. FISH AND WILDLIFE SERVICE
Midway Atoll National Wildlife Refuge

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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 (PMNM). 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 (*Neomonachus schauinslandi*) and Laysan duck (*Anas laysanensis*). Over 70% of the total global population of Laysan albatross (*Phoebastria immutabilis*) breeds at the refuge, with a majority of the Midway population nesting on the 1,128-acre Sand Island.

This Biological Assessment (BA) documents an action proposed by the United States Fish and Wildlife Service (USFWS) within the PMNM on Midway Atoll and examines the impacts to determine the effects on each federally listed species and designated critical habitat present in the Action Area. Three determination outcomes are possible: (1) “no effect” determination (NE); (2) request Service concurrence with a “may affect, not likely to adversely affect” determination (NLAA); or, (3) request formal consultation with the Service for a “may affect, likely to adversely affect” determination (LAA).

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.

The Proposed Action was identified as a need in the Papahānaumokuākea Monument Management Plan (PMMP), completed in December 2008, as Strategy AS-4 with a goal of developing an eradication plan within five 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 mammals, birds, reptiles, plants and invertebrates. Forty to sixty percent of all recorded bird and reptile extinctions are attributed to invasive rodents.

The goal of the Proposed Action by the USFWS is to protect seabirds and their habitats on MANWR’s Sand Island. The other islands of MANWR, Eastern and Spit, are included in the action area because of the federal definition of the term but excluded from the bait application area because mice are not currently present on them. Eastern Island is further included because it supports the project’s Laysan duck mitigation plan. The action area also includes the portion of the lagoon between Eastern and Sand Island; and the waters between Honolulu and Midway. The USFWS is planning and would conduct the Proposed 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 Hawai‘i 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 (see Section 2.2.2) and placing bait stations in commensal areas (see Section 2.2.1). 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 July/August 2019. Conducting the operation during the summer dry season would target mice when their food resources are at their lowest and their abundance is declining, minimize the risk of rain-washing of rodenticide pellets into the ocean, and make aerial bait applications easier to control because of seasonally low wind conditions. The July/August period is also the time of year when relatively few wintering shorebirds, which may be susceptible to primary and secondary exposure, 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 during this time of year also reduces, but does not eliminate, the potential for collisions between operational aircraft and seabirds.

This BA evaluates the potential adverse effects of the Proposed Action to 17 federally-listed species and one critical habitat under the jurisdiction of the U.S. Fish and Wildlife Service and/or the National Marine Fisheries Service (Table 1.2). This BA evaluates one (1) bird, two (2) plants, fourteen (14) marine species, and one critical habitat. It has been determined that the Proposed Action is “likely to adversely affect” one species, the Laysan duck, pursuant to the Endangered Species Act (ESA), and “may affect but not likely to adversely affect” the 16 other species and critical habitat. Therefore, informal consultation and concurrence (NMFS) and formal consultation (USFWS) under Section 7 of the ESA are both required. This BA provides specific protective measures outlined in the Midway Seabird Protection Project Draft Environmental Assessment (2018) that would be implemented to avoid and minimize impacts to these species and critical habitat.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACRONYMS AND ABBREVIATIONS

Acronym	Phrase
ANCOVA	Analysis of Covariance
APHIS	Animal and Plant Health Inspection Service
ASAP	Alien Species Action Plan
BA	Biological Assessment
BMPs	Best Management Practices
CFR	Code of Federal Regulations
CI	Confidence Interval
CITES	Convention on International Trade in Endangered Species
CR	Critically Endangered
DNA	Deoxyribonucleic Acid (e.g. mitochondrial)
DPS	Distinct Population Segment
ED	Effective Dose
ED_{50}	Dose at which 50% of the test population will show an effect; not necessarily death
ED_5	Dose at which 5% of the test population will show an effect; not necessarily death
EEZ	Exclusive Economic Zone
EPA	Environmental Protection Agency (US)
ESA	Endangered Species Act of 1973
ETOPS	Extended Twin-Engine Operations
FAA	Federal Aviation Association
FENA	Females Estimated to Nest Annually
FR	Federal Register
GPS	Global Positioning System
IC	Island Conservation
IUCN	International Union for Conservation of Nature
LAA	Likely to Adversely Affect
LD_{50}	Lethal dosage of a toxin to 50% of laboratory tested animals; measured in mg (D)/kg of animal body weight
MANWR	Midway Atoll National Wildlife Refuge
MBTA	Migratory Bird Treaty Act
MHI	Main Hawaiian Islands
MMPA	Marine Mammal Protection Act
MSL	Mean Sea Level
MUS	Management Unit Species
NE	No Effect
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act

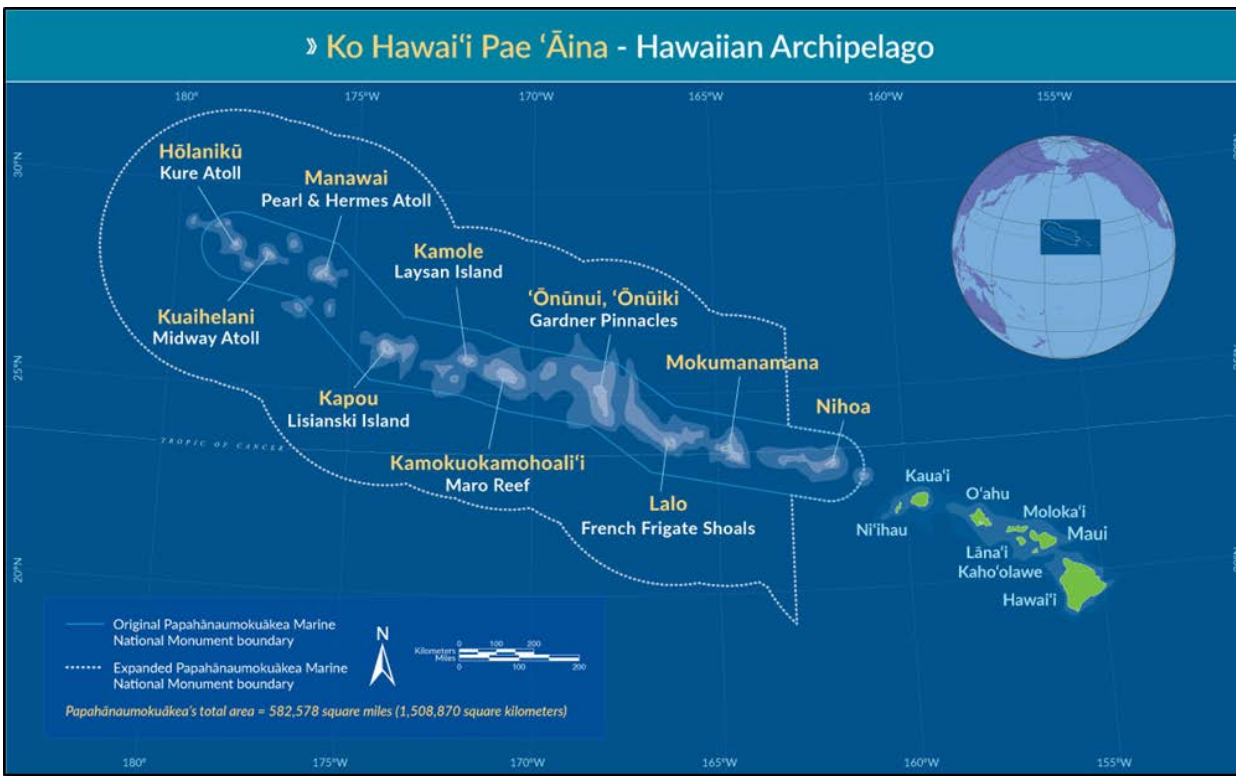
NISA	National Invasive Species Act
NLAA	Not Likely to Adversely Affect
NOAA	National Oceanographic and Atmospheric Agency
NT	Near Threatened
NWHI	Northwest Hawaiian Islands
NWRC	National Wildlife Research Center
PMDY	Henderson Field Airport International Air Transport Association Airport Code
PMMP	Papahānaumokuākea Monument Management Plan
PMNM	Papahānaumokuākea Marine National Monument
SCL	Straight Carapace Length
SMP	Structure Management Plan
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
USGS	U.S. Geological Survey
VU	Vulnerable

CHAPTER 1: INTRODUCTION

1.1 INTRODUCTION

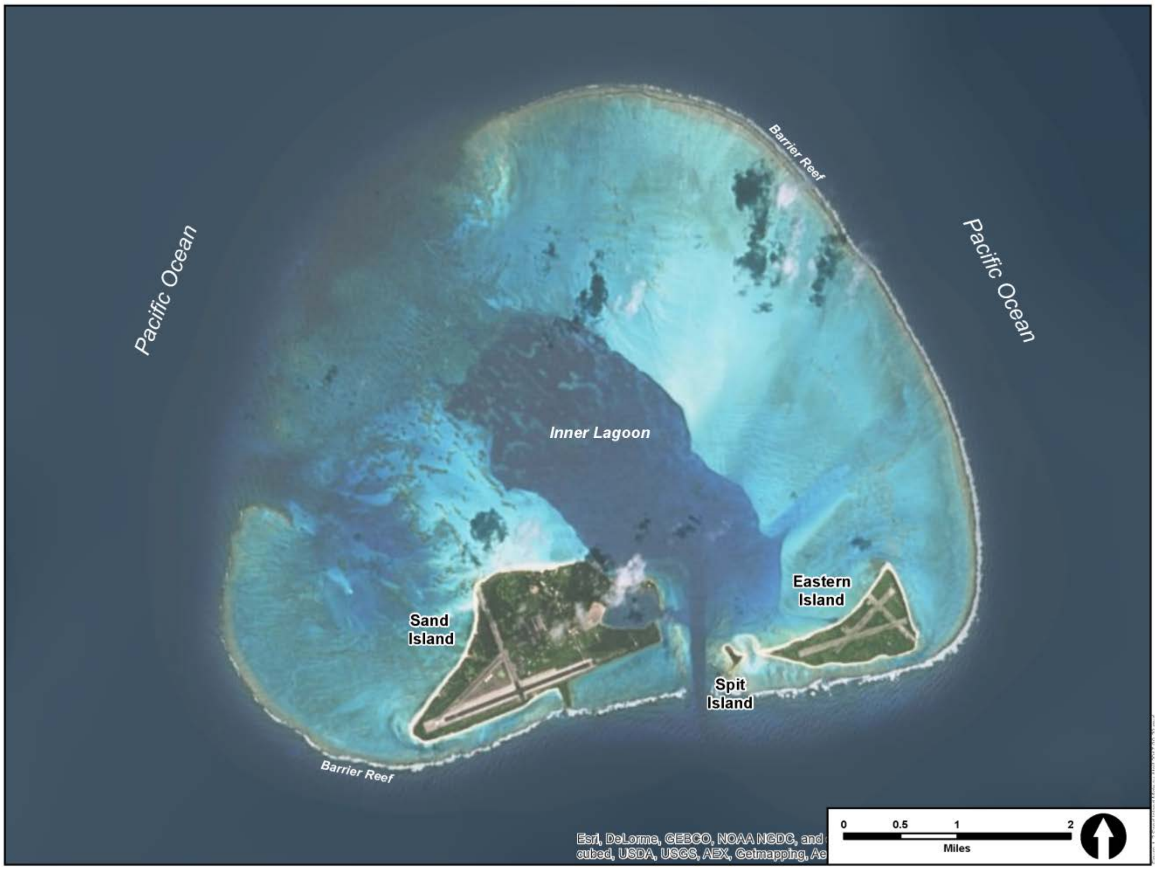
Sand Island is one of three islands comprising the Midway Atoll National Wildlife Refuge (MANWR), which is part of the Papahānaumokuākea Marine National Monument (PMNM) in the Northwestern Hawaiian Islands (NWHI) (see Figure 1.1 and Figure 1.2). The Papahānaumokuākea Monument Management Plan (PMMP) completed in December 2008 identified six priority management needs, with supporting action plans and corresponding desired outcomes for the PMNM (USFWS 2008). A specific component of Priority 3, Reducing Threats to Monument Resources, was the development of an Alien Species Action Plan (ASAP). Specifically, the ASAP identified the eradication of the house mouse on Sand Island, Midway Atoll as Strategy AS-4 (see Table 1.1).

Figure 1.1 Location Map of Main Hawaiian Islands, the Northwestern Hawaiian Islands Archipelago, the Papahānaumokuākea Marine National Monument Boundary, and Midway Atoll.



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

Figure 1.2 Midway Atoll National Wildlife Refuge (MANWR) and Location of Sand, Eastern and Spit Islands.



Source: Planning Solutions, Inc. and Hamer Environmental (2017)

Eradicating the invasive house mouse from Sand Island and subsequently maintaining a rodent-free status for the island in perpetuity requires implementation of Strategy AS-4 from the PMMP. To eradicate invasive mice, a lethal dose of rodenticide will 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. Implementing Strategy AS-4 constitutes a federal agency action that may have an impact on threatened and endangered species, and critical habitats of Sand Island.

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)

The purpose of this Biological Assessment (BA) is to request concurrence and consultation per Section 7 of the Endangered Species Act (ESA) for federally-listed species and designated critical habitat that may be affected by the Proposed Action. Concurrence is requested with a "may affect, not likely to adversely affect" determination (NLAA), and consultation is requested with a "may affect, likely to adversely affect" determination (LAA).

This BA evaluates the potential adverse effects of the Proposed Action to 17 federally-listed species and one critical habitat under the jurisdiction of the United States Fish and Wildlife Service (USFWS) and/or the National Marine Fisheries Service (NMFS). The listed species and critical habitat evaluated, and the agencies being consulted, are listed in Table 1.2.

Table 1.2 Federally-listed species that may occur within the Action Area (n=17 species, n=1 critical habitat).

Common Name	*Scientific Name*	*Federal Status*	*Effects*
Birds (USFWS)			
Laysan duck	*Anas laysanensis*	Endangered	LAA
Plants (USFWS)			
Pōpolo	*Solanum nelsonii*	Endangered	NLAA
Lo'ulu	*Pritchardia remota*	Endangered	NLAA
Marine species (USFWS and NMFS)			

Common Name	Scientific Name	Federal Status	Effects
Hawaiian monk seal and Critical Habitat	*Neomonachus schauinslandi*	Endangered	NLAA
Hawaiian green sea turtle Central North Pacific DPS	*Chelonia mydas*	Threatened	NLAA
Hawksbill sea turtle	*Eretmochelys imbricate*	Threatened	NLAA
Marine species (NMFS)			
Loggerhead sea turtle North Pacific Ocean DPS	*Caretta caretta*	Endangered	NLAA
Olive ridley sea turtle	*Lepidochelys olivacea*	Threatened	NLAA
Leatherback sea turtle	*Dermochelys coriacea*	Endangered	NLAA
False killer whale MHI Insular DPS	*Pseudorca crassidens*	Endangered	NLAA
Blue whale	*Balaenoptera musculus*	Endangered	NLAA
Fin whale	*Balaenoptera physalus*	Endangered	NLAA
Sei whale	*Balaenoptera borealis*	Endangered	NLAA
Sperm whale	*Physeter macrocephalus*	Endangered	NLAA
North Pacific right whales	*Eubalaena japonica*	Endangered	NLAA
Giant manta ray	*Manta birostris*	Threatened	NLAA
Oceanic whitetip shark	*Carcharhinus longimanus*	Threatened	NLAA
Source: Hamer Environmental (2018)			

The Proposed Action is "likely to adversely affect" (LAA) one species, the Laysan duck, and "may affect but not likely to adversely affect" (NLAA) the 16 other species and critical habitat. Therefore, concurrence and formal consultation under Section 7 of the ESA are both required. This BA provides specific protective measures that would be implemented to avoid and minimize impacts to these 17 species and critical habitat.

The USFWS is planning and would conduct the Proposed 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 Animal and Plant Health Inspection Service (APHIS), the National Oceanographic and Atmospheric Agency (NOAA), U.S. Geological Survey, and the State of Hawaii Office of Hawaiian Affairs.

1.2 BACKGROUND

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). Over three million birds, encompassing 25 different species, can be found at MANWR and all of them are susceptible to predation by mice.

The federally listed Laysan duck (*Anas laysanensis*) population is important because of the very limited range and small global population size of this species. The translocated population of Laysan ducks is a species considered "critically endangered" (CR) by the IUCN as well as one of the most imperiled waterfowl in the northern hemisphere (BirdLife International 2016).

Invasive house mice (*Mus musculus*) and black rats (*Rattus rattus*) became established on Midway Atoll's Sand Island more than 75 years ago during military occupancy. Eradication of rats from the NWHI was confirmed in 1997 (USFWS unpublished data, Rauzon 2001, Reynolds and Klavitter 2006), leaving the house mouse as the sole rodent and non-native mammal present. The Proposed Action was identified as a need in the PMMP, completed in December 2008, as Strategy AS-4 with a goal of developing an eradication plan within five years.

The need for the Proposed 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 (DuhrSchultz et al. In Press). The refuge is home to the largest albatross colony in the world. It is the most important and successful breeding ground for black-footed albatross and Laysan albatross; the NWHI are home to approximately 97.5 and 99.7 percent of the total worldwide population of these albatross species, respectively, and both are considered "near threatened" (NT) by the International Union for Conservation of Nature (IUCN). By itself, the MANWR is globally significant, supporting 36 percent of all black-footed albatross and 73 percent of all Laysan albatross. A complete census finalized in January 2017 concluded that Sand Island alone has approximately 360,000 pairs of Laysan albatross and 15,084 pairs of black-footed albatross (USFWS Unpublished).

The detrimental effects of house mice predation on nesting albatross was first detected on Sand Island in 2015. Time lapse photography recorded mice repeatedly crawling onto and biting the head, neck, and backs of adult birds (see Figure 1.3 and Figure 1.4). Necropsy and histopathology results from recovered carcasses indicate bacterial infection from bite wounds as the cause of death. In that nesting year (2015-2016), three areas on the island totaling 4.08 ac. (1.65 ha) were affected, and there were 42 adult bird fatalities, and 70 nests were abandoned. During the next nesting year (2016-2017) the affected area increased to 27 ac. (11 ha) and mice predation caused 242 adult albatross fatalities and 994 abandoned nests (DuhrSchultz et al. In Press).

As mouse predatory behavior is likely to spread on Sand Island, the negative impacts to Laysan ducks could be significant to the global population. If mice are tenacious enough to attack and cause mortality to the Laysan albatross, one of the largest ground-nesting seabirds at MANWR, then it is likely that mice are having similar negative effects on other ground nesting birds, including the Laysan duck. In addition, mice could be competing with ducks for invertebrate food resources. Mice are known to be a seed predator on *Eragrostis variabilis*, an important grass providing cover for Laysan ducks. The proposed mouse eradication would allow recruitment of native grasses useful for Laysan ducks as shelter, nesting, and foraging habitat (VanderWerf 2012).

Predation of vulnerable populations of native seabirds is a real and ongoing threat on Sand Island that demands an immediate and effective response. Eradication of the house mouse would also facilitate the protection and restoration of all native species and habitats present in the refuge, including federally listed species and any designated critical habitats.

Figure 1.3 Adult Laysan albatross on Sand Island showing effects of predatory mice.

Source: USFWS (2016)

Figure 1.4 Mouse biting the head of adult Laysan albatross on Sand Island

Source: USFWS (2016)

CHAPTER 2: DESCRIPTION OF THE PROPOSED ACTION

After careful study, the USFWS has concluded that the only viable approach to completely remove the house mouse from Sand Island, MANWR is the use of rodenticide(s) (USFWS 2018). 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 completely eradicating mice. Use of rodenticide requires the delivery of rodenticide-impregnated bait into every potential mouse territory.

The Proposed Action is detailed further in this chapter. In general, the action will be accomplished in three phases, pre-operations, during operations, and post-operations. The action will employ three different methods of bait delivery (bait stations, and hand- and aerial bait broadcast). Bait applications will occur in July/August 2019 (Table 2.1). Conducting the operation during the summer dry season would target mice when their food resources are at their lowest and their abundance is declining. This timing additionally targets an optimal weather window of seasonally low rains and winds, and the period when relatively few shorebirds and seabirds are present and when the peak of the monk seal pupping season is over.

Table 2.1 Timeline of the Proposed Action for a July/August Bait Application Schedule

Timeline for Phases of Proposed Action July/August 2019 Bait Drop Schedule	2018							2019											
	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
Phase 1 Pre-Operations (2018-Jun to 2019-Jun)																			
Laysan duck (LADU) mitigation planning	■	■	■	■	■	■	■												
Arrival of materials for LADU mitigation needs					■	■	■	■	■	■									
Aviary/Infirmary construction (Sand Island)						■	■	■	■	■	■	■							
Aviary/Infirmary & wetland enhancement (Eastern Island)						■	■	■	■	■	■	■							
LADU Capture efforts									■	■	■	■	■	■	■	■	■	■	■
LADU Captive care on Sand Island									■	■	■	■	■	■	■	■	■	■	■
Wing-clipping and translocations to Eastern Isl.												■	■	■	■	■	■	■	■
Arrival of cargo and personnel for project monitoring													■	■					
Staff trainings									■	■	■	■	■						
Establish baiting grids (hand-broadcasting)														■					
Baseline monitoring begins														■					
Bait station preparations													■	■					
Cargo arrival and staging of operational equipment												■	■						
[redacted]																			

Timeline for Phases of Proposed Action July/August 2019 Bait Drop Schedule	2018							2019											
	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
Phase 2 During Operations (2019-Jul/Aug)																			
LADU capture continues																			
Translocate all LADU to Eastern Isl.																			
Covering ponds/water pools on Sand Isl.																			
Monitoring continues																			
Bait station grids placed; check and re-bait																			
Hand- and aerial broadcasting – first and second application																			
Hand- and aerial broadcasting – third application																			
Phase 3 Post-Operations (2019-Aug to 2019-Dec)																			
LADU mitigation continues/phased out																			
Monitoring continues/phased out																			
Bait station grids checked and re-baited/phased out																			
Final mop-up applications																			
Staging area breakdown; project crew & gear depart																			
Source: Hamer Environmental (2018)																			

2.1 PHASE 1: PRE-OPERATIONS

Preparations for the Proposed Action would occur during Phase 1. Elements of this phase include ship transport of gear and materials from Honolulu to MANWR, initiating the duck mitigation and the project's monitoring plans, training personnel, and preparing for Phase 2.

Phase 1 encompasses the arrival of project materials and equipment. Strike avoidance procedures would be implemented (Section 2.4) along with any additional measures recommended in the PMNM permit to avoid ship strikes with threatened or endangered marine species. If necessary, the vessel would shut down and the engine would only be restarted after the species leave(s) the area. Biosecurity measures per MANWR's Biosecurity Plan would be followed (Appendix A). Rodent-proofing measures would be in place for arriving air and watercraft. Biosecurity inspections of personnel and personal luggage would occur at the point-of-entry. Cargo would be offloaded into a secured receiving area until inspected.

Preliminary stages of implementing the Laysan Duck Mitigation Strategy would focus on meeting the objectives specified in the plan for the capture and captive-holding of ducks, and on wing-clipping methods on Sand Island (Appendix C – Sections 4.3 and 4.4). Initial mitigation actions include locating and preparing aviary sites, and obtaining equipment and materials for building traps, aviaries, and temporary holding pens (Appendix C – Section 4.3). Personnel would begin capturing ducks in February/March 2019 for a July/August 2019 bait drop schedule (Table 2.1). Collection stations to process captured ducks would be temporarily setup for the initial capture efforts. Personnel will include a wildlife veterinarian and an aviculturist, three capture specialists and three protection team members. Protection team members will assist with captive care tasks including food preparation, feeding aviary birds, cleaning aviaries, observation of marked birds on Eastern, supplemental feeding on Eastern, Guzzler cleaning, surveillance on Sand Island, and other duties (Appendix C – Ch. 1., Table 1.2).

Baseline monitoring per the Proposed Action's Monitoring plan (Appendix B) would begin in Phase 1. Initial work would include obtaining and organizing scientific equipment and supplies and establishing sampling and monitoring stations. As Phase 1 progresses, the collection of samples for the documentation of baseline conditions would occur.

Other preparations that would take place ahead of the baiting operation include establishing baiting grids and staging of bait (Sections 2.2.1 and 2.2.2, respectively) and covering seeps. Establishing grids would include marking each hand-broadcast point with flagging or pins and recording each using global positioning system (GPS) technology. Staging bait is used for hand-broadcasting and involves caching bait at various accessible locations to minimize the time and effort needed for baiters to refresh their supplies as they progress across the treatment areas.

Proximate to the first aerial bait application, seeps would be covered to prevent bait from entering. There are several natural and manmade seeps present in the baiting area which provide habitat for Laysan ducks, shorebirds, and migratory waterfowl. The seeps include small pools that are near the water tanks, in areas of former housing along Henderson Street, and west of the active dump. Tarps and/or shade cloth would be used to cover guzzlers for the duration of the project. Seeps would likely be covered with shade cloth that is supported and secured in a manner to keep the cover over the water. The seeps will be covered shortly before the application and then rolled up afterwards between applications to eliminate potential problems caused by persistent wind and the chance of rain, both of which could cause challenges in effectively keeping the water covered. Removing the cover would be done in a way that collects any bait that settled on top (e.g. rolling up the cover or sweeping it off first). The risk of any pellets settled near the shore falling in the water is very low, given the open terrain and sparse vegetation around these sites on Sand Island.

2.2 PHASE 2: DURING OPERATIONS

All of Sand Island's 1,128 ac. (456 ha) will be treated with rodenticide during Phase 2 via bait stations, hand-broadcasting, and aerial broadcast applications using a helicopter and bait bucket. The action will involve the aerial broadcast of bait pellets containing rodenticide into all potential mouse territories on Sand Island along with supplemental hand-broadcasting of bait in designated areas (Section 2.2.2) and placing bait stations in commensal areas (Section 2.2.1). The first rodenticide application would occur in July 2019. A second application would occur roughly 7-10 days later, and a third application conducted roughly 7-10 days after the second application. Active management to prevent nontarget impacts to native wildlife and the marine environment will be in effect during each application effort. Monitoring in the form of biological sampling and surveying of specific ecosystem components will occur throughout this phase.

Laysan duck mitigation will continue during Phase 2. The ~200 captive ducks held in aviaries on Sand Island will be relocated to Eastern Island aviaries immediately before the bait application to minimize the chance of them accidentally ingesting bait pellets or insects that have fed on the bait. The exception would be ducks under more intensive veterinary care. The methods of duck transport and personnel-hours projected is detailed in the Laysan Duck Mitigation Strategy (Appendix C – Sections 4.2 and 4.4; Ch. 1 Table 1.2).

2.2.1 BAIT STATIONS

Bait stations were previously and successfully used at MANWR in the 1990s to eradicate *Rattus 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 ~10 ft. (3 m) intervals. Bait stations will incorporate designs that extend the life of the bait and prevent larger, non-target species from entering and accessing the bait. For this eradication, bait stations will be placed in commensal areas, on piers, and possibly along areas of the rocky coastline. Within the commensal environment, areas like kitchens and buildings where people live will be treated with enclosed bait stations (either tubes or bait boxes with lids), all other buildings will be treated with bait trays, and unsafe or difficult to access locations will be treated with bait bolas. Once stations are placed, bait crews would arm and check stations regularly and rearm each station over a period of months until bait take by rodents declines to zero.

2.2.2 HAND-BROADCAST

Rodenticide bait pellets would be hand-broadcasted in specific designated areas. Any work related to hand broadcasting will occur proximately to each of the aerial bait drops. For successful hand-broadcast of bait, preparation is required to ensure efficient application and to minimize delays and errors in bait application. Preparations for bait application include preparing the baiting grid and staging bait. In general, about one person-hour of preparation for every 2 person-hours of baiting would be needed for hand-broadcasting.

The areas that would be designated for hand-broadcasting operations would not require vegetation clearing or preparation of transects. These areas would include: 1) an approximate 0.02 mi.^{2} (5.6 ha) area buffer around the water catchment pond located between the runways, 2) a potential narrow strip of land between the coast and the runway (at the southeast end of the runway), and 3) unoccupied commensal environments such as within aboveground and underground structures. For hand-broadcasting of bait around the water catchment pond, an estimated 16 person-hours would be needed to prepare the baiting grid and stage bait, and an additional 32 person-hours per application to apply bait. If hand-broadcasting occurs on the narrow strip of land at the southeast end of the runway, another 16 hours of prep and 32 hours of baiting per application would be needed. Unoccupied environments not targeted for bait station treatment may be hand-broadcasted instead. Overall, for the entire operation, a maximum of 240 total person-hours is estimated to be needed for hand-broadcasting given 3 scheduled drops, 8-person teams, and 10-hour work days.

2.2.3 AERIAL BROADCAST

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.

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. Bait application rates are set to ensure that adequate amounts of bait remain available to mice for long enough to be effective. Keitt et al. (2015) found up to four nights of bait availability may be necessary to eradicate mice. 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 always controlled by the pilot who opens and closes the bait bucket on demand to apply bait in desired areas and minimize bait application in other areas, such as the marine environment. Further, a video camera can be fitted to the underside of the helicopter to confirm that bait is being spread when the pilot opens the bucket. The bucket will 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 this deflector.

Three bait drops are planned with 2 helicopters to maximize the chance of completing each drop in a single day. These drops would be spaced 7-10 days apart. Overall, it is expected that bait drop densities would average 65 lbs./ac (73 kg/ha) in the bait application area. This program would ensure that bait is available to mice for a minimum of 4 nights each drop, and it would intercept any new generations of mice that may have been missed or emerge after earlier bait applications. All applications would be made in compliance with the Environmental Protection Agency (EPA) bait label. The bait would be applied according to a helicopter flight plan that accounts for the need to: (*i*) apply bait relatively evenly and to prevent any gaps in coverage and minimize overlap in bait application; (*ii*) accommodate island topography; (*iii*) minimize bait spread into the marine environment; (*iv*) minimize disturbance to native wildlife and; (*v*) ensure human safety.

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 in wind speeds greater than 30 knots, or when heavy rains are forecast to occur within 72 hours. While 30 knots is a maximum sustained wind for operations, wind will be assessed in conjunction with other weather conditions and operational hazards before conducting flights. In addition, for areas near the shoreline, the bait bucket 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 narrow shorelines, 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. For the Proposed Action, bait pellets have been formulated such that they would dissolve quickly, often within 15-30 minutes, such that the concentration of rodenticide in the nearshore waters would be at undetectable levels and would pose very low, if any risk to marine fish and invertebrates, coral, and algae. Bait would be applied at the lowest rate possible to achieve eradication. 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. Any bait spills above a defined threshold would be collected and disposed of according to label instructions.

2.3 PHASE 3: POST-OPERATIONS

Post operation activities will follow the last bait application and focus on finalizing the project. A final sweep of the island for mice following the last aerial and hand-broadcast bait applications will dictate any further actions regarding additional baiting needs and the departure of project crew and equipment. Commensal bait stations would continue to be armed and checked until no bait is taken or the number of mice caught goes to zero.

Surveys of the beaches, coastal waters, and terrestrial areas will be conducted to monitor various aspects of the operation (Appendix B). These surveys will include assessing bait persistence, removing mouse carcasses, retrieving sick or injured wildlife, and collecting samples (including non-target fatalities) for pesticide testing. Every precaution will be taken to avoid impacting non-target species while maximizing the chance of project success. We will use adaptive management techniques to adjust the project if we experience any significant unintended consequences to non-target organisms. 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.

Monitoring efforts (Appendix B), specifically those efforts conducted as part of the Laysan Duck Protection Strategy (Appendix C), would focus efforts on determining the release time of captive ducks (Appendix C – Section 4.6). Birds being held in the Eastern Island aviaries would be kept there until there is confirmation through a four-step process to determine when it is safe to release ducks back to Sand Island. These four steps include: 1) there are no pellets remaining in the environment; 2) brodifacoum residue levels measured in selected invertebrates reach levels deemed safe (Horak et al. 2018, Mineau 2018) (Appendix C – Sections 4.6.2.1); 3) migratory shore-birds returning from their northern breeding grounds appear to be staying healthy upon arrival, and; 4) sentinel canaries and Indian mynahs are released on Sand Island and show no ill effects (Appendix C – Sections 4.6.2.1). Monitoring will also include the recapture of any released ducks demonstrating signs of toxicosis (Appendix C – Section 4.3.3). Population size, reproductive performance, and behavior of Laysan ducks will be monitored into 2020 (Appendix B).

2.4 CONSERVATION MEASURES INCORPORATED INTO THE ACTION

Several conservation measures are incorporated into the Proposed Action. Conservation measures are actions that are part of the project description that will be implemented to benefit listed species. The following avoidance and minimization measures will be taken:

- Implement the Laysan Duck Mitigation Strategy (Appendix C) and Laysan duck conservation measures outlined in the Proposed Monitoring Plan (Appendix B).

- Exercise extreme care during all phases of the project (Table 2.1) to minimize trampling or damaging pōpolo and lo'ulu. Prior to the project's field work, refuge staff will be briefed on the locations of pōpolo and lo'ulu populations in the action area, will be provided photo(s) and identifying description(s) of pōpolo and lo'ulu, and will take precautions to avoid, divert and/or limit human disturbance in areas with known pōpolo and lo'ulu populations.
- Maintain a 100 ft. (30.5 m) buffer from basking Hawaiian monk seals and sea turtles. This buffer will apply to all aspects of the project and for the entire duration of project activities.
- During aerial bait broadcast, helicopters will fly over resting Hawaiian monk seals but avoid hovering over or near them. Specialists will be on site that can monitor seals throughout the bait drop for disturbance and exposure risk and provide recommendations to the project manager based on those observations
- Exercise extreme care to not disturb basking Hawaiian monk seals and pupping activities during monitoring and sample-collecting activities or should biosecurity rapid response measures have to be implemented.
- During aerial bait broadcast, helicopters would fly over sea turtle basking areas but avoid hovering over or near them. Specialists will be on site that can monitor sea turtles throughout the bait drop for disturbance and exposure risk and provide recommendations to the project manager based on those observations
- A deflector on the helicopter's bait bucket will be used to minimize drift into the marine environment when flight paths are parallel with the shoreline.
- Helicopter pilots and on-the-ground observers would visually monitor the aerial application of bait, and if a malfunction were detected, operations would cease until the problem is corrected.
- Helicopter pilots will apply bait within weather windows favorable for aerial broadcasting (*e.g.*, low wind, low or no precipitation, good visibility).
- Strictly adhere to biosecurity guidelines (Appendix A) throughout the entire project, and especially during the transport of Laysan ducks and avian support crews from Sand Island to prevent the spread of mice to the rodent-free Eastern Island.
- To minimize the chance of ship strikes to listed marine species, the following Best Management Practices will be used:
- Strictly adhere to Best Management Practices (BMPs) for strike avoidance guidelines and protocol during the ocean transport of materials and equipment between Honolulu and Midway Atoll. Vessels delivering materials and equipment will implement strike avoidance procedures and any additional measures to avoid the risk of negatively affecting endangered marine species (Table 4.1). The BMPs for ship strike avoidance are:
- All vessels would comply with biosecurity protocols specified in Appendix A.

- Reduce vessel speed to 10 knots or less when piloting vessels in the proximity of marine species listed in Table 4.1;
- Reduce vessel speed to 5 knots or less when piloting vessels in areas of known or suspected activity for those marine species listed in Table 4.1;
- The vessel would stop when protected marine species are within 656 ft. (200 m) of the ship. Vessel will resume operations only after the animal(s) depart the area.

CHAPTER 3: ACTION AREA

The Action Area, per Section 7 of the ESA (50 CFR § 402.02), means all areas to be directly or indirectly affected by the Proposed Action, including the immediate area involved in the action. Midway Atoll lies in the NWHI at 28˚15′ N and 177˚20′ W and consists of three sandy islets. Sand Island, where the bait application will take place, is the largest island at 1,128 ac. (456 ha); the other two are Eastern Island at 366 ac. (148 ha) and Spit Island at 15 ac. (6 ha) (see Figure 1.2). A channel, roughly 0.6 mi. (1 km) wide is present between Sand and Spit Islands. The distance between Spit and Eastern Islands is roughly 98 ft. (30 m) although this fluctuating channel can be difficult to distinguish at times. The Action Area includes Sand and Eastern Islands, the portion of the lagoon between these Islands, and the waters between Honolulu and Midway. During the project, Laysan ducks will be temporarily held on Eastern Island until rodenticide pellets are no longer available in the bait application area (Sand Island) for consumption, or when biological samples collected and analyzed indicate little to no risk of toxicity (see Appendix C).

The three islands together encompass a total land area of 1,498 ac. (606 ha) with a mean elevation of approximately 10 ft. (3 m) above mean sea level (+MSL). Together these three islands 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, Hawai‘i (see Figure 1.1).

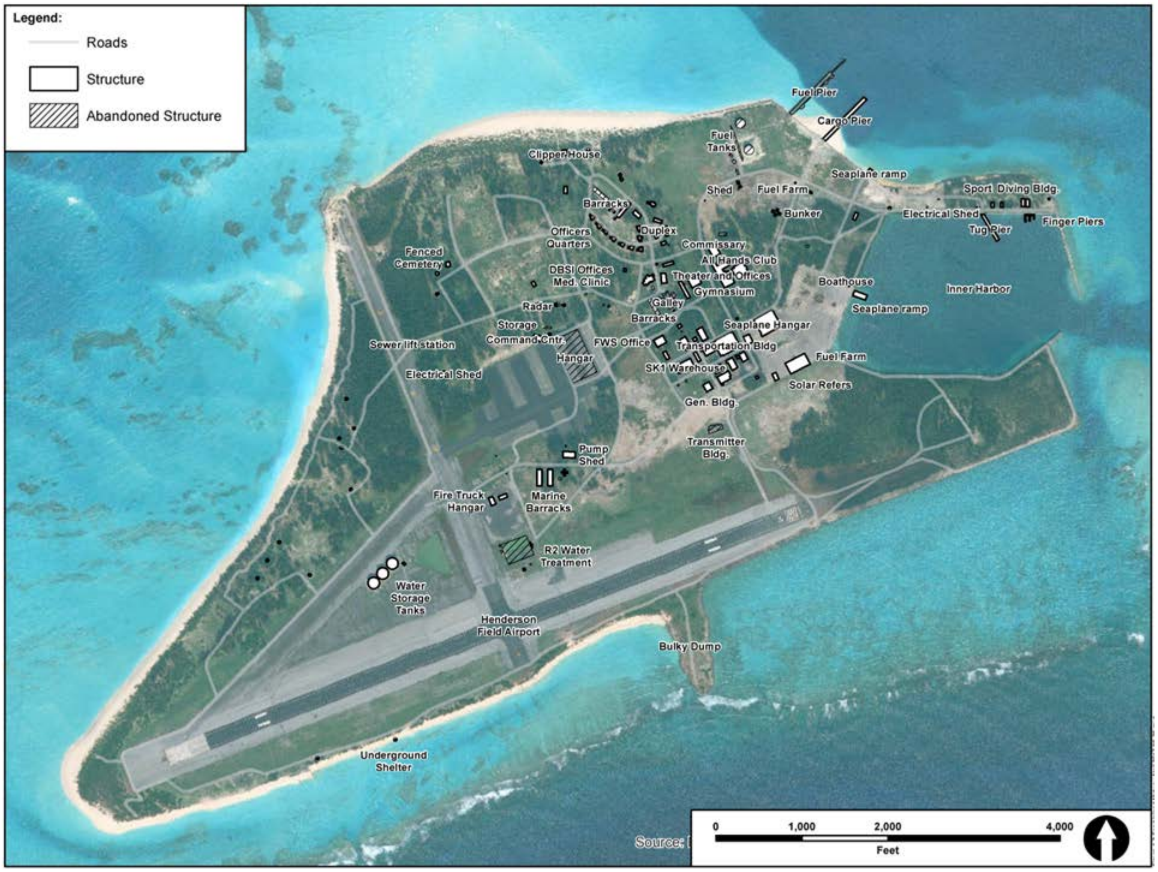
Midway Atoll became an overlay refuge in 1988, while remaining under the jurisdiction of the Department of the Navy. On October 31, 1996 President William Clinton officially established MANWR as a standalone refuge by Presidential Executive Order No. 13022. On September 13, 2000, the lands and waters 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, and expanded by President Obama’s Presidential Proclamation No. 8112.

Geographically, MANWR is part of the Hawaiian Islands archipelago, yet it is not part of the State of Hawai‘i. Rather, it is an unincorporated territory of the United States. Therefore, the State Hawai‘i has no jurisdiction over MANWR. Current funding for operations comes from the USFWS, supplemented by the Federal Aviation Administration (FAA), which fully funds airport operations costs on Sand Island and a share of infrastructure operations costs. A small amount of funding is generated by the other users of MANWR.

3.1 SAND ISLAND

As of 2018, the year-round community of people on Sand Island includes USFWS staff (4) and volunteers (1-4), base operations staff (~37) (mostly comprised of Thai nationals employed by Chugach Management), FAA airport staff (4) or research scientists (variable). There is also temporary construction workers and other contractors (<30) at times (USFWS Unpublished). Sand Island has extensive infrastructure, processes, and utilities in place to support the approximately 50-60 people that live and work there year-round, 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. There is well-developed infrastructure including subterranean utilities (electricity, potable water, and a closed sewer system), paved roadways, and roughly 115 structures including a commercial kitchen and dining hall (Figure 3.1). An influx of visitors to support island-based projects can elevate the population numbers to ~100 inhabitants while unplanned emergency landings from aircraft in distress has, and can, temporarily balloon local numbers to several hundred (USFWS unpublished data).

Figure 3.1 Roads and Infrastructure on Sand Island, MANWR (Action Area)



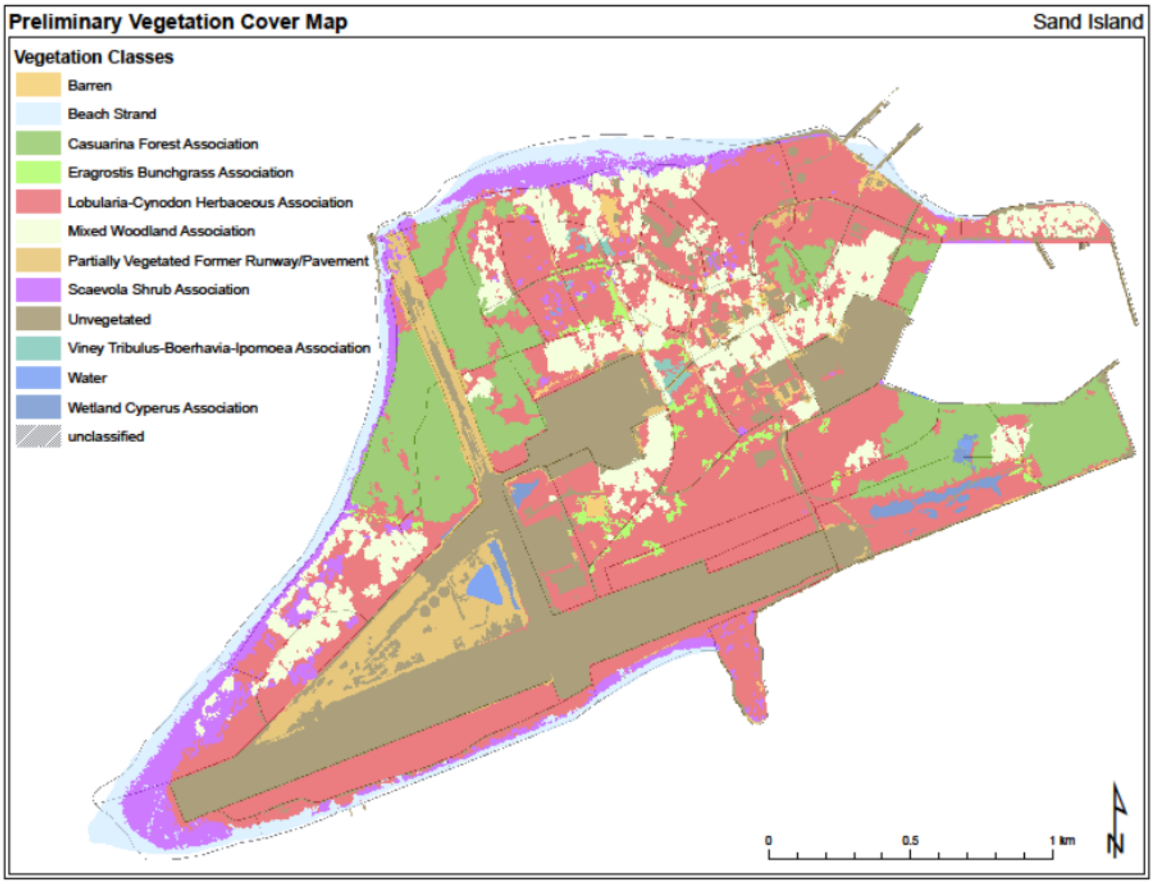
Source: Planning Solutions, Inc. (2018)

The infrastructure on MANWR provides a highly suitable base from which to implement the Proposed Action's 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.

The Henderson Field Airport is designated by the International Air Transport Association as airport code PMDY. A PMDY is a fully-certified airport maintained according to the standards specified in the FAA's Title 14 CFR, Part 139. Henderson Field Airport has a 7,900 ft. (2,407 m) runway capable of handling almost any type of aircraft. Midway is used as a required emergency landing site for extended twin-engine operations (ETOPS) flights across the Pacific Ocean.

Vessels accessing the island by water do so via a harbor and docking pier. Marine traffic is infrequent but includes a resupply barge or transport vessel approximately six times a year and annual National Oceanic and Atmospheric Administration (NOAA) research vessels that make MANWR a stop while voyaging to the more remote NWHI. Vegetation communities of Sand Island include Ironwood tree forests, mixed woodland, shrubs and vines, herbaceous and grassy, wetlands, beach strands, and barren areas (Figure 3.2).

Figure 3.2 Map of Vegetative Cover on Sand Island, MANWR



Source: Kelly Goodale, USFWS (2018)

3.2 EASTERN ISLAND

Eastern Island lies nearly a mile to the east of Sand Island. It is uninhabited today but was occupied during World War II. Like Sand Island, Eastern Island is naturally composed of coral sand and enhanced with man-made fill. A large part of Eastern Island is an abandoned three-runway airfield, and the rest is mainly open fields, roads, and sand beaches (Figure 3.3 and Figure 3.4). Rats were eradicated from Midway Atoll in 1995 and house mice are not present on Eastern Island. Since 2003, a focused invasive plant management program is effectively reducing the nonnative plant populations like *Verbesina* on Eastern Island thereby allowing native species to thrive (Duncan 2013). A population of critically endangered Laysan ducks were translocated to the island in 2005 (Reynolds and Klavitter 2006). The only human activities on Eastern Island currently are: (*i*) bird surveys; (*ii*) vegetation restoration and; (*iii*) guzzler maintenance for the Laysan duck.

Figure 3.3 Overgrown Airfield Runways on Eastern Island, MANWR

Source: http://footenotes.net/Pages/Midway.htm

Figure 3.4 Roads and Infrastructure on Eastern Island, MANWR

Source: Google Earth (2016)

3.3 WATERS BETWEEN HONOLULU AND MIDWAY

Midway Atoll is located approximately 1,313 mi. (2,113 km) northwest of Honolulu, Hawaiʻi (Figure 1.1). Midway atoll is at the western end of the Hawaiian archipelago. Materials and equipment needed for the Proposed Action would be shipped from Honolulu to Midway Atoll and back to Honolulu, as well as transit through the PMNM. Underway, the appropriate provisions for avoiding adverse effects to protected resources would be implemented, specifically, invasive species protocols and strike avoidance measures. The Biosecurity Plan addresses the specific measures to prevent an invasive species incursion (Appendix A), and BMPs for strike avoidance of listed marine species are outlined in Section 2.4.

CHAPTER 4: LISTED SPECIES AND CRITICAL HABITAT CONSIDERED

The Proposed Action may have adverse effects on federally-listed species and critically-designated habitats under the jurisdiction of USFWS and NMFS. This BA examines the status of those species and habitats that may be affected and provides information on their population size, distribution, life history, threats, and ongoing conservation measures. Information resources used include species recovery and conservation plans, status reviews, published and unpublished literature, and listing decisions.

This BA evaluates the potential adverse effects of the Proposed Action to seventeen federally-listed species and one critical habitat (see Table 4.1). Species and critical habitat assessed in this BA are categorized according to the agencies with jurisdictional responsibility. These agencies are: USFWS (3 species), joint USFWS and NMFS (3 species and 1 critical habitat), and NMFS (11 species). Species solely under the jurisdiction of USFWS have terrestrial components of their life cycle that may be impacted, while those under joint jurisdiction with NMFS have both terrestrial and marine components of their life cycle that may be impacted. Species that are listed as being under the jurisdiction of NMFS only have the marine component of their life cycle that may be impacted.

Table 4.1 Federally-listed species that may occur within the Action Area (n=17 species, n=1 critical habitat).

Common Name	***Scientific Name***	***Federal Status***
Birds (USFWS)		
Laysan duck	*Anas laysanensis*	Endangered
Plants (USFWS)		
Pōpolo	*Solanum nelsonii*	Endangered
Lo’ulu	*Pritchardia remota*	Endangered
Marine species (USFWS and NMFS)		
Hawaiian monk seal and Critical Habitat	*Neomonachus schauinslandi*	Endangered
Hawaiian green sea turtle Central North Pacific DPS	*Chelonia mydas*	Threatened
Hawksbill sea turtle	*Eretmochelys imbricate*	Threatened
Marine species (NMFS)		
Loggerhead sea turtle North Pacific Ocean DPS	*Caretta caretta*	Endangered
Olive ridley sea turtle	*Lepidochelys olivacea*	Threatened
Leatherback sea turtle	*Dermochelys coriacea*	Endangered
False killer whale MHI Insular DPS	*Pseudorca crassidens*	Endangered
Blue whale	*Balaenoptera musculus*	Endangered
Fin whale	*Balaenoptera physalus*	Endangered

Common Name	Scientific Name	Federal Status
Sei whale	*Balaenoptera borealis*	Endangered
Sperm whale	*Physeter macrocephalus*	Endangered
North Pacific right whales	*Eubalaena japonica*	Endangered
Giant manta ray	*Manta birostris*	Threatened
Oceanic whitetip shark	*Carcharhinus longimanus*	Threatened
Source: Hamer Environmental (2018)		

4.1 LAYSAN DUCK (*ANAS LAYSANENSIS*)

4.1.1 TAXONOMY AND SPECIES DESCRIPTION

The Laysan duck is a dabbling duck endemic to the Hawaiian Islands. This species is in the family Anatidae of the Anseriformes order. Also called Laysan teal, this species is ESA-listed due to its restricted distribution and small wild population.

Laysan ducks are considered small. Adults are approximately 15-17 in. (38-43 cm) in length and weigh around 15-18 oz. (420-500 g). Overall, it is a chocolate-colored bird with contrasting bi-colored body feathers, an iridescent purplish-green speculum (wing patch), and a prominent white eye ring (USFWS 1982, Moulton and Marshall 1996). Legs and feet are a pale dull orange and usually brighter in males.

4.1.2 HISTORICAL AND CURRENT DISTRIBUTION AND POPULATION

The Laysan duck was extirpated across the Hawaiian archipelago with an 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 Atoll in 2004 and from Midway Atoll to Kure Atoll in 2014 (Reynolds and Klavitter 2006, Reynolds et al. 2015).

The duck population on 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 duck's nesting and terrestrial foraging habitat (Work et al. 2010, Reynolds et al. 2017). An avian Botulism type C (*Clostridium botulinum*) outbreak also occurred following the tsunami flooding event, contributing to overall mortality documented in 2011 (Reynolds et al. 2017, USFWS unpublished data). After a 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 (Work et al. 2010, Reynolds et al. 2017). Botulism has emerged as a problem for the Laysan duck on MANWR, and mortality has occurred even with intervention by the USFWS (capture and treatment, hold and release, and habitat modification).

In an analysis of Laysan duck population sizes on MANWR, Reynolds et al. (in press) used 8 years of monitoring data to estimate population size and test the validity of an index to accurately monitor the abundance of this species. For her analysis, Reynolds fitted 587 Laysan ducks with unique markers from 2004 to 2015 and she recorded 21,309 re-sightings until March 2016. She also conducted standardized survey counts from 2007–2015. Then, a modified Lincoln-Petersen mark-re-sight estimator and statistical (ANCOVA) models were developed to test the relationship between survey counts and population abundance. Her results showed strong, positive correlations between the seasonal maximum counts and population estimates. The statistical models supported the use of standardized bi-monthly counts of unmarked birds as a valid index to monitor population trends among years and within a season at MANWR.

In 2015, Reynolds estimated there were between 314 and 435 Laysan ducks (95% CI for population estimate) on MANWR. 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. The model was then used to estimate the population of Laysan ducks on MANWR using survey data from March 2017 to March 2018 that included numbers from the non-breeding season (October-February). Using a maximum count of 372 ducks, the model returned a population estimate of 600 ducks with a range of 526-685 (95% CI) individuals (K. Goodale, Pers. Comm.).

In comparison, an estimate on Laysan Island in 2012 was 339 individuals (95% CI: 265–413). A more recent estimate is 581 adult birds (95% CI 503–682) on Laysan Island (Reynolds and Citta 2007). Further, wetlands were created on Kure Atoll and 28 Laysan Ducks were translocated there from Midway Atoll by a team including USGS, USFWS, and DOFAW in the fall of 2014; these had produced at least 19 fledglings by May 2015 and totaled 35-42 birds by 2016 (Reynolds et al. 2015), with continued successful breeding (Pyle and Pyle 2017).

4.1.3 HABITAT DESCRIPTION AND DIET

Laysan ducks utilize native vegetation for nesting, foraging, and shelter. Habitat requirements for adults and young include vegetative cover, an invertebrate prey base, a source of fresh water, and protection from mammalian predators (especially for ducklings) (USFWS 2004). 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).

The Laysan duck feeds almost solely on macroinvertebrates, primarily insects (Moulton et al. 1996). On Laysan Island, prey include Dipteran brine fly adults, larvae, and pupae taken in and around lakes and ponds, along with brine shrimp, whereas on MANWR, much of the prey is nonnative macroinvertebrates including cockroaches. During periods of drought and low water conditions, the birds depend more on terrestrial prey (BirdLife International 2016), such as invertebrates, seeds, and succulent plants (USFWS 2004). They also eat the larvae and pupae of noctuid moths (*Agrotis dislocate*) under low vegetation in upland areas. Ducklings have more restrictive requirements than adults because of their high nutritional requirements for growth and initial inability to process saltwater. Duckling activities are concentrated near sources of fresh water with nearby cover and high prey densities (USFWS 2004).

4.1.4 LIFE HISTORY

The Laysan duck is largely nocturnal and sedentary. The species is non-migratory and characterized by female-only parental care and high adult survival. On Laysan, long-term pair bonds are common (BirdLife International 2016). Relatively long-lived with a low reproductive rate, birds live about 12 years in the wild and 18 in captivity (Moulton and Weller 1984, Reynolds and Kozar 2000); on Laysan, ducks produce a clutch size averaging 3.8 eggs (USFWS 2004). This species can and does fly but it is much more prone to walk or run, as observed on Laysan when in pursuit of its main prey, brine flies (*Neoscatella sexnotata*, Ephydridae) (Moulton and Marshall 1996). The timing of breeding varies significantly between years, with the beginning of incubation varying from December to July (Reynolds et al. 2007). Egg-laying can begin as early as February and occur as late as November, but typically occurs from April to August; the initiation and duration of egg-laying varies from year to year.

On Laysan, molting typically occurs between July and August for males and between July and September for females. On MANWR, molt is August to October (USFWS unpublished data).

4.1.5 THREATS

Current threats to Laysan ducks vary. A small population size and extremely limited distribution make this species highly vulnerable to demographic fluctuation and chance of adverse environmental influences from droughts, severe storms, epizootics, predators, and invasive species (Mitchell et al 2005, Pyle and Pyle 2017, USFWS 2009). Alien species (mice, invasive weeds, and possibly predatory insects) can alter the Laysan duck's habitat (USFWS 2009). Habitat degradation and loss within PMNM may be intensified by increased storm severity and sea level rise associated with global climate change (Vanderwerf 2012). Mass mortality from avian botulism is also a threat, especially for the MANWR population of Laysan ducks that appear more sensitive to botulism outbreaks (USFWS 2009). The last severe outbreak of botulism at MANWR occurred in 2016 (K. Goodale, pers. comm.).

4.1.6 RECOVERY STRATEGY AND ONGOING CONSERVATION MEASURES

The primary recovery goal for Laysan ducks in the near-term is to achieve ESA down-listing from Endangered to Threatened status. The overall goal is delisting or removal from the endangered species list altogether.

Past and current conservation measures for Laysan Island are listed in the Laysan Island Ecosystem Restoration Plan (USFWS 2004). Measures recommended include those to restore the ecosystem: "weed control; alien invertebrate identification and control; vegetation, invertebrate, and vertebrate monitoring; propagation and out-planting of native plants; plant and invertebrate restoration; pollen core studies; vertebrate restoration (including the Laysan duck); and snake-eyed skink eradication" (Morin and Conant 1998). Management at MANWR includes monitoring the ecology and demography of the species as well as the enhancement and creation of freshwater habitats (VanderWerf 2012).

Conservation strategies undertaken at MANWR include measures to reduce the potential of an avian botulism outbreak (Appendix D). These measures occur on Sand and Eastern Islands and can include: weekly population monitoring that includes carcass removal and searches for sick birds; wetland carcass searches twice per week minimum during the summer months; and use of heavy equipment, manual removal of algae, and enhancement of habitat to improve water quality (Goodale 2018 in Appendix D).

Mice could also be competing with ducks for invertebrate food resources. Mice are known to be a seed predator on *Eragrastis* spp., an important grass and plant cover for Laysan ducks. The Proposed Action would allow recruitment of native grasses pertinent for Laysan duck shelter, nesting, and foraging (VanderWerf 2012).

4.1.7 GLOBAL CONDITION AND ACTION AREA

The Laysan duck persists only on Laysan Island and on the islands of Midway and Kure Atolls. As mouse predatory behavior is likely to spread in the Action Area, the negative impacts to Laysan ducks could be significant to the global population. If mice are tenacious enough to attack and cause mortality to the Laysan albatross, one of the largest ground-nesting seabirds on MANWR, then it is likely that mice are having similar negative effects on other ground nesting birds, including the Laysan duck.

Reintroduced birds on MANWR appear to breed successfully at an earlier age and produce larger clutches than birds on Laysan, probably owing to more food and a lower population density. Birds at MANWR breed in their first year and produce an average clutch of seven eggs whereas birds on Laysan nest in their second year, producing an average of 3.3 eggs (Reynolds et al. 2008, Walters and Reynolds 2013). Duckling survival is low on both atolls (BirdLife International 2016).

Botulism is a main concern for MANWR populations. After a severe botulism outbreak during 2016, 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 (Work et al. 2010, Reynolds et al. 2017). Efforts to prevent botulism outbreaks on MANWR are currently being implemented (Appendix D).

4.2 PŌPOLO (*SOLANUM NELSONII*) AND LO'ULU (*PRITCHARDIA REMOTA*)

4.2.1 TAXONOMY AND SPECIES DESCRIPTION

Pōpolo is a sprawling or trailing shrub up to 3 ft. (1 m) tall, in the nightshade genus of plants (*Solanum*) of the Solanaceae family (potato plants) and Solanales order (Gemmill 1998). Pōpolo was listed by the USFWS in 2016 as an endangered species wherever found (USFWS 2016a).

The Nihoa fan palm, or lo‘ulu, is a federally endangered species of palm endemic to the island of Nihoa. 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) (USFWS 1998).

4.2.2 HABITAT DESCRIPTION

Typical habitat for pōpolo is coral rubble or sand in coastal sites up to 490 ft. (150 m) in elevation (Symon 1999, TNCH 2007, HBMP 2010).

Loʻulu occurs in the dry climate of Nihoa but is distributed on the island that suggests the plant thrives in areas of greater water availability because many plants are found in valleys and near freshwater seeps by cliffs (USFWS 1998).

4.2.3 HISTORICAL AND CURRENT DISTRIBUTION AND POPULATION

Historically, pōpolo was known from the island of Hawaiʻi, the island of Niʻihau, Nihoa Island, Laysan Island, Pearl and Hermes Reef, and Kure Atoll (Lamoreaux 1963, Clapp et al. 1977, HBMP 2010). Currently, pōpolo occurs on the islands of Hawaiʻi and Molokaʻi, and on the northwestern Hawaiian Islands of Kure, Midway (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). Currently at MANWR, there are 915 pōpolo plants on Sand Island (Figure 4.1), ten plants on Spit Island, and one plant on Eastern Island (USFWS unpublished.

At the time of listing in 1996, loʻulu was limited to two extant populations on Nihoa (USFWS 1996). In 2009, approximately 300 seeds were brought to Midway Atoll to plant in the Service's greenhouse for out-planting within the atoll; a few plants survive on both Sand and Eastern Islands (Figure 4.2).

4.2.4 THREATS

The relatively isolated occurrences of pōpolo and loʻulu in the northwestern Hawaiian Islands are negatively affected (on the low-lying islands) by nonnative plants and by stochastic events such as tsunamis. Climate change may result in alteration of the environmental conditions and ecosystems that support this species. Pōpolo and loʻulu 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).

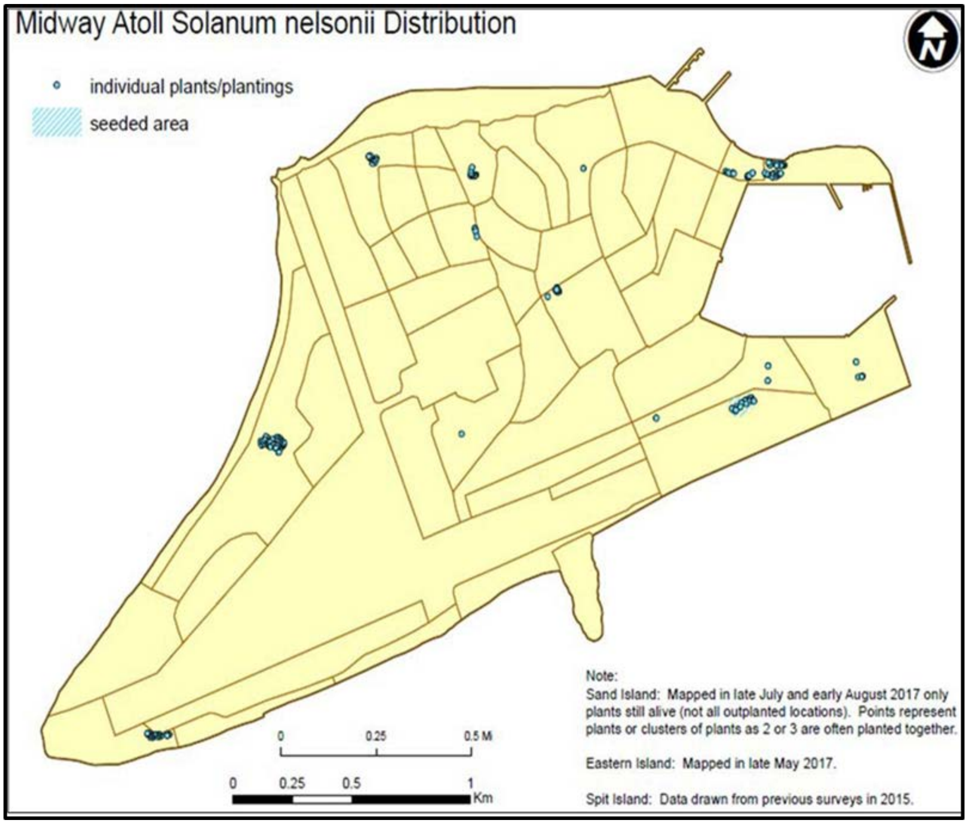
4.2.5 RECOVERY STRATEGY AND ONGOING CONSERVATION MEASURES

Conservation measures for pōpolo and loʻulu in MANWR include native plant propagation efforts, fencing or flagging areas where nursery out-plantings are located, monitoring established out-planted populations, and removing invasive nonnative plants. In 2017, planting and seeding of pōpolo was done in various locations on Sand and Eastern Islands (see Figure 4.1). Out-plantings are done to change the landscape, moving towards more native-dominated (and less non-native) plant communities. Out-plantings of pōpolo, along with Kāwelu (*Eragrostis variabilis*), ʻĀweoweo (*Chenopodium oahuense*), and other native species, is a conservation strategy whereby these plants will take advantage of the open landscape (and slightly less competitive environment). Loʻulu is represented in ex situ collections such as nurseries or arboretums (USFWS 1998, University of Hawaiʻi 2009) to ensure species viability. Recovery of the Nihoa populations include removing invasive weeds and monitoring seedling growth. Out-planting in other locations such as MANWR also safeguard against extinction.

4.2.6 GLOBAL CONDITION AND ACTION AREA

As of May 2018, the population of pōpolo at MANWR is 926 plants (Sand=915, Eastern=1, Spit=10 (USFWS unpublished). Propagation efforts have been extremely successful and under management, out-plantings proliferate (see Figure 4.1) (USFWS unpublished). Currently, only five lo‘ulu plants exist on MANWR with most located on Sand island (Goodale, K., pers. comm.) (Figure 4.2).

Figure 4.1 Pōpolo (*Solanum nelsonii*) locations on Sand Island (Action Area), MANWR.



Source: USFWS Unpublished.

Figure 4.2 Locations of Lo'ulu (*Pritchardia remota*) at MANWR

Source: R.V. Taylor (2017)

4.3 HAWAIIAN MONK SEAL (NEOMONACHUS SCHAUINSLANDI) AND ITS CRITICAL HABITAT

4.3.1 TAXONOMY AND SPECIES DESCRIPTION

The Hawaiian monk seal is one of the most endangered marine mammals in the world and the rarest pinniped in US waters (NOAA Fisheries 2016). Formerly in the genus Monachus, this earless seal is in the family Phocidae and order Carnivora (NMFS 2007). The Hawaiian monk seal and the Mediterranean monk seal are the only remaining monk seal species; a third species, the Caribbean monk seal, is extinct (NOAA Fisheries 2016).

In 1976, the Hawaiian monk seal was designated as “depleted” under the Marine Mammal Protection Act (MMPA), and as “endangered” under the ESA (NMFS-NOAA 2007). The Hawaiian monk seal is the only seal native to Hawai‘i, and, along with the Hawaiian hoary bat, is one of only two mammals that are endemic to the islands (NMFS 2007). This seal species has anatomical features that resemble those of the earliest monk seal fossils from 14-16 million years ago (Repenning and Ray 1977, Arnason et al. 1995, and Dèmère et al. 2003).

The ancient Hawaiian name was “llio holo i ka uaua” meaning “dog that runs in rough water”. 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 24-33 lbs. (11-15 kg) at birth and are about 3 ft. (1 m) long. The Hawaiian monk seal is silvery-grey colored on the back with lighter creamy coloration on their underside; newborns are black. Additional light patches and red and green tinged coloration from attached algae are common. The back of the animals may become darker with age, especially in males. Monk seals are known to live between 25-30 years (Marine Mammal Center 2018).

4.3.2 HISTORICAL AND CURRENT DISTRIBUTION AND POPULATION

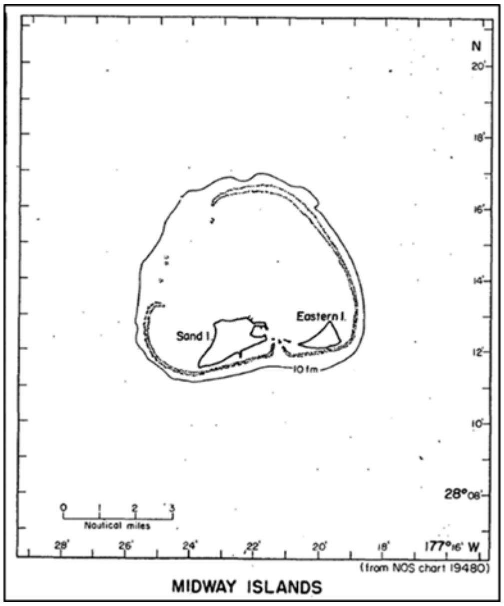
The Hawaiian monk seal's entire range is within U.S. waters. Primarily, these seals occur in two regions: the NWHI, comprising eight subpopulations located on remote atolls and small islands, and the MHI, comprising one subpopulation on eight large high islands and associated small islets (Littnan et al. 2015). The NWHI seals are found on: (*i*) Kure Atoll; (*ii*) Midway Atoll; (*iii*) Pearl and Hermes Reef; (*iv*) Lisianski Island; (*v*) Laysan Island and; (*vi*) French Frigate Shoals, (*vii*) Mokumanamana (Necker) Island and (*viii*) Nihoa Island (NMFS and NOAA 2007). Most of the seals in the NWHI are in the PMNM, which was designated in 2006 (NOAA Fisheries 2016). While sightings were previously rare in the MHI, a sub-population of about 300 seals are regularly seen there and births have been documented on all the major islands (Baker and Johanos 2004). Sightings outside of the main range have occurred at Johnston Atoll, Palmyra Atoll, and Wake Island (Ragen and Lavigne 1999). Following decades of decline, Hawaiian monk seal abundance increased 3% annually from 2013-2016. This positive trend is largely due to multiple years of increased juvenile survival in the NWHI (NOAA Fisheries 2016).

4.3.3 HABITAT AND DIET

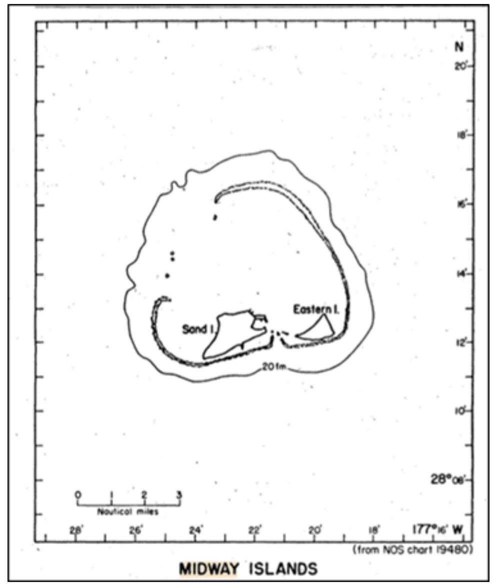
Hawaiian monk seals live in warm subtropical waters and spend two-thirds of their time at sea. They use waters surrounding atolls, islands, and areas farther offshore on reefs and submerged banks. These seals have also been found using deep water coral beds as foraging habitat. Hawaiian monk seals sometimes spend days at sea before returning to the islands where they sleep and digest their food. 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 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 (Figure 4.2).

In 1986, critical habitat was designated for the Hawaiian monk seal solely in the NWHI (Figure 4.3). The designation included "all beach areas, lagoon waters, and ocean waters out to a depth of 10 fathoms" and included "Midway Atoll (except Sand Island)" (NOAA-NMFS 1986). Sand Island was excluded because it had been substantially modified by the military and human activities, making it less desirable habitat for monk seals. In 1988, critical habitat for Hawaiian monk seals was extended from 10 to 20 fathoms in all areas previously designated as critical, which included Midway Atoll "except Sand Island and its harbor" (NOAA-NMFS 1986).

Figure 4.3 Designated critical habitat for Hawaiian monk seals at MANWR in 1986 (left) and 1988 (right).



Source: NOAA-NMFS (1986)

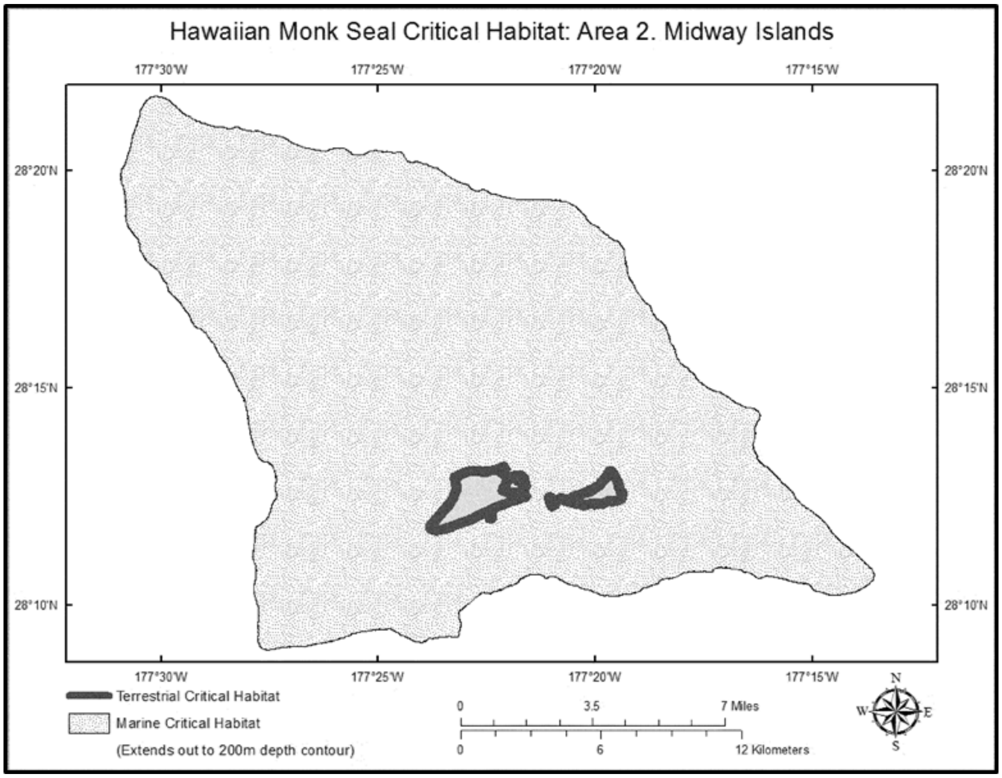


Source: NOAA-NMFS (1988)

Designated critical habitat for Hawaiian monk seals was last revised in 2015 (80 FR 50925) (Figure 4.4). This revision expanded and increased the protection of monk seals in the NWHI, added protection in areas of the MHI, and refined the description of critical habitat areas in the NWHI to be consistent with critical habitat defined for the MHI. As a result, "areas that are inaccessible to seals and/or have manmade structures that lack the essential features are not included in the designation for Hawaiian monk seal critical habitat throughout all sixteen specific areas" in the NWHI (NOAA-NMFS 2015).

Critical habitat for monk seals is defined by three essential features: "preferred pupping and nursing areas, marine foraging areas, and/or significant haul-out areas that will support conservation for the species" (NOAA-NMFS 2015). Specifically, critical habitat includes "all beach crest vegetation to its deepest extent inland, lagoon waters, inner reef waters, and marine habitat through the water's edge, including the seafloor and all subsurface waters and marine habitat within 32.8 ft. (10 m) of the seafloor, out to the 656 ft. (200 m) depth contour line (relative to mean lower low water) (NOAA-NMFS 2015). Suitable areas on Eastern and Spit islands are included in this designation (Figure 4.4). Sand Island is included in the 2015 designation as having critical habitat because it supports all three essential features for Hawaiian monk seal conservation; however, cliffs, manmade structures (and the land on which they are located), and hardened shorelines in existence prior to September 21, 2015 when the ruling went into effect, do not meet the definition of critical habitat and are not included in the designation. This includes the entirety of Midway Atoll's harbor and hardened shorelines along Sand Island (NMFS 2015).

Figure 4.4 Current critical habitat designated for Hawaiian monk seal at MANWR.



Source: NOAA-NMFS (2015)

The three essential features of Hawaiian monk seal critical habitat as defined by NMFS (2014) and ruled effective by NOAA-NMFS (2015) are:

1. **Terrestrial areas and the adjacent shallow sheltered aquatic areas with characteristics preferred by monk seals for pupping and nursing**. Preferred pupping areas generally include sandy, protected beaches located adjacent to shallow sheltered aquatic areas. Terrestrial pupping habitat may include various substrates accessible to seals for hauling out, such as sand, shallow tide-pools, coral rubble, or rocky substrates. Some preferred sites may also include areas with low lying vegetation utilized by the pair for shade or cover, or relatively low levels of anthropogenic disturbance. The adjoining sheltered aquatic sites may include reefs, tide pools, gently sloping beaches, and shelves or coves that provide refuge from storm surges and predators. Preferred pupping and nursing areas are defined as those areas where multiple females have given birth or where a single female has given birth in more than one year.

2. **Marine areas from 0-656 ft. (0-200 m) in depth that support adequate prey quality and quantity for juvenile and adult monk seal foraging.** Foraging areas essential to this species incorporate a wide range of benthic habitats. Monk seals focus their foraging efforts on the bottom, capturing prey species located on the bottom within the substrate of the bottom environment or within a short distance of the bottom (such that the prey may be

easily pinned to the bottom for capture). Therefore, features that support Hawaiian monk seal foraging include the seafloor and all subsurface waters and marine habitat within 32.8 ft. (10 m) of the seafloor; that portion of the water column above 32.8 ft. (10 m) from the bottom is not included within the critical habitat designation. Marine areas used by monk seals for travel and socializing are also not considered as critical habitat (NOAA-NMFS 2015).

3. **Significant areas used by monk seals for hauling out, resting, or molting**. Hawaiian monk seals do not congregate in large numbers. However, they reliably return to stretches of coastline that are favored for resting, molting, and socializing. Although many areas may be accessible for hauling out and are occasionally used, observed haul-out patterns demonstrate that certain areas of coastline are more often favored by Hawaiian monk seals for these activities. These haul-out sites are generally characterized by sandy beaches, sand spits, low rocky shelves and reef, or rocky areas accessible to seals. Significant haul-out areas are defined as natural coastlines that are accessible to Hawaiian monk seals and are frequented by Hawaiian monk seals at least 10 percent as often as the highest used haul-out site(s) on individual islands or islets. Stretches of coastline that maintain a combination of characteristics favored by monk seals for resting, molting and socializing may best be identified by evaluating actual monk seal usage of each island and using the frequency of use as a proxy for identifying those areas with significant characteristics

4.3.4 LIFE HISTORY

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. Video camera deployments on adult male monk seals have indicated that while in the water they spend 34% of their time resting, 9% interacting socially, and 57% of their time foraging and traveling (Parrish et al. 2000).

4.3.5 THREATS

Hawaiian monk seals face many threats. Low genetic diversity is a major concern. Threats also include food limitations in NWHI, loss of haul-out and pupping beaches due to erosion in NWHI, especially for juveniles and sub-adults; entanglement in marine debris; male aggression towards females; and human interactions in the MHI. Other impacts include becoming bycatch in fishing gear, mother-pup disturbance on beaches, and exposure to disease outbreaks (NMFS and USFWS 2007).

4.3.6 RECOVERY STRATEGY AND ONGOING CONSERVATION MEASURES

Hawaiian monk seals are monitored in MANWR by NMFS-NOAA, and periodic actions are undertaken with seals to enhance their survivability as part of a cooperative conservation effort between NMFS-NOAA, USFWS, USCG, and several non-governmental organizations (NGOs). Survivorship of juveniles is low and contributes to the endangered status of the species. Efforts to increase survivorship include a captive care program established by NOAA-Fisheries on Sand Island in 2006; six females were released in March 2007.

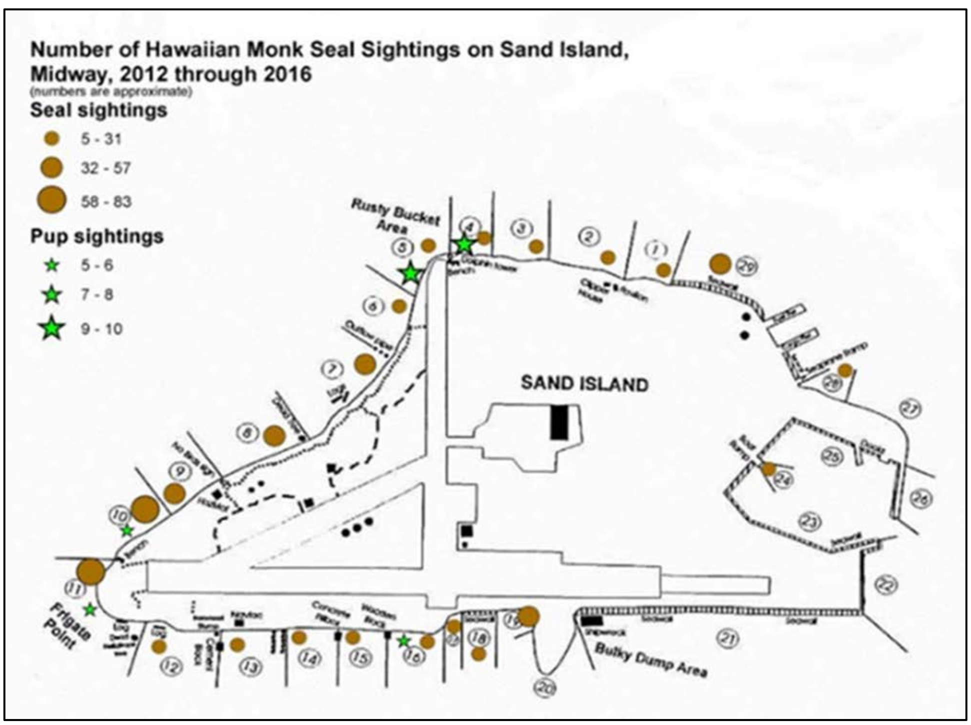
Public education campaigns, including projects to reduce monk seal-human interactions on the MHI, are building awareness about conserving the species and habitat. Volunteer groups are being expanded to help rescue and rehabilitate animals and prevent undue stress by keeping beachgoers away from resting animals. Direct efforts to disentangle seals and remove debris from haul-out sites have led to the removal of 492 metric tons (over 1 million pounds [446,335 kg]) of marine debris in NWHI since 1996, reducing injuries and death due to entanglement and digestion of marine debris (NOAA Fisheries 2016).

4.3.7 GLOBAL CONDITION AND ACTION AREA

The best estimate of the current total Hawaiian monk seal population is 1,400 seals, with about 1,100 residing in the NWHI from Nihoa to Kure Atoll (NOAA Fisheries 2016). Hawaiian monk seals are present year-round at MANWR, generally hauling ashore to rest (see Figure 4.2). The pupping season is predominantly February to July with only 3-4 animals typically having pups on in the Action Area (USFWS, unpublished data).

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 hr. In total, observers conducted 41 standardized beach surveys and recorded 486 Hawaiian monk seal sightings over this 5-year period. For seal data collection purposes, the perimeter of Sand Island is divided into 29 areas, or sectors, to describe the spatial properties of seal habitat use (see Figure 4.5).

Figure 4.5 Sand Island Hawaiian Monk Seal Sightings: 2012-2016



Source: USFWS (2016)

Beach count data are summarized below by sector location (Table 4.2). 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). Therefore, as many as 74 monk seals could be present on or around the Action Area during the Proposed Action. Seals within the Midway population move freely between all islets. Therefore, these animals could be present on or around both Sand and Eastern Island during the bait drop. Of course, seals are always coming and going from MANWR, and only a portion of the subpopulation is expected to be hauled out on beaches at any one time.

Table 4.2 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.

Sector	*Non-Pup Size Classes*			*Totals*		
	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 (Johanos 2017)

4.4 CENTRAL NORTH PACIFIC DPS GREEN SEA TURTLE (CHELONIA MYDAS)

4.4.1 TAXONOMY AND SPECIES DESCRIPTION

The Central North Pacific DPS green sea turtle (hereinafter, the green sea turtle) is a marine reptile in the Cheloniidae family and Testudines order (NMFS and USFWS 2007). The green sea turtle was first described by Linnaeus (1758) as Testudo mydas, with Ascension Island in the Atlantic as the type locality. Schweigger (1812) first applied the binomial *Chelonia mydas* that is still in use today (NMFS and USFWS 1998a). In 1978, the green sea turtle in Hawaiʻi was ESA-listed as threatened, and in 2016, they were removed from the range-wide and breeding population listing of ‘green sea turtle’ and instead were listed as one of eight distinct population segments (DPSs) as threatened (USFWS 2016b). In the NWHI, it is the Central North Pacific DPS of green sea turtles that are present.

In general, the green sea turtle is the largest of the cheloniids, with adults that can exceed 3.3 ft. (1 m) in carapace length and 220 lbs. (100 kg) in body mass. Green sea turtles at French Frigate Shoals in the NWHI average 36 in. (92 cm) in straight carapace length (SCL; range 81-106 cm, n=379) (Balazs 1980). The carapace is smooth with shades of black, gray, green, brown, and yellow; their plastron is yellowish white. Green sea turtles have a comparatively small head compared to their large body size (USFWS 2017). Hatchlings average about 1.8-2.1 in. (4.7-5.4 cm) in carapace length, and 0.05-0.07 lbs. (22-31 g) in weight (Marquez 1990, in Eckert 1993). The plastron of young green sea turtles becomes orange or yellowish orange, and the carapace remains predominantly black with various shades of olive and yellowish gold forming swirls and irregular patterns on their shells (NMFS and USFWS 1998a).

4.4.2 HISTORICAL AND CURRENT DISTRIBUTION AND POPULATION

Defining the global geographic range of the green sea turtle is difficult. By nature, these animals are highly migratory, and their life histories exhibit complex movements and migrations through geographically disparate habitats. Mitochondria DNA research conducted by Bowen et al. (1992) showed a fundamental phylogenetic split distinguishing all green turtles in the Atlantic-Mediterranean from those in the Indian-Pacific Oceans. In the Pacific Ocean, populations of green sea turtles are distributed in the eastern Pacific, the west coast of the continental United States; in the central Pacific, the state of Hawaiʻi and the unincorporated U.S. territories of Howland, Baker, Wake, Jarvis, and Midway Atoll, Johnston Atoll, Palmyra Atoll, and Kingman Reef; in Oceania, Guam, the Commonwealth of the Northern Mariana Islands (CNMI), and American Samoa. The U.S.-affiliated but independent nations of the Republic of the Marshall Islands (RMI), Federated States of Micronesia (FSM), and the Republic of Palau are also included. The FSM consists of the states of Yap, Pohnpei, Chuuk, and Kosrae (NMFS and USFWS 1998a).

The Central North Pacific DPS green sea turtle nests throughout the Hawaiian archipelago, with over 90% of nesting occurring at French Frigate Shoals, NWHI, where 200-700 females are estimated to nest annually (FENA = Females Estimated to Nest Annually) (Balazs et al. 1992). Low-level nesting (less than 25 FENA) is known or is likely to occur at Laysan Island, Lisianski Island, and Pearl and Hermes Reef (NMFS and USFWS 1998a). Balazs et al. (2015) summarized all existing data and knowledge on the demographic variables of green sea turtles in Hawaiʻi. After reviewing all data, from 1973 to 2012, they concluded that this population of green sea turtle is not at carrying capacity (Balazs et al. 2015). Specifically, they found that the population growth rates from 1973 to 2003 (Chaloupka et al. 2008), 1973 to 2004 (Chaloupka and Balazs 2007), and 1973 to 2012 "are statistically indistinguishable, indicating that the last 10 years have not demonstrated any slowing of population growth or negative density dependence as some predicted" (e.g., Chaloupka and Balazs 2007) (Balazs et al. 2015). The authors concluded that the population is "still growing at a robust rate and underscores historical analyses (e.g., Kittinger et al. 2013, Van Houtan and Kittinger 2014) that suggest the population was significantly more abundant historically" (Balazs et al. 2015). Because the Balazs et al. (2015) paper reviews all current and historical demographic data, it is the best available scientific data.

4.4.3 HABITAT DESCRIPTION AND DIET

Numerous publications identify current or historically important foraging areas in the NWHI (Necker Island, FFS, Lisianski Island, Pearl and Hermes Reef, Laysan Island, Midway Atoll, and Kure Atoll) (Balazs 1980, Balazs 1987, Arthur and Balazs 2008). Adult green sea turtles are herbivores, feeding on seaweeds, seagrasses, and algae (NMFS and USFWS 1998a). 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 and USFWS 1998a).

Critical habitat for this DPS has not been determined at this time but will be proposed in a future rulemaking (USFWS 2016b). This species is known to bask throughout the NWHI but it nests at only a subset of the islands, such as French Frigate Shoals (Figure 1.1) (Littnan et al. 2009, NOAA 2018).

4.4.4 LIFE HISTORY

Adult green sea turtles periodically undertake reproductive migrations between resident foraging pastures and distant sites where copulation and egg-laying take place. According to Owens (1980), mating precedes egg-laying by 25-35 days. Adult females emerge at night to excavate nests and deposit eggs during the warmer months of the year. In Hawai‘i, green sea turtles lay up to six clutches of eggs per season, with a mean of 1.8 (Balazs 1980). Clutches consist of about 100 eggs each, deposited into a nest at 10- to 15-day intervals; females do not breed every year, skipping two to three years, or sometimes more (NMFS and USFWS 1998a). Once the eggs are laid and covered they incubate in the sand unattended for about two months (54-88 days in Hawai‘i, with a mean of 64.5 [Balazs 1980]). The hatchlings dig upward in a communal effort and take 2-3 days before reaching the surface and emerging usually at night.

In the remote NWHI, and especially at French Frigate Shoals, adult male and female green sea turtles regularly haul out during the daytime to bask along the shoreline (Balazs 1980, Whittow and Balazs 1982). This behavior is not known to occur elsewhere in the insular Pacific region, although diurnally emerging non-nesting green sea turtles have been reported from the Galapagos and Australia (NMFS and USFWS 1998a).

In the Main Hawaiian Islands green sea turtles migrate to French Frigate Shoals in the NWHI from foraging pastures located both to the northwest and the southeast, involving one-way distances up to 808 mi. (1,300 km). In 1991, three females were satellite-tracked from their nesting grounds at

French Frigate Shoals to foraging grounds in Kaneohe Bay and Johnston Atoll. All three traveled beyond sight of land in water thousands of meters deep, two of them against prevailing winds and currents (Balazs 1994). Enough evidence exists to show that the turtles return to the same resident foraging areas following their time spent at the breeding grounds.

4.4.5 THREATS

Many facets of the green sea turtle's life history and ecology remain unknown. This absence of essential information constitutes a serious impediment to the long-term conservation and recovery of the affected populations. Historically, green sea turtles were relied upon as a source of nutrition by those residing in the Pacific Islands region (NOAA Fisheries 2017), and illegal harvesting of eggs and turtles is a continual threat (NMFS and USFWS 1998a).

From a global perspective, populations of green sea turtles in Hawaiʻi appear to have a somewhat less dire status, probably due to effective protection at the primary nesting areas and better enforcement of regulations prohibiting take of the species (NMFS and USFWS 2007). Threats to this DPS include impacts associated with increasing human populations and development, such as increased artificial lighting that divert newly emerged hatchlings away from the sea (NMFS and USFWS 2007), and diseases such as the tumorous disease (fibropapillomatosis) that threatens to eliminate improvements in the status of the stock. Fibropapillomatosis is a disease that causes multiple tumors to grow on the turtles' skin and internal organs. These tumors can interfere with the turtles' ability to see, swim, eat, breathe and reproduce, and they can eventually lead to their death (Chaloupka et al. 2009). Loss of nesting habitat due to climate change and sea level rise is a serious threat (Romine et al. 2013, Reynolds et al. 2012), as is marine debris (entanglement in and/or ingestion of) (NMFS and USFWS 1998a).

4.4.6 RECOVERY STRATEGY AND ONGOING CONSERVATION MEASURES

The National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (USFWS) share responsibilities at the Federal level for the protection, research, management, and recovery of Pacific sea turtle populations under U.S. jurisdiction. The USFWS jurisdiction for sea turtles covers terrestrial habitat such as beaches where nesting and/or basking is known to occur, and NMFS has jurisdiction over the turtle's off-shore and open ocean habitats. 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. The fishing industry has undergone a series of regulatory changes to protect marine turtles and the short-tailed albatross (NMFS 2001).

4.4.7 GLOBAL CONDITION AND ACTION AREA

Despite an overall declining trend globally, green sea turtle population growth rates are variable among nesting populations and regions. The green sea turtle population in Hawaiʻi is increasing in abundance and has increased 53% over the last 25 years. Low levels of green sea turtle nesting also occur in Guam, American Samoa, the Northern Mariana Islands, and other U.S. island territories. Information on population trends for green sea turtles in regions other than the Hawaiian stock is limited (NOAA Fisheries 2016).

Green sea 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 Island 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 (USFWS unpublished data).

4.5 HAWKSBILL SEA TURTLE (ERETMOCHELYS IMBRICATA)

4.5.1 TAXONOMY AND SPECIES DESCRIPTION

The hawksbill sea turtle is a marine reptile in the Cheloniidae family and Testudines order. In 1970, the hawksbill sea turtle in Hawaiʻi was ESA-listed as endangered throughout its range (Federal Register 1970, NMFS and USFWS 1998b). Hawksbills are small to medium-sized and have an elongated oval shell with overlapping scutes on the carapace. This sea turtle has a relatively small head with a distinctive hawk-like beak, and flippers with two claws. General coloration is brown with numerous splashes of yellow, orange, or reddish-brown on the carapace. Juveniles are black or very dark brown with light brown or yellow coloration on the edge of the shell, limbs, and raised ridges of the carapace. As an adult, the hawksbill may reach up to 3 ft. (0.91 m) in length and weigh up to 300 lbs. (136 kg), although adults more commonly average about 2.5 ft. (0.76 m) in length and typically weigh around 176 lbs. (80 kg) or less. It is the only sea turtle with a combination of two pairs of prefrontal scales on the head and four pairs of costal scutes on the carapace.

4.5.2 HISTORICAL AND CURRENT DISTRIBUTION AND POPULATION

The hawksbill is circumglobally distributed throughout the tropical and, to a lesser extent, subtropical waters of the Atlantic, Indian, and Pacific Oceans. They are migratory, and individuals undertake complex movements through geographically disparate habitats during their lifetimes (Mortimer and Donnelly 2008). Hawksbill nesting occurs in at least 70 countries, although much of it now is at low densities. Their movements within the marine environment are less understood, but they are believed to inhabit coastal waters in more than 108 countries (Groombridge and Luxmoore 1989, Baillie and Groombridge 1996).

In Hawaiʻi, hawksbills nest only on the beaches of the MHI, primarily along the east coast of the island of Hawaiʻi. Two of these sites (Halape and Apua Point) are in Hawaiʻi Volcanoes National Park (Balazs et al. 1992, Katahira et al. 1994). Other beaches on Hawaiʻi with recorded nesting include Kamehame, Punaluʻu, Horseshoe, Ninole, Kawa and Pohue. These known hawksbill beaches do not have nesting turtles each year. Kamehame Point on Hawaiʻi and a black sand beach at the river mouth of Halawa Valley at the east end of Molokaʻi are the most consistently used beaches for nesting. In surveys from 1989-1993, eighteen hawksbills were tagged, and 98 nests documented. There are no measurable trends in stock numbers, either up or down (NMFS and USFWS 1998b). This species can be found nesting and foraging in other Pacific U.S. territories but research on the population status and trends in these areas is on-going (NOAA Fisheries 2017).

4.5.3 HABITAT DESCRIPTION AND DIET

Hawksbills frequent rocky areas, coral reefs, shallow coastal areas, lagoons or oceanic islands, and narrow creeks and passes. They feed around coral reefs and rock outcroppings and primarily consume sponges. Their unique hooked beak is well adapted for probing into holes and crevices to find prey. Hawksbills play an important role in the health of coral reef systems by keeping certain types of sponges from taking over space and resources from corals and other organisms (NOAA Fisheries 2017). They are seldom seen in water deeper than 65 ft. (19.8 m). Nesting may occur on almost any undisturbed deep-sand beach in the tropics. Adult females can climb over reefs and rocks to nest in beach vegetation. Hatchlings are often found floating in masses of sea plants. Hawksbills 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 (needles).

Critical habitat for hawksbill sea turtles has not been identified or designated (NOAA Fisheries 2017). Through satellite tracking, the Hamakua Coast of Hawaiʻi Island has been identified as important foraging grounds (NOAA Fisheries 2017).

4.5.4 LIFE HISTORY

Hawksbills mature very slowly and are long-lived (Chaloupka and Musick 1997), although their actual average lifespan is unknown (NOAA Fisheries 2017). It is estimated that hawksbills become sexually mature between 20-25 years of age and will then nest every 2-3 years. They can lay as many as 3-5 clutches (nests) in one nesting season with about 16 days in between each nesting event. On average, a hawksbill nest will contain anywhere from 130-180 eggs (NOAA Fisheries 2017), although several records exist of over 200 eggs per nest (USFWS 2015). The eggs will incubate in the sand for around 62 days before the hatchlings dig their way up to the surface and make their way to the ocean (NOAA Fisheries 2017). In the Hawaiian Islands, nesting occurs from late May with hatching completed by early December; peak nesting activity occurs from late July to early September (Katahira et al. 1994).

The hawksbill turtle and its eggs have historically been a nutritional source for people in the Pacific Islands region. The shell of the hawksbill has been described as "the world's first plastic" and has served a multitude of purposes, both ornamental and practical. Bones were used to make tools, and other turtle parts were used as medicines. Turtles have also traditionally been the focus of important ceremonial or religious practices (NOAA Fisheries 2017).

4.5.5 THREATS

The decline of this species is primarily due to human exploitation for tortoiseshell. Although the legal trade of hawksbill shells ended when Japan agreed to stop importing them in 1993, a significant illegal trade continues. Other threats include loss or degradation of nesting habitat from coastal development and beach armoring; disorientation of hatchlings by beachfront lighting; nest predation by native and non-native predators; degradation of foraging habitat; marine pollution and debris; watercraft strikes; and incidental take from commercial fishing operations. Tourism development can also have detrimental effects on the coral reef feeding habitats of hawksbill turtles in the Main Hawaiian Islands and throughout the rest of this rapidly developing region (NOAA Fisheries 2017). There is evidence that oil pollution has a greater impact on hawksbills than on other species of sea turtle (Meylan and Redlow 2006). In the Main Hawaiian Islands (MHI), increased human presence, nest predation, and beach erosion are the primary threats (NMFS and USFWS 1998b).

4.5.6 RECOVERY STRATEGY AND ONGOING CONSERVATION MEASURES

The National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (USFWS) share responsibilities at the Federal level for the protection, research, management, and recovery of Pacific sea turtle populations under U.S. jurisdiction.

In 1975 the hawksbill sea turtle was included on Appendices I (Atlantic population) and II (Pacific population) of CITES (Mortimer and Donnelly 2008). By 1977 the entire species was moved to Appendix I to prohibit all international trade. Further protection is afforded through the Convention on Migratory Species (listed on Appendices I and II). Regional agreements also help to conserve hawksbills and their habitats (Regional Summaries, Appendix II). The increasing public awareness and interest in hawksbills continues to be an important recovery strategy. Numerous countries have temporarily or permanently banned all exploitation of sea turtles and their eggs and are attempting to improve enforcement of international bans on the tortoiseshell trade. International conservation efforts include collaborative projects with countries around the world to test turtle excluder devices on trawling nets, modified gillnets, circle hooks in longlines, and buoy gear.

4.5.7 GLOBAL CONDITION AND ACTION AREA

According to some early historical accounts, hawksbills may have occupied this the NWHI region in past centuries (NMFS and USFWS 1998b, Van Houtan et al. 2012). The hawksbill sea turtle is considered a rare visitor to MANWR. Though rare, documented records exist. A hawksbill was observed and photographed in the Midway Atoll lagoon in the location on the north side of the atoll known as “Reef Hotel” (Klavitter et al. 2013). On August 2011 at Midway Atoll, researchers on a snorkeling survey for *Pinctada* oysters photographed a juvenile at a 6.6 ft. (2 m) depth on the eastern backreef (Van Houtan et al. 2012). No confirmation could be made genetically to determine the turtle’s nesting beach, but Van Houtan et al. (2012) postulates that proximity might suggest these turtles came from the Hawaiian population because the next-nearest known nesting area is American Samoa (Hutchinson et al. 2008), which is 4 times the distance 2,734 mi. (4,400 km) away. A satellite track of a post-nesting female hawksbill showed the turtle traveling to the NWHI halfway between Kauai and Nihoa (G. Balazs, pers. comm., February 2012 *in* Van Houtan et al. 2012).

4.6 MARINE SPECIES (NMFS)

4.6.1 LOGGERHEAD SEA TURTLE NORTH PACIFIC DPS

The loggerhead sea turtle was first listed as threatened under the ESA in 1978 (NMFS and USFWS 1998c). In 2011, the loggerhead was grouped into nine DPSs, of which the population surrounding Midway is within the endangered North Pacific Ocean DPS (NMFS-NOAA 2011a). Turtles within this DPS forage in the central and eastern Pacific, returning to natal beaches in Japan to reproduce, and then remain in the western Pacific (Polovina et al. 2006).

There is no loggerhead nesting on the western seaboard of the United States or in Hawai‘i, nor is there any documentation to suggest that nesting occurs in any of the U.S. unincorporated island territories of the Pacific (Balazs 1982). Similarly, there are no nesting records from Guam, Commonwealth of the Northern Mariana Islands, Palau, Republic of the Marshal Islands (Thomas 1989), Federated States of Micronesia (Pritchard 1982), or American Samoa (Tuato’o-Bartley et al. 1993). There are very few records of loggerheads nesting on any of the many islands of the Central Pacific; the species is considered rare or vagrant in this region (NMFS and USFWS 1998c). This loggerhead DPS is not known to cross the equator nor to mix with individuals from the Southern Pacific DPS and are genetically isolated from populations outside of the Pacific by an estimated one million years (NOAA Fisheries 2014). The North Pacific Ocean DPS is threatened by elimination and degradation of nesting habitat, sea level rise, and incidental bycatch in fishing gear. Critical habitat has been designated only for the Northwest Atlantic DPS of loggerheads.

4.6.2 OLIVE RIDLEY SEA TURTLE

Adult olive ridleys are easily distinguished from other sea turtle species. The olive ridley is the smallest living sea turtle with an adult carapace length usually between 24-28 in. (60-70 cm) and a weight rarely exceeding 110 lbs. (50 kg) (Schulz 1975). Their name comes from their round-shaped, pale olive carapace, and yellow-olive plastron. Globally, their population numbers are high but heavily exploited (NMFS and USFWS 1998d). The species is threatened by the impacts of poaching, incidental bycatch, and habitat degradation and development (NMFS and USFW 2014). No critical habitat has been designated for the olive ridley (NMFS and USFWS 1998d).

This species commonly nests along continental margins using arribidas (mass, synchronized nesting). It is possible that young turtles move offshore and occupy areas of surface current convergences to find food and shelter among aggregated floating objects until they are large enough to recruit to the nearshore benthic feeding grounds of the adults (NMFS and USFWS 2014). It is unknown whether the olive ridley has a truly pelagic habit; further research is needed in this regard. At sea in the eastern tropical Pacific, olive ridleys readily associate with objects floating in the water including anything from logs to plastic debris to dead whales (Pitman 1992, Arenas and Hall 1992) and appear strongly attracted to brightly colored objects (Arenas and Hall 1992). Olive ridleys often bask at the surface in the eastern Pacific where they are frequently accompanied by seabirds. The birds, mainly boobies, roost on the exposed carapaces of the turtles and feed on fish that aggregate beneath them (NMFS and USFWS 1998d, Pitman 1993).

While rare in Hawaii, olive ridleys have occasionally been killed by commercial fishing vessels (NMFS and USFWS 1998d). The entanglement of juveniles and adults in marine debris around the Hawaiian Islands is reported from Kailua-Kona (Hawaii), Pukoo (Molokai), Hana (Maui), and Oahu (Balazs 1985). A single nesting event was recorded on Maui in 1985 (NMFS and USFWS 1998d). Genetic analysis of olive ridley sea turtles taken in the Hawai‘i-based longline fishery shows that about two-thirds of the animals came from the eastern Pacific, while the remaining one-third originated in the western Pacific or Indian Ocean, suggesting that Hawai‘i represents a point of convergence for these source areas (Mitchell et al. 2005).

4.6.3 LEATHERBACK SEA TURTLE

The leatherback is the largest of the sea turtle species and the only one that lacks a hard-shelled carapace and scutes. Instead their carapace is a tough rubbery black skin about 1.5 in. (3.8 cm) thick and consists of leathery, oil-saturated connective tissue overlaying loosely interlocking dermal bones (NMFS and USFWS 1998e). Their carapace has seven ridges along its length and tapers to a blunt point, which helps the leatherback move more effectively in water. Their front flippers are proportionally longer than in other sea turtles and their back flippers are paddle-shaped. A ridged carapace and large flippers improve energy efficiency and enable long distance foraging migrations (NOAA Fisheries 2018a).

Leatherback turtles in the Pacific Ocean are experiencing a dramatic drop in nesting numbers, and recent reports estimate the number of breeding females at between 2,700 and 4,500, though this number is uncertain due to a lack of information on the typical number of nests per female (NMFS 2013). Leatherback turtles have a variety of adaptations that allow them the widest foraging range of any living reptile, however nesting is confined to tropical and subtropical latitudes. Western Pacific leatherback populations nest in Malaysia, Indonesia, Papua New Guinea, and the Solomon Islands; they are not known to breed with Eastern Pacific leatherbacks and are genetically distinct though their ranges overlap. Significant threats to the leatherback result from poaching, development, marine debris, beach erosion, and low hatch rates (NMFS 2013). Western Pacific leatherback populations are estimated to have dropped by 80% in recent decades. Critical habitat for the leatherback turtle was established in the U.S. Virgin Islands in 1979 and along much of the west coast of the United States in 2012, although it does not extend to the Hawaiian Islands (NMFS-NOAA 2012a).

The United States does not have any nesting of leatherbacks in its jurisdiction in the Pacific but has important foraging areas on the continental U.S. west coast and near the Hawaiian Islands (NMFS and USFWS 1998e). Leatherbacks encountered in Hawaii, including those caught incidental to fishing operations, may represent individuals in transit from one part of the Pacific to another (Balazs 1973). In August 1979 at least ten individuals, including juveniles, were sighted in pelagic waters northwest of Hawaii (40-42° N, 175-179° W) (Balazs 1982). A large (682 kg) female became entangled at night two miles offshore Kailua-Kona (Balazs 1985). One leatherback sea turtle washed up dead at Midway Atoll in the early 1990s (USFWS 2017). As only one leatherback has ever been observed at Midway Atoll, the species is most likely very uncommon within the Refuge, probably only occasionally migrating through deep, pelagic waters. Satellite tracking studies show that leatherback turtles tagged on the California coast migrated in offshore waters at the southeastern end of the Hawaiian archipelago on their way to an area just north of Australasia (TOPP 2006).

4.6.4 FALSE KILLER WHALE MHI INSULAR DPS

The Main Hawaiian Islands (MHI) insular DPS of false killer whales was listed as endangered under the ESA in 2012 while the NWHI population was determined to be separate and distinct but is not listed under the ESA. The MHI DPS is most threatened by interactions with local fisheries. Genetic differentiation between the two populations and offshore pelagic populations of false killer whales sufficiently shows that the populations do not interbreed and that the MHI population is unlikely to be readily replaced by other populations should it become extinct. The MHI DPS is known to preferentially use habitat on “the northern coast of Molokaʻi and Maui, the north end of Hawaii Island, and a small region southwest of Lānaʻi” (NMFS-NOAA 2012b).

4.6.5 BLUE WHALE

Estimates of commercial whaling takes of blue whales are at least 9,500 between 1910 and 1965. Since protection by the International Whaling Commission in 1966 and listing under the ESA in 1970, insufficient data has been available to estimate population trends. Distribution of blue whale populations is not well understood, however recent studies suggest that blue whales from the central Pacific appear to summer southwest of Kamchatka, the Aleutian Islands, and the Gulf of Alaska and to spend winters in the western and central Pacific, including Hawaiʻi. Presence of blue whales within the Hawaiian Islands is through very infrequent sightings and through recordings of whale song. Blue whales are generally found further offshore than other whale species. The most recent estimates of individuals within the Hawaiʻi exclusive economic zone (EEZ) are between 38 and 81 whales. Threats from fishery-related mortality or serious injury are considered insignificant, but the effects of sonar and other noise sources are still of concern (NMFS-NOAA 2014a).

4.6.6 FIN WHALE

The fin whale was listed as endangered under the ESA in 1970. Hawaiʻi populations of fin whales are believed unlikely to mix with two other North Pacific populations of fin whales in Alaska and California/Oregon/Washington. The eastern North Pacific population was estimated at 25,000 – 27,000 prior to whaling and 8,000 – 11,000 in 1973 (following ESA listing and the cessation of fin whale hunting in the Pacific in 1972) (NMFS-NOAA 2011b). The 2010 stock estimate reports similar numbers, with only 101 – 174 in the Hawaiʻi stock (NMFS-NOAA 2014b). There is no critical habitat designated for the fin whale in the Pacific.

Fin whale occur in Hawaiian waters infrequently (Edwards et al. 2015). Fin whales have been sighted off the NWHI during the 2002 and 2010 NMFS surveys, as well as around the main Hawaiian Islands (NMFS-NOAA 2011b, Edwards et al. 2015). Confirmed sightings occurred around Lānaʻi Island (single whale, December 2012) and off the Kona coast of Hawaii Island (pair of whales, January 2015) (CRC 2018). Data from whale studies that used direct observations, ship transect surveys, acoustic detection methods, mark/recapture techniques, satellite tagging, and opportunistic sightings were combined to determine global distribution; fin whales occurred off Oahu (all months, 1978-1981 and 1992-1993), Kauai (February 1994), and in the Hawaii EEZ (Jul-Dec 2002 and Aug-Dec 2010), NWHI (Mar-Apr 2007), MHI (Feb 2009), and southwest of MHI (Jul-Nov 2005) (Edwards et al. 2015).

4.6.7 SEI WHALE

In a 2011 stock estimate, the population of sei whales remaining in U.S. Pacific waters was estimated at a minimum of 120 whales. Whaling catch data suggests a decline to about 8,600 individuals in 1974 from 42,000 in 1963 following decades of heavy harvests in Japanese waters that suggest the population was already below carrying capacity at that time. Sei whales were listed as endangered under the ESA in 1970. Relatively little data exists to provide information about species recovery since that time (NMFS-NOAA 2012c). Sei whales in Hawaiian waters was estimated to number 77 individuals (Smultea et al. 2010). The limited available data on this species suggest that it is rare near the MHI and that a small number use deep offshore waters during the fall (Smultea et al. 2010).

4.6.8 SPERM WHALE

Sperm whales typically occur in deep pelagic waters and are uncommon in waters less than 984 ft. (300 m). They were listed as endangered under the ESA in 1970 and no change to the listing has been made since that time. Estimated population size of sperm whales in Hawaiian waters is between 2,500 and 3,400 (NMFS-NOAA 2015). There is no critical habitat designated for the sperm whale. Only one sighting has been recorded at Midway Atoll; a sperm whale washed up dead on the surrounding coral reef in the late 1990s (USFWS 2017). The skeleton is currently on display outside the USFWS National Wildlife Refuge visitor center at Midway Atoll.

4.6.9 NORTH PACIFIC RIGHT WHALE

Right whales have large heads, no dorsal fins, and are mostly black in color with callosities around the head region and a broad, deeply notched tail (NMFS 2006). The North Pacific and North Atlantic populations of right whales were first considered as one species of ‘northern right whale’ before they were reclassified into two separate species in 2008 into the North Pacific right whale (*Eubalaena japonica*) and North Atlantic right whale (*E. glacialis*) (NOAA Fisheries 2018b). North Pacific right whales encompass two geographically distinct populations, eastern and western. Globally, this species is among the rarest of all the large whale species (NOAA Fisheries 2018b). The range of eastern North Pacific right whales is believed to encompass the Gulf of Alaska and the Bering Sea, while the western population ranges from near the Commander Islands, the coast of Kamchatka, along the Kuril Islands, and in the Sea of Okhotsk (NMFS 2017).

Both North Pacific right whale populations are at serious risk of extirpation, especially the eastern population (Brownell et al. 2001, Reilly et al. 2008, LeDuc et al. 2012, Sekiguchi et al. 2014). The most recent stock assessment report for the eastern stock provides a best estimate of abundance of 31, with a minimum population estimate of 26 right whales (Muto et al. 2017). LeDuc et al. (2012) provided data on the genetic characteristics of a sample of 24 North Pacific right whales (eastern and western), which showed some loss in genetic diversity, and indicated the eastern stock remains at severe risk of extinction with an effective population size of only 11.6 animals (the number of individuals in a population who contribute offspring to the next generation). Critical habitat was designated for the North Pacific right whale on April 8, 2008 in the Bering Sea and the Gulf of Alaska (NOAA Fisheries 2018b).

Eastern North Pacific right whales have been documented in Hawaii. A sighting occurred off Maui on 2 April 1996 (Salden and Mickelsen 1999), and two encounters were recorded in 1979, one between the islands of Maui and Kaho'olawe on 25 March 1979 and the other southwest of Moloka'i on the Penguin Bank on 11 April 1979 (Herman et al. 1980). Rowntree et al. (1980) reported a sighting in the 'Au'au Channel off west Maui on 25 March 1979. There is speculation that the Eastern North Pacific right whale may migrate with humpback whales (*Megaptera novaeangliae*) into Hawaiian waters (Herman et al. 1980). One right whale observed in both Hawaii waters and the Bering Sea in 1996 represents the only confirmed evidence of an annual migration (Kennedy et al. 2010).

4.6.10 GIANT MANTA RAY

There are two species of manta rays: giant manta rays (*Manta birostris*) and reef manta rays (*Manta alfredi*). Both species are recognized by their large diamond-shaped body with elongated wing-like pectoral fins, ventrally placed gill slits, laterally placed eyes, and a wide terminal mouth with two structures called cephalic lobes that bring water into the mouth for feeding activities. Two distinctive colorations occur, a chevron pattern with a mostly black back and white belly, and an overall black with little to no white markings. Manta rays also have distinct spot patterns on their bellies that can be used to identify individuals (Miller and Klimovich 2016).

The giant manta ray was recently listed as Threatened throughout its range in January 2018 (NMFS-NOAA 2018a). It is the largest of the two species, reaching weights of up to 5,291 lb. (2,400 kg) and having a wingspan of up to 23 ft. (7 m) (the width is about 2.2 times the length of the body) (Marshall et al. 2018). Mantas are filter feeders that mainly eat plankton, and unlike other rays, their tail lacks a stinger. It takes a female 8-10 years to mature; gestation is approximately one year and only one pup is birthed every 2-3 years (MarineBio 2017). The giant manta is considered migratory (Marshall et al. 2018). In the Pacific Ocean, the largest subpopulations and records of individuals of the species come from the Indo-Pacific and the eastern Pacific portion; at present, there is insufficient data to determine and designate critical habitat for this species (NMFS-NOAA 2018a).

Swimming behavior in the manta differs across habitats. Travelling over deep water they swim at a constant rate in a straight line while further inshore they usually bask or swim idly around. Mantas may travel alone or in groups up to 50 and they may associate with other fish species, sea birds, and marine mammals (Ebert 2003). In southeastern Brazil, mantas are common around coasts from spring to fall and they travel further offshore during the winter; they keep close to the surface and in shallow water in daytime, while at night they swim at greater depths (Luiz et al. 2009).

Under threat by illegal trade practices, such as fisheries that harvest the animal’s gill rakes for use in Chinese medicine, giant mantas also face threats from the fishery industries (killed as by-catch), from a decline of offshore reefs used for feeding, cleaning, etc., from marine debris and pollution, and from a lack of prey availability (NMFS-NOAA 2018a). In 2009, Hawaii became the first of the United States to introduce a ban on the killing or capturing of manta rays. Previously, no fishery for mantas existed in the state, but migratory fish that pass the islands are now protected (Marshall et al. 2018).

Because the ruling for ESA protection is so recent, recovery strategies and ongoing conservation measures include basic fact-gathering, such as further solicitation for relevant information and drafting a species recovery plan. Further, tourism involving manta ray interactions benefits locals and visitors by raising awareness of natural resource management and educating them about the animals (Lück and Downie 2008). Tourism can also provide funds for research and conservation. Constant unregulated interactions with tourists, however, can negatively affect mantas by disrupting ecological relationships and increasing disease transmission. This species is circum-global in range, but within this broad distribution, individual populations are scattered and highly fragmented (CITES 2013). In Hawai‘i, the species has a high site fidelity for reefs around French Frigate Shoals (Miller and Klimovich 2016).

4.6.11 OCEANIC WHITETIP SHARK

At one time oceanic whitetip sharks were thought to have been among the most numerous pelagic sharks on the planet. Bycatch in commercial fishing practices and harvesting for the shark fin trade have all but extirpated this species (Young et al. 2016, NOAA Fisheries 2018c). In 2018, NOAA Fisheries listed the species as threatened under the ESA (NMFS-NOAA 2018b). A stocky-built shark with a bluntly rounded snout and incredibly powerful jaws, the oceanic whitetip shark is so named because of the white tips on the pectoral, first dorsal, pelvic, and caudal fins.

Solitary and slow moving (Baum et al. 2015), this shark is distributed worldwide. The species is epipelagic, found mainly in offshore, tropical, and warm-temperate waters (Young et al. 2016). On occasion individuals are seen in shallower waters near land, especially around oceanic islands but are found at depths of up to 492 ft. (150 m) (NMFS-NOAA 2018b). This species has a clear preference for open ocean waters between 10˚N and 10˚S and a trend of decreasing numbers out to latitudes of 30˚N and 35˚S, with abundance decreasing with greater proximity to continental shelves (Backus et al. 1956, Strasburg 1958, Compagno 1984, Bonfil et al. 2008).

Oceanic whitetips are top pelagic predators and opportunistic hunters that prefer to forage in the upper layers of deep-water areas. The oceanic whitetip shark feeds on bony fishes including lancetfish, oarfish, barracuda, jacks, dolphinfish, marlin, tuna, and mackerels. Other prey consists of stingrays, sea turtles, sea birds, gastropods, squid, crustaceans, and carrion (dead whales and dolphins) (Compagno et al. 2005). Little is known about the movement or possible migration paths for oceanic whitetips. In the Pacific, Musyl et al. (2011) used pop-up satellite tags to observe this shark's behavior and found a complex movement pattern that was generally restricted to the central region of Pacific tropical waters north of the North Equatorial Countercurrent and near to the tagging location. Oceanic whitetips are often accompanied by remoras (*Echeneidae species*), dolphinfish (*Coryphaena species*) and pilot fish (*Naucrates doctor*), and reportedly demonstrates an unusual association with the shortfin pilot whale (*Globicephala macrorhynchus*) in Hawaiian waters (Baum et al. 2015). Although the exact reason for this shark swimming along with pods of pilot whales is unknown, it is thought that oceanic whitetip sharks are following them to sources of squid, which the pilot whales are extremely efficient at locating (Young et al. 20016).

Drastic declines have occurred in geographic-specific areas of the oceanic whitetip's global population (Young et al. 2016). However, these declines are not indicative of total extirpation of the species. There appears to be some indication for relative stability in population sizes 5-10 years at the post-decline depressed state, as evidenced by the potential stabilization of two extremely small populations (*e.g.*, NW Atlantic and Hawaii) (Young et al. 2016), which suggests that this species is potentially capable of persisting at a reduced population size (NMFS-NOAA 2018b).

Efforts are currently being made to collect essential data on population declines from regions where demographic trends are poorly understood. Genetic bottlenecks may be a cause for concern in the near future because a species already relatively low on genetic diversity that undergoes significant levels of exploitation may experience increased risk in terms of reduced fitness, evolutionary adaptability, and potential extirpations (Camargo et al. 2016). Besides bycatch and shark finning, threats to this species include loss of habitat, lack of regulatory protection, decreased genetic diversity, and climate change.

CHAPTER 5: EFFECT ANALYSIS OF FEDERALLY PROTECTED SPECIES AND HABITAT

An effect analysis on seventeen federally protected species and one designated critical habitat found within the Action Area includes an examination of potential impacts of the Proposed Action. This section of the BA analyzes potential impacts from primary and secondary exposure of species to the rodenticide, and operational and other hazards associated with the Proposed Action, including impacts from housing and caring for Laysan ducks on Eastern island, implementing any biosecurity measures, carrying out monitoring efforts, and assessing the potential for ship strike to marine species from the transport of materials from Honolulu to MANWR. Further, this section discusses the mitigation and minimizations strategies that will be incorporated into the Proposed Action (Section 2.4).

Potential impacts resulting from implementing biosecurity measures during the Proposed Action are addressed for each species. A Biosecurity Plan (Appendix A) has been in place on MANWR for many years, and it addresses prevention and rapid response measures pertinent to the Proposed Action. Implementing the plan's rapid response measures would occur in the event of an incursion by a non-native, and especially, an invasive species. For example, in response to an incursion, impacts through increased human disturbances could result. Implementing the plan's biosecurity measures to prevent the spread of nonnative invasive species – specifically, the spread of mice from Sand Island to Eastern Island – will be strictly adhered to.

Potential impacts resulting from scientific monitoring during the Proposed Action are also considered in this section for each species the Proposed Monitoring Plan (Appendix B) outlines activities that include field observations, field equipment and trap maintenance, monitoring efforts, and sample-collecting in the Action Area. Implementing the project monitoring plan could cause additional impacts, such as increased human disturbances. Last, the effects analyses considered potential impacts on marine species from the transport of project materials between Honolulu and Midway Atoll. The only likely impact would be the potential for ship strikes on these species.

5.1 LAYSAN DUCK

5.1.1 RELEVANT BASELINE INFORMATION

The use of brodifacoum to eradicate mice on Sand Island poses risks to Laysan ducks that must be mitigated to ensure that the benefits of the proposed action outweighs the risks it poses to non-target species, a fundamental principle of rodent eradications. Total risks to non-target species is the result of toxicity of the compound to these species and their potential exposure to the toxicant. The toxicity of the compound is determined to a significant extent by species' intrinsic susceptibility, and the toxicokinetics of the compounds used (Eason et al. 2002). Brodifacoum is known to be highly toxic to birds (Eason et al. 2002) and toxicity is a fixed element of risk.

Minimizing exposure of brodifacoum to Laysan ducks during and post-operation is a viable option to mitigate spatial and temporal risks resulting from the proposed action. Laysan ducks are non-migratory, year-round residents on MANWR and timing the operation to any specific season is not an option to minimize exposure to brodifacoum. Eastern Island has been confirmed to be mouse-free and offers an opportunity for the translocation of Laysan ducks from Sand Island during and post-operation. The Laysan duck population on MANWR is estimated at 600 ducks with a range of 526-685 (95% CI) individuals (K. Goodale, Pers. Comm.). Eastern Island currently has the habitat capacity to support 85 to 102 Laysan ducks (SWCA 2017) without further enhancements to the habitat. With the enhancements proposed, the capacity for Laysan ducks on Eastern Island outside of the captive care facilities would be designed to support approximately 400 ducks.

It is feasible to capture the majority of Laysan ducks at Midway Atoll and therefore mitigation efforts will be attempted to protect as many individuals from the population as feasible, thus potentially safeguarding all genetic variation remaining in this group of ducks descended from the original translocated population of 40 individuals.

5.1.2 IMPACTS

Laysan ducks could be injured or killed during each phase of the operation including during capture, translocation, handling, captivity, or after bait is dropped and available on the ground on Sand Island (Table 2.1). The maximum numbers of injury/mortality estimated in Table 5.1 represent a worse-case scenario and are unlikely to occur. The primary source of injury and mortality risk to adults is expected to occur to ducks that are not captured before the bait is dropped (the aerial and hand-broadcast baiting phase) or if released back onto Sand Island too early (release phase), or to ducks kept in captivity (Table 5.1). The estimated worst-case mortality to adult ducks is not expected to exceed 33% of the total population. For subadults and ducklings, natural mortality is high, and so there will be some natural mortality to birds that are wing-clipped but free on Eastern Island. Since it will be difficult to distinguish natural injury and mortality of these age classes from injury/mortality indirectly due to project operations on Eastern (overcrowding of birds, aggression, etc.), the numbers in Table 5.1 also include expected natural injury and mortality to these age classes. It should also be noted that a duck could be injured, recover, and receive some other form of injury, or later die from another phase. Thus, the total estimated number of ducks injured or killed cannot be simply summed between all the phases of the operation. No mortality or injury to ducklings and eggs will occur during the release phase of the operation since these age classes are expected to be subadults by that time. The protection and mitigation strategy for Laysan ducks will be in effect to minimize adverse effects and impacts throughout the project (Appendix C, D and E).

Table 5.1 Estimated range of injury and mortality to each Laysan duck age class from the Proposed Action

Project Phase	**Estimated Range of Laysan Duck Injury and Mortality**								
	Adults				Subadults		Ducklings		Eggs
	Injury		Mortality		Min/Max Injury	Min/Max Mortality	Min/Max Injury	Min/Max Mortality	Max. Mortality
	Min	Max	Min	Max	Range	Range	Range	Range	Range
Capture[1]	0	30	0	6	0-5	0-5	0-10	0-10	0-20
	0.0%	5.0%	0.0%	1.0%					
Translocation	0	30	0	6	0-5	0-5	0-10	0-10	0-20
	0.0%	5.0%	0.0%	1.0%					
Handling[2]	0	30	0	6	0-5	0-5	0-10	0-10	0-20
	0.0%	5.0%	0.0%	1.0%					
Captivity	0	120	0	60	0-30	0-30	0-75	0-10	0-80
	0.0%	20.0%	0.0%	10.0%					
Aerial and Hand-Broadcast Baiting[3]	30	120	30	60	0-60	0-60	0-30	0-30	0-20
	5.0%	20.0%	5.0%	10.0%					
Release[4]	6	60	6	60	10-50	10-30	N/A	N/A	N/A
	1.0%	10.0%	1.0%	10.0%					
Totals/Ranges	**36**	**390**	**36**	**198**	**10-155**	**10-135**	**0-135**	**0-70**	**0-160**
Total %	**6.0%**	**65.0%**	**6.0%**	**33.0%**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**

[1]Includes the number of ducks that may be injured or killed during capture operations.

[2]Includes the number of ducks that may be injured/killed during wing clipping and botulism vaccination

[3]Includes the number of ducks that may be injured/killed from bait being available on the ground and from hand-broadcasting operations.

[4]Includes ducks that could molt on Eastern Island and fly back to Sand Island before the environment is considered safe for release.

The potential impacts to Laysan ducks are influenced by the exposure to brodifacoum available both spatially (in their diet) and temporally (over time). Spatially, brodifacoum will be available to Laysan ducks in different ecological compartments such as bait pellets, invertebrates, and soil. Temporally, brodifacoum will remain available at biologically significant levels for an unknown amount of time after the bait application. Forecasting the potential pathway and risk of exposure over time for Laysan duck on Midway is challenging without a comprehensive understanding of the food web, and *a priori* knowledge of the persistence of brodifacoum. Thus, risk must be inferred from toxicological and ecotoxicological data from other rodent eradication projects (Pitt et al. 2015, Pierce et al. 2008, Merton et al. 2002, McClelland 2002, Howald et al. 1999, Eason and Spurr 1995, The Ornithological Council 2010).

5.1.2.1 Spatial Risk from Brodifacoum

Without mitigation, Laysan ducks would have several potential exposure pathways to brodifacoum once bait is delivered to Sand Island and moves through different ecological compartments. Initial tests with non-toxic bait pellets on MANWR, indicated that Laysan ducks would highly likely consume bait pellets, and thus, would be at high risk of primary poisoning. Based on feeding trials conducted on Midway, it is likely Laysan ducks (i.e., adults, juveniles, and ducklings) remaining on Sand Island while bait is available on the ground will consume a lethal dose of brodifacoum (see Section 5.1.3 for toxicity calculations).

Invertebrates are known to feed on bait pellets, and although generally not negatively affected by anticoagulant rodenticides (Booth et al. 2003, Hoare and Hare 2006) (but see Booth et al. 2003 and references therein), may accumulate brodifacoum and function as secondary pathways of exposure to animals that feed on them. Laysan ducks are known to consume invertebrates as part of their diet and therefore, a secondary path of exposure to the rodenticide is possible and highly likely. Without mitigation, it is possible that Laysan ducks (i.e. adults, juveniles, and ducklings) would accumulate lethal doses through secondary exposure and succumb to mortality. Moreover, sub-lethal effects (e.g. lethargy, subcutaneous, intramuscular, and internal hemorrhaging, piloerection, diarrhea, bloody diarrhea, and anorexia) are possible.

5.1.2.2 Temporal Risk from Brodifacoum

Unconsumed bait pellets containing brodifacoum will be available on the ground for an unknown amount of time on Sand Island. Degradation time of bait pellets will be dependent on weather conditions, most notably rain and humidity given that decomposer organisms such as molds, fungus and microbes will potentiate degradation by physically breaking down bait pellets and rodenticide. During bait trials on Midway, bait pellets in ironwood forest appeared as fresh pellets after at least 17 days of relatively dry conditions (Wes Jolley, pers. comm.). On Desecheo Island, bait pellets remained in palatable form for at least 20 days after the first application (Shiels et al. 2017). On Lehua Island, bait pellets containing Diphacinone, but with similar inert matrix to B25D, remained relatively intact for at least 24 days, degrading slowly and consistently (Island Conservation 2017). Finally, on Kahoolawe Island, inert bait pellets placed in exclusion cages on hardpan surfaces remained for at least five months (Island Conservation, unpublished). Once bait pellets are applied to Sand Island, the project team has no control over how long it will take for bait pellets to degrade. A primary path of exposure to Laysan ducks will exist for as long as bait pellets are available on the ground.

Once bait pellets degrade, brodifacoum residues binds tightly to organic matter in soil where the rodenticide is degraded by soil micro-organisms and exposure to oxygen and sunlight. The half-life in soil is ~ 84 to 175 days, depending on the soil type and aerobic vs. anaerobic soil conditions. The rate of microbial degradation is 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 will increase in colder climates and decrease in warm sunny places. The rate of brodifacoum degradation is unknown on Midway. On Anacapa Island in southern California, only one of 48 soils samples taken six months post bait applications tested positive for brodifacoum (Howald et al 2010). Furthermore, concentration of brodifacoum in bait pellets left in exclusion cages had decreased by 55% in six weeks and 92% in six months (Howald et al 2010).

Invertebrates are known to consume bait pellets containing brodifacoum and the amount of time that residues will be present in invertebrates that are part of the Laysan duck diet is unknown. Therefore, there is inherent uncertainty in the temporal scale for which brodifacoum residues will remain available at biologically significant levels after the operation is completed through a secondary/tertiary path of exposure. Laboratory studies have found brodifacoum at low but detectable levels in cockroaches 42 days after exposure (Brooke et al. 2013). Cockroaches, analyzed by whole body, had brodifacoum concentration of 45 ng/g (ppb) four years after an eradication attempt on Desecheo Island (Shiels et al. 2017). On Palmyra, brodifacoum residues peaked after bait application and then decreased, but were still detectible in hermit crabs, fiddler crabs, cockroaches, ants and geckos 46-52 days after the last application of bait (Pitt et al 2012).

Moreover, there is the potential that Laysan ducks could bio-accumulate brodifacoum residues over time through the consumption of invertebrates contaminated at very low levels. Although brodifacoum will eventually move out of the Laysan duck's food web into the soil matrix, where it will be degraded by bacteria, molds and fungus to base components of C02 and H20, it may be remobilized by invertebrates into the food web over time, with uncertain ecological consequences (see examples: cockroaches - Shiels et al. 2017 – and Lizards - Rueda et al. 2016).

5.1.2.3 Operational Impacts

Since Laysan ducks are more likely to walk from place to place rather than fly, and tend to freeze when disturbed rather than flush, they are at a very low risk for collision with the helicopters during bait drop operations. Disturbances from helicopter noise and hand-broadcasting of bait could disturb ducks. Disturbance to individual ducks during the rodenticide treatment period, would aid the mitigation plan by helping locate and capture any remaining ducks. Laysan ducks are upland nesters and sensitive to ground-disturbing activities. If present, nests and eggs can be accidentally trampled by ground crews, or adults can be flushed off the nest, resulting in injury and death of adults, subadults, and ducklings, and destruction of eggs and/or ducklings in the nest; if adults are flushed off the nest, the disturbance would only be temporary, but injury or death could result. Ground crews can also accidentally separate broods, which could result in injury and death to the adult and ducklings. If bait applications occur when Laysan duck nests are present, and where hand-broadcasting of bait requires ground-based personnel to traverse across or apply bait in duck nesting habitat, staff will be instructed to remain vigilant for birds and nests. If ground teams encounter adults, broods or nests, they will cease work and contact the duck team who will respond immediately and attempt to capture and relocate them to Eastern Island. Once ducks are removed, the ground team can continue their work.

5.1.2.4 Other Impacts

Three previous translocations of Laysan ducks have demonstrated a tolerance for boat travel in transport boxes very well and for much longer trips than across MANWR's lagoon to Eastern Island. Reynolds and Klavitter (2006) successfully transported 42 ducks from Laysan Island to Sand Island in 2004 and 2005 (20 and 22 birds, respectively) via a 50-hour boat trip each year. In 2014, 28 ducks were successfully boat-transported from Midway to Kure Atoll (USFWS 2014, Reynolds et al. 2015). To successfully transport ducks from Sand Island to Eastern Island aviaries prior to the first bait application, protocols for boat transport would follow those of previous efforts (Reynolds et al. 2004, 2014, Reynolds and Klavitter 2006, Reynolds et al. 2015).

While Laysan duck translocation operations have had no mortality in captivity we are cognizant of the potential dangers of captive care including enhanced disease transmission risk, behavioral disruption, prevention of subordinates from getting to food dispensers, and risk of injuries from fighting. Additionally, the higher density of seabird presence, such as Laysan Albatrosses, can increase risk of harm to smaller Laysan ducks. Finally, there is a higher risk of botulism outbreaks when there is a high density of ducks using a few water sources. Mitigation measures to address behavioral issues and avian botulism are addressed in Appendices C, D and E.

If there was a new incursion of a non-native invasive species to MANWR during the Proposed Action, rapid response measures in the Biosecurity Plan would be immediately enacted (Appendix A). These measures have the potential to impact ducks. Impacts include flushing ducks off their nest, trampling of eggs and nests, trampling of vegetative cover, and increased human noise and presence. These impacts could result in injury and death of adults, subadults, and ducklings, and destruction of eggs and/or ducklings in the nest. Given that the Biosecurity Plan's prevention measures will be adhered to stringently, it is expected that rapid response measures will not need to be enacted. Therefore, associated impacts are unlikely.

Monitoring efforts have the potential to affect Laysan ducks through added human disturbance. Monitoring duck behavior and health will include follow-up field observations, setting and retrieving cameras on nests to track productivity, and collecting prey samples for determining residue levels of bait in the duck's food source. These monitoring methods do not require ducks to be handled, minimizing stress levels in ducks and potential for injury. Any added human disturbance from monitoring efforts is expected to be minor and short-term.

5.1.3 STRATEGIES TO REDUCE AND MITIGATE IMPACTS

The mitigation and impact minimization strategies proposed for the Laysan duck focus efforts on eliminating or minimizing exposure of Laysan ducks to brodifacoum whenever possible. It addresses both spatial and temporal risks to Laysan ducks resulting from the proposed action. Given the inherent uncertainty of this type of intervention, the proposed strategy identifies and addresses uncertainty, as well as creates redundancy to produce a successful outcome. Moreover, it identifies and addresses potential cumulative risks that could result from the proposed mitigation actions.

The goal of the proposed mitigation and impact minimization strategy is to ensure a viable long-term population of Laysan ducks on MANWR. Success is defined as all the surviving captive Laysan duck individuals released back to Sand Island once the operation is concluded and the return of the remaining ~400 wing-clipped birds on Eastern Island when their feathers molt and they regain flight capability to return to Sand Island. For reference, the population currently present on Midway is the result of a translocation effort that included 42 birds; in 6 years, this population grew more than 15-fold to 661 birds**.**

5.1.3.1 Eliminating or Minimizing Exposure

Laysan ducks would be removed from Sand Island and temporarily translocated to Eastern Island where they would not be exposed to bait pellets and have a low likelihood of exposure to contaminated invertebrates. Given the limited carrying capacity of Eastern Island (85 - 102 Laysan ducks) (SWCA 2017), enhanced shelter, food and water sources for Laysan ducks is required. The enhancements would increase the carrying capacity of Eastern Islands to approximately 400 ducks.

The proposed action would implement the Laysan duck protection and mitigation strategy (Appendix C) which involves two redundant levels of protection to ensure the survival of as many healthy individuals as possible (~600) as described below:

1. The first set of actions would include the capture of 200 Laysan ducks (40% males and 60% females, and 60% adults), and placement in aviaries on Sand Island until implementation, then transporting all ducks to Eastern Island and placing them in aviaries there until the risk window has passed as assessed by the residue monitoring strategy described later in this document. Individuals included in this strategy will be monitored more closely and their return to Sand Island is completely under the control of the project team.

2. The second set of actions would include capturing Laysan ducks, holding them for 10 days in order to give them two doses of botulism vaccine, clipping flight feathers, marking with color bands, and transporting to Eastern Island for release. Individuals that are part of this strategy are expected to be unable to fly until the next year's molt and remain on Eastern Island. Given the limited carrying capacity of Eastern Island, we would provide enhanced shelter, food and water sources to increase the carrying capacity. Monitoring of movements, behavior, breeding, and survival would be done using a combination of observations at a distance using spotting scopes to minimize disturbance.

Capturing of ducks (all life stages adults, juveniles, ducklings, eggs) will start in Phase 1 of the Proposed Action (Chapter 2 Tables 2.1a, 2.1b) and will continue until the residue monitoring strategy determines that the risk window has passed (Appendix C – Sections 4.5). For the bait drop to proceed, our goal is to capture a minimum of 200 ducks for captive care and a minimum of 200 ducks with clipped wings to occupy the enhanced habitat on Eastern Island. Any ducks not captured that are subsequently exposed to the rodenticide and demonstrating signs of bait ingestion or toxicosis such as colored feces, lethargy and weakness or bleeding would be captured and treated with the antidote Vitamin K by a veterinary professional to offset the negative effects of the rodenticide (Appendix C – Section 4.5). Recent studies with rats suggest that even if re-captured and antidoted for the haematological effects of brodifacoum, individuals may suffer longer-term neurological effects (Kalinin et al. 2017). These results have not been demonstrated in birds. Ducks showing signs of exposure would be held in temporary holding pens under observation and any decision-making would occur based on the duck's on-going health prognosis. Laysan ducks that survive after treatment will be wing-clipped and transported to Eastern Island for captive care there until Sand Island was deemed safe (Appendix C – Section 4.6). The existing duck lab in the USFWS building has the appropriate facilities, equipment and medications to handle duck health emergencies and will be used as an avian clinic. It is estimated that approximately 8-15 personnel will be needed to handle these activities (Appendix C – Table 2).

Laysan duck detectability on Midway, MANWR varies across the different seasons and parts of the reproductive cycle. During the proposed capture period, detectability is highest in February, then decreases through the month of April and is low from May to June (Appendix C – Figure 1). Detectability of ducks then starts increasing again in July and August. Intensive searching of all areas of Sand Island by experienced duck capture experts will ensure that most animals are located. By starting early, we will have the capability to cover every square meter of Sand Island with duck search efforts. Any ducks that evade detection will likely succumb to brodifacoum poisoning so extreme effort will be made to locate all ducks.

Only specifically-trained and federally-permitted personnel will handle Laysan ducks. Personnel will include ornithologists, avian rehabilitators, aviculturists, and licensed veterinarians. A veterinarian will be on site for the duration of the initial capture period, bait application period, and post application holding period (Appendix C – Table 2).

Transport of the ducks is described in the Laysan duck Mitigation Strategy (Appendix C – Chapter 4.4). In general, transport will consist of numerous boat trips across the approximately one-mile route via several boats available for transit to Eastern Island with as many birds as can be carried safely at a time, with one bird in each transport box. Subgroupings of captive ducks that were established in the Sand Island aviaries will be maintained to avoid a new round of social disruption and hierarchy establishment. Aviculturists will alternately rotate shifts on Eastern Island where a small camp will be established, to ensure care for captive animals regardless of weather and sea conditions. Three previous translocations of Laysan ducks have demonstrated that they tolerate boat travel in transport boxes very well and for much longer trips than across the lagoon. There has never been a loss due to transporting Laysan ducks by boat using small transport boxes or cat carriers as described in the Laysan duck Mitigation Strategy, which supports the project’s expectation that there will be minimal duck mortality due to transport (Table 5.1).

5.1.3.2 Monitoring and Assessment of Spatial and Temporal Risk

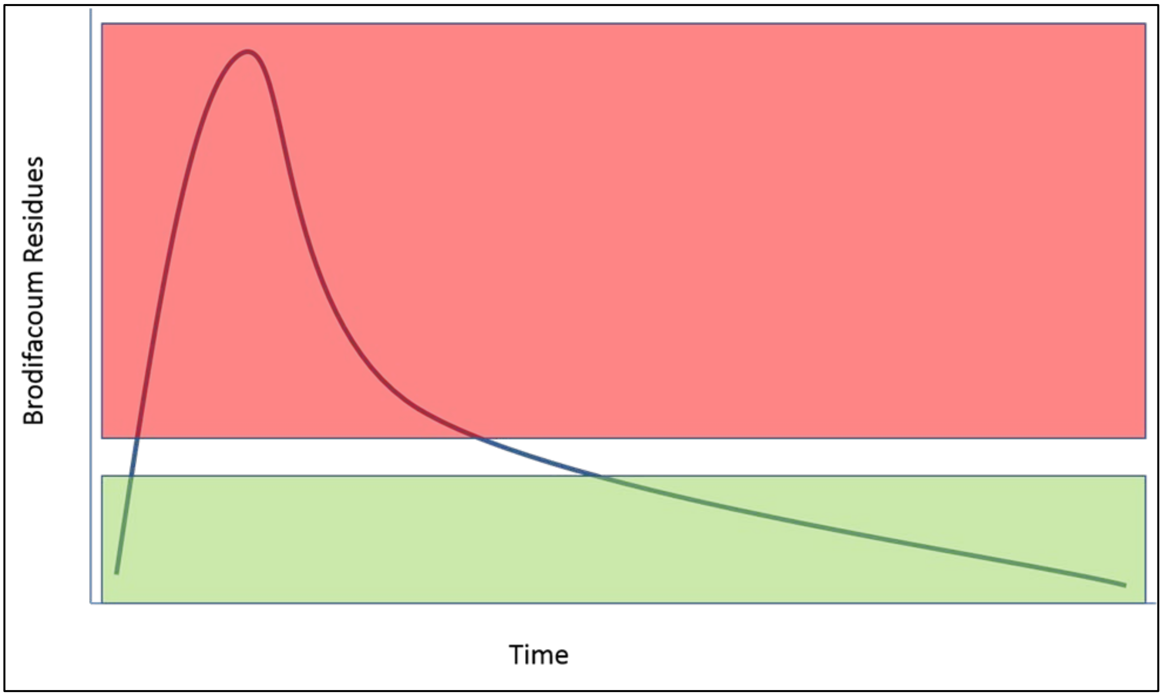
Bait degradation and disappearance will be monitored on Sand Island using pre-established bait plots in which persistence is checked daily until all pellets are gone. Brodifacoum residues would be monitored in relevant ecological compartments including soil, and invertebrates starting at three weeks after the last application and at an appropriate frequency to inform risk mitigation response thereafter. Sentinel diet monitoring will be implemented using species known to be part of the Laysan duck diet (e.g. cockroaches) at appropriate frequency to inform risk mitigation response. Brodifacoum residue testing would be used to test temporal risk assumptions and would inform mitigation responses. Brodifacoum residues will be assayed and quantified by a qualified laboratory.

5.1.3.3 Residue Monitoring and Duck Release Strategy

Sampling and analysis of brodifacoum levels will be used to test assumptions regarding the expected values in different ecological compartments based on best available data and risk analysis and will inform Laysan duck release strategy (e.g. timeline for initial release). Typically, what is observed following bait application is a pulse of brodifacoum residues into the ecosystem and a subsequent decline of residue levels over time. Although presence of residues in the food web represents a risk, Laysan duck will tolerate a low level of environmental residues when the rate of ingestion equals or is less than the rate of metabolism. Forecasting that threshold and identifying the biologically safe residue level *a priori* relies on estimates from toxicological and ecotoxicological data and is supported from empirical (real time) data (See Figure 5.1).

Figure 5.1 Expected brodifacoum degradation curve following an eradication operation.

Red indicates biologically significant levels of brodifacoum residues and green indicates safe levels of brodifacoum residues. The uncertainty lies in identifying what are the thresholds for biological significance and the amount of time that the system will take to degrade brodifacoum to those safe levels.



Source: USFWS (2018)

Toxicity is most frequently represented as the LD_{50}. LD_{50} is the chemical dose where 50% of the test animals died and is usually administered as a single dose. However, there is sufficient evidence to suggest that laboratory-derived LD_{50} values are not appropriate for predicting field safety to non-target species in response to the use of second-generation anticoagulant rodenticides (Mineau, 2018). For the Laysan duck risk assessment, we used an approached proposed by Thomas et al. (2011) and improved on by Mineau (2014). This approach provides a relationship between liver residues and the probably of evident coagulopathy at necropsy (Thomas 2011) and uses data on the proportion of a single dose that is retained in the liver over time (Mineau 2014). These two sets of information allow for a calculation of a “field-derived LD_{50}” or more accurately ED_{50} (dose at which half of the test population will show an effect – not necessarily death) (Mineau 2018).

However, to be protective at the individual level for a rare or threatened species, ED_{50} is not appropriate, and for this analysis we used an ED_5 (5% of the exposed population will be affected by coagulopathy – not necessarily death). If we assume a 500g Laysan duck, its liver weight will be approximately 11g (after relationships in broiler chickens – Deaton et al. 1969). Using the approach described above, the calculated threshold whole body ED_5 is 0.47-1.8 µg total intake of brodifacoum for an average Laysan duck (Mineau 2018).

Because brodifacoum can bio-accumulate through multiple exposures, expressing the risk as a proportion of daily food intake is not appropriate (Mineau 2018). Instead, we used an 'accumulation window' of about 200 days (the mid-point estimate for the half-life of brodifacoum in rat liver tissue) (Horak et al. 2018).

Pitt et al. (2015) found that residues in cockroaches averaged 2.3 µg/g 10-15 days after bait drop, and 0.9 µg/g about 45 days later. It is reasonable to assume that, over time, a certain amount of brodifacoum will 'escape' the insect food chain to be lost to soil and the abiotic environment more generally. Fitting these two points to an exponential curve (a common curve type when describing residue degradation or loss from a system) and defining the peak residues as day 1[1] (even though it took 10-15 days for the residues to maximally contaminate the cockroaches) yields the following:

Residue level (µg /g) = 2.3496 * exp (-0.0213 * days after peak residue)

Predicting forward, cockroach residues at 200 days (our chosen period of residue accumulation) post peak would be approximately 0.03 µg/g. We calculated the cumulative residue intake over a 200-day period which produces a recommended prolonged withholding time for the ducks of 13-15 months needed to drop the risk level below an ED_5.

It is important to note that we are being very protective by choosing an ED_5 when the outcome is coagulopathy rather than mortality, representing a conservative approach. It is also reasonable to assume that an increasing part of the duck's diet over time will be made up of unexposed cockroaches and other invertebrates, so the suggested holding times may be over-estimated. Therefore, a prudent, and conservative estimate, the first release of Laysan ducks may be at the 4-6-month post bait application, with continued surveillance and monitoring of the ducks (i.e. if any negative effects are detected, adaptive management can be enacted to revert it). The first cohort of released birds would be monitored and followed for at least 6 months to confirm if they are showing symptoms of accumulating residues (Mineau 2018).

Furthermore, field application of this proposed models will require real time estimates of remaining residue levels in the Midway ecosystem. Sentinel diet sampling and analysis would be performed at intervals appropriate to inform the mitigation strategy. It will be important to look at the overall loss rate of residues from the food-chain in the early days, weeks and months following the bait drop to characterize the residue decline curves.

5.1.3.4 Cumulative Risks

The proposed mitigation actions have the potential to create additional and potentially cumulative risks to the Laysan duck population on Midway.

There is inherent risk when handling critically endangered wildlife. There is the possibility of injury to the head, bill, neck, eye, leg, foot, and wing and even mortality of ducks during the capture effort. Capture methods are detailed in the Laysan duck protection strategy and will minimize injury whenever possible. There have been no injuries among ducks handled in this way in the Monument so it is impossible to estimate likelihood of injury.

[1] We are only interested in the declining phase of residues after peak

Maintaining Laysan ducks in captivity poses risks to individual ducks and there is the possibility of injury or mortality among captive-held birds. Aviaries will be designed and maintained to safely hold Laysan ducks in captivity for extended periods of time (>5 months). To minimize risks posed to captive ducks, precautions will be implemented that include a using a flooring that prevents ducks from developing foot and leg issues and is easy to clean, predator control measures around and within the aviaries, and closed-circuit camera monitoring of duck behavior (i.e., no human interference). Aviaries will be designed to keep group sizes small enough to be able to detect food exclusion, fighting problems, and signs of disease. Skilled staff will be available onsite to address emergency situations.

Botulism outbreaks have occurred on Midway with severe negative impacts to the Laysan duck population. Personnel will be trained to prevent (Appendix D), as well as prepared to handle, botulism outbreaks (Appendix E). All initially captured ducks will be held for at least 10 days to receive two doses of the Botulism vaccine.

The accidental introduction of mice on Eastern Island has the potential to jeopardize the proposed mitigation strategy. Biosecurity measures for the transport of gear, supplies, and personnel between Sand and Eastern Islands will be stringent to prevent the accidental introduction of mice to Eastern Island. Protocols will include using mouse-proof containers, performing rigorous inspections, employing bait stations and/or traps at both boat landings, and using mouse detection gear deployed on Eastern Island.

With implementation of the protection and mitigation strategies described, only short-term effects such as interruption of a breeding season and stress to individual ducks due to capture and captive holding are expected. The original population of Laysan ducks at MANWR (2004-2005) was 42 birds; in 6 years this population grew more than 15-fold to 661 birds despite several setbacks caused by botulism outbreaks. There are likely to be some short-term adverse impacts to the population of ducks on Sand Island, but it should recover quickly, especially if a direct food competitor, the house mouse, is removed. Thus, the action is not expected to have long-term adverse effects to the Laysan ducks at the refuge. Laysan duck populations appear to thrive with appropriate management and conservation efforts. The original population on Laysan Island grew to the island’s carrying capacity of about 400-600 (Seavy et al. 2009) in the decades after rabbits were eliminated in 1924. The translocated population of ducks in 2004-2005 to MANWR grew rapidly to 471−535 post-fledglings by 2008 (Reynolds et al. 2012, 2013). These translocated ducks on MANWR appear to breed successfully at an earlier age and produce larger clutches (6-8 ducklings per clutch) than birds on Laysan, probably owing to more food and a lower population density. Birds at MANWR breed in their first year and produce an average clutch of seven eggs whereas birds on Laysan nest in their second year, producing an average of 3.3 eggs (Reynolds et al. 2008, Walters and Reynolds 2013). An estimated decline of about 42% on MANWR in 2011 to 2012 occurred after the Tōhoku earthquake-generated tsunami and associated botulism outbreak (Reynolds et al. 2015). The last botulism outbreak occurred in Fall 2016 and reduced the population to 350 individuals. As of February 2018, the population had increased to 600 individuals. This is an increase of 71% over ~18 months. Therefore, the Laysan duck population on MANWR is expected to recover quickly (2-3 years or less depending on actual mortality rates) after any mortality occurs from the Proposed Action.

5.2 PŌPOLO AND LOʻULU

5.2.1 RELEVANT BASELINE INFORMATION

Pōpolo and loʻulu are not expected to be affected by exposure to rodenticide bait pellets. Plants are not known to be susceptible to toxic effects from rodenticides. Further, the rodenticide brodifacoum is strongly bound on soil particles and is not taken up by plants (WHO 1995).

5.2.2 IMPACTS

5.2.2.1 Primary Impact

None are expected. 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).

5.2.2.2 Secondary Impact

None are expected. 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).

5.2.2.3 Operational Impacts

Pōpolo and loʻulu would not be affected by helicopter operations. Helicopters would fly predetermined straight-line paths at sufficient heights and speeds to prevent injury or mortality to plants on the ground from wind-generated disturbance. Plants, including the two-listed species above, would not be affected by helicopter operations since helicopters would be flying an average of 164 ft (164 m) above the ground during baiting operations. Ground-based operations may cause potential injury or mortality to plants. Pōpolo and loʻulu could be accidentally trampled when establishing bait grids and servicing bait stations. Hand broadcasted bait will be distributed by a team who systematically walk on parallel transects stopping at predetermined intervals to disperse pellets as evenly as possible by hand. This will only be done in: (*i*) areas not covered by the helicopter bait drop and could include a small area buffer around the water catchment pond located between the runways; (*ii*) a potential narrow strip of land between the coast and the airport runway (at the southeast end of the runway); (*iii*) portions of a narrow sea wall that extents from the north end of the harbor southward and; (*iv*) if necessary, in a narrow buffer around covered seeps and ponds. Specific conservation measures will be in place to minimize the potential for trampling pōpolo and loʻulu (see Section 5.2.3). Project staff will be trained to identify these plants and will survey work areas for the plant's presence.

5.2.2.4 Other Impacts

Implementing biosecurity and monitoring measures are not expected to negatively impact these species. Human disturbance from biosecurity and monitoring efforts is expected to have the same impacts and results as those caused by Operational Impacts (see Section 5.2.2.3).

5.2.3 MITIGATION AND IMPACT MINIMIZATION STRATEGIES

Pōpolo thrives extremely well at MANWR with managed care. Few out-plantings of loʻulu exist in the Action Area. The locations of all pōpolo and loʻulu plants are known; the locations of each species will be marked and avoided by ground personnel. Staff will be especially trained to identify this species to avoid potential trampling during ground operations. Extreme care will be exercised when setting out grids for hand-broadcasting of bait or servicing bait stations. All personnel working on Eastern will be made aware of the one pōpolo plant located in a restoration area near the pier to avoid unintentional trampling. Loʻulu has been out-planted on Sand Island and the 5 immature loʻulu plants are fenced for protection from accidental trampling and thus are easy to avoid and work around (USFWS unpublished data). Minimization measures that will be in place to protect pōpolo will also protect loʻulu. Project staff will be trained to identify loʻulu and they will exercise extreme care to avoid accidental trampling when setting grids, hand-broadcast of bait or servicing bait stations.

5.3 HAWAIIAN MONK SEAL AND CRITICAL HABITAT

5.3.1 RELEVANT BASELINE INFORMATION

Hawaiian monk seals are present on MANWR year-round, generally hauling ashore to rest. The pupping season on MANWR is predominantly February to July with only 3-4 animals typically having pups on Sand Island. In 2016, the total number of Hawaiian monk seals present on MANWR was estimated to be 74 seals (12 pups and 62 non-pups). Therefore, as many as 74 monk seals could be present on or in nearshore waters around Sand Island during the Proposed Action.

5.3.2 IMPACTS

5.3.2.1 Primary Exposure

Hawaiian monk seals do not forage on land and therefore, 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 adult and sub-adult monk seals. The population of older Hawaiian monk seals on Lehua Island were found not to interact with bait pellets during a placebo trial in 2015 for a rat eradication study (Mazurek 2015). Moreover, bait pellets degrade quickly in water and fragments sink to the bottom (Howald et al. 2010, Siers et al. 2018, Pitt et al. 2015). The bait bucket is equipped with a deflector to eliminate or reduce the amount of drift into the water. Given that bait pellet longevity is expected to be short-lived and that seals are unlikely to interact with bait pellets, impacts from primary exposure are therefore insignificant.

5.3.2.2 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 (USFWS 2018). 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. Weaned pups often mouth and may consume sea cucumbers and other prey items in the wave wash and nearshore environment (NMFS unpublished data). Pupping in MANWR is predominantly February to July, peaking in April to May, and nursing lasts 39 days; only 3-4 seals typically have pups on Sand Island (USFWS, unpublished data). The bait bucket is equipped with a deflector to reduce or eliminate the chance of bait entering the nearshore environment. Additionally, the monk seal pupping areas on Sand Island are known and can be surveyed prior to aerial baiting operations for the presence of pups. Using this information will allow staff to implement a more focused and effective mitigation strategy. Thus, impacts from secondary exposure to nursing and newly weaned pups would be unlikely, and therefore, insignificant.

5.3.2.3 Operational Impacts

Monk seals may experience impacts from air and ground-based operations. Injury may occur if seals are disturbed and are caused to move or flush into the ocean. Aerial distribution of bait has been determined to be the least disturbing method to seals and ground crews will maintain a 100 ft distance from resting seals.

Precautions to minimize helicopter noise and eliminating human disturbance from ground-based work crews would protect seals at known basking and pupping areas (Figure 4.2). 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). Noise disturbance would be short-lived, and therefore, insignificant.

5.3.2.4 Other Impacts

Monk seals may experience impacts from implementing monitoring and biosecurity measures. The impacts and results would be the same as discussed in Operational Impacts (Section 5.3.2.3).

5.3.2.5 Impacts to Critical Habitat

Midway Islands support one of the six major NWHI breeding subpopulations of Hawaiian monk seals described under the NMFS stock assessment for the species (Carretta et al. 2014). The Proposed Action is likely to impact but not likely to adversely impact the three essential features of monk seal critical habitat.

1. The Proposed Action is unlikely to directly affect essential terrestrial habitats and shallow adjacent waters used for pupping and nursing. Critical habitat of preferred pupping and nursing areas are defined as those areas where multiple females have given birth or where a single female has given birth in more than one year (NMFS 2015). Pupping in MANWR is predominantly February to July, peaking in April to May, and nursing lasts 39 days; only 3-4 seals typically have pups on Sand Island (USFWS, unpublished data). The Proposed Action would introduce an auditory disturbance to these habitats through helicopter noise, and ground crews could introduce human disturbance (*e.g.* noise, visual presence). Impacts to the habitat could include making it less desirable to seals as to discourage use for short periods of time. Areas containing monk seal critical habitat, especially pupping and nursing areas, are known on Sand Island (Figure 4.2). Using this information will allow staff to implement a more focused and effective mitigation strategy. During each of two, potentially three aerial applications, helicopters will fly pre-determined flight transects, and to achieve a uniform

coverage, will fly at a pre-determined speed. To reduce noise and disturbance impacts during aerial and hand bait broadcasting, helicopters will avoid hovering near Hawaiian monk seals (ashore or in near shore waters in critical habitat) and ground crews would avoid or limit the disturbance to nearshore vegetation. 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 insignificant. The level of disturbance for individuals is likely to be low since the disturbance would occur at each site only once or twice during each baiting application. Designated areas to be hand-broadcast armored shorelines in some areas, and a narrow strip of along the main runway and these areas are not a part of the definition of critical habitat; therefore, hand-broadcast baiting will have no effect on marine critical habit.

2. The Proposed Action is unlikely to directly affect essential marine areas from 0-656 ft. (0-200 m) in depth that support adequate prey quality and quantity for juvenile and adult monk seal foraging. The Proposed Action is unlikely to cause modifications to the bottom-associated habitat and prey that make up the critical marine foraging habitat. Bait pellets will not be applied to the marine habitat although some pellets may inadvertently enter into marine waters. To minimize the impact to essential marine areas, helicopter transects will not include flight paths over the marine environment. Additionally, deflectors would be used for aerial broadcasting to prevent bait from entering the ocean. Therefore, the impacts of the operation on essential marine areas are likely to be insignificant.

3. The Proposed Action is unlikely to directly affect significant haul-out areas used for resting, socializing and molting. Potential impacts to this essential feature of monk seal critical habitat is the same as those for pupping and nursing habitat. Haul-out areas on Sand Island are known (Figure 4.2), allowing staff to focus mitigation efforts more effectively. Noise and human disturbance to monk seals hauled out on beaches or rocky areas from helicopters dropping bait will be temporary and insignificant (see Section 2.2.3), and ground crew disturbances would be infrequent and short-lived. Mitigation measures described below will avoid and minimize potential impacts to monk seals and their critical habitat.

5.3.2.6 Ship Strike

The marine aspects of this species is under jurisdiction of NMFS. Ships navigating through Refuge waters and entering MANWR's lagoon have the potential to accidentally strike monk seals in the water potentially causing injury or mortality. 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). Adhering to mitigation measures that restrict a vessel's speed to 5 knots or less within lagoon waters and keeping a watchful eye for monk seals when navigating Refuge waters would make the potential for ship strikes unlikely, and therefore, insignificant.

5.3.3 MITIGATION AND IMPACT MINIMIZATION STRATEGIES

Strategies employed to minimize impacts to monk seals will also minimize impacts to the essential features of the seal's critical habitat. Monk seals are more likely to experience significant disturbance from hand-broadcasting activities versus broadcasting bait by helicopter. Since we will not be able to estimate any given time a monk seal will spend in one area, waiting until animals have moved on before broadcasting bait would cause significant delays in obtaining full bait coverage. Given the low risk of exposure and high risk of disturbance of hand-broadcasting, we currently plan to bait via helicopter over areas with monk seals and turtles. Helicopter broadcast of inert bait over monk seals was conducted at Lehua Island, and observations showed that seals were not disturbed by helicopters (Mazurek 2015). We will also have specialists on site that can monitor seals throughout the bait drop for disturbance and exposure risk and provide recommendations to the project manager based on those observations. We will also follow all conservation recommendations from our Section 7 consultation with the NMFS which is currently in progress.

Areas defined as monk seal critical habitat (Section 4.3.3) are mapped and known on Sand Island (Figure 4.2), which enhances protection efforts. All project personnel on the ground would maintain a 100 ft. (30.5 m) buffer from basking seals during operations. During aerial bait broadcast, helicopters will avoid hovering near Hawaiian monk seals and would avoid distributing pellets over seals on the shore. Additionally, a deflector on the helicopter's bait bucket will be used to minimize drift into the marine environment when flight paths are parallel with the shoreline, and helicopter pilots and on-the-ground observers would visually monitor the aerial application of bait along shorelines, and if a malfunction were detected, operations would cease until the problem is corrected. A biologist from the Hawaiian Monk Seal Research Program will also be on MANWR during the project to monitor project activities and monk seals. Ship strike avoidance measures would be in place (Section 2.4). These include reducing vessel speed to 5-10 knots in the presence of, and in known areas of, monk seals, maintaining a 656 ft. (200 m) buffer around seals encountered in the water, and implementing shutdown protocol if necessary until species leave(s) the area.

5.4 GREEN SEA TURTLE (CENTRAL NORTH PACIFIC DISTINCT POPULATION SEGMENT)

5.4.1 RELEVANT BASELINE INFORMATION

Adult green sea turtles frequent the lagoons of MANWR year-round, but infrequently nest on the atoll's beaches. One confirmed nest was recorded in 2005 and in 2007, and several crawls and possible nests were observed but not confirmed on Sand Island, on a beach to the west of Bulky Dump and North Beach. Hatching in these few nests occurred in June and July. Little is known about the effects that brodifacoum may have on sea turtles. Rodenticide toxicity experiments have not been conducted in many turtle species and therefore lethal concentrations are unknown for this species.

5.4.2 IMPACTS

5.4.2.1 Primary Exposure

Green sea turtles could potentially eat bait pellets that drift into the water. The amount of bait that enters the water would be reduced or eliminated with the use of a bait bucket deflector and pre-determined flight paths that buffer the shoreline. Bait pellets are formulated to degrade in water and fragments sink to the bottom (Howald et al. 2010, Siers et al. 2018, and Pitt et al. 2015). Further, preliminary findings of a USDA National Wildlife Research Center (NWRC) 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 2011), 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. Given the low probability of bait entering the water and the rapid decomposition of bait in water and given that turtles would need to ingest a significant amount of brodifacoum to experience toxicosis, it is unlikely for green sea turtles to be exposed or affected by the bait pellets. Because exposure is unlikely, impacts are insignificant.

5.4.2.2 Secondary Exposure

Secondary exposure to green sea turtles of the toxicant is very unlikely due to their diet. Adults eat marine plants that are often found in "pastures" at depths of about 10-33 ft (3-10 m), where sunlight can penetrate down to the bottom. Hatchlings (young or juvenile) eat a variety of marine plants as well as invertebrates like crabs, jellyfish and sponges (Friends of Midway Atoll© 2010). There is a low probability of bait entering the water, and bait pellets decompose rapidly in water and are not taken up by marine plants. Because a sea turtle's diet is primarily plant-based and given that turtles would need to ingest a significant amount of brodifacoum to experience toxicosis, secondary exposure is unlikely, and therefore, impacts are insignificant.

5.4.2.3 Operational Impacts

Green sea turtles may be disturbed when loafing on the beach. Injury may occur if sea turtles are disturbed during operations and are caused to move or flush into the ocean. Ground crews would maintain a 100 ft distance from resting turtles. Aerial-broadcasting is the preferred and least disturbing method to use in areas with loafing sea turtles. Precautions to minimize helicopter noise would protect basking turtles. 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). Further, loafing by turtles occurs predominantly later in the day and thus disturbance should be minimal during the early morning and afternoon when the operation would take place. 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. Because disturbances would low and short-lived, impacts would be insignificant.

5.4.2.4 Other Impacts

Green sea turtles may experience impacts from implementing monitoring and biosecurity measures. The impacts and results would be the same as discussed in Operational Impacts (Section 5.4.2.3)

5.4.2.5 Ship Strike

The marine aspects of this species is under jurisdiction of NMFS. Ships navigating through Refuge waters and entering MANWR's lagoon have the potential to accidentally strike sea turtles in the water potentially causing injury or mortality. Green sea turtles are frequently observed in Refuge waters and within MANWR's lagoon. Adhering to mitigation measures that restrict a vessel's speed to 5 knots or less within lagoon waters and keeping a watchful eye for green sea turtles when navigating Refuge waters would make the potential for ship strikes unlikely, and therefore, impacts are insignificant.

5.4.3 MITIGATION AND IMPACT MINIMIZATION STRATEGIES

Green sea turtles are more likely to experience significant disturbance from hand-broadcasting activities, we plan to bait via helicopter over areas with sea turtles. We will also follow all conservation recommendations from our Section 7 consultation with the NMFS which is currently in progress. During the bait drops there will be specialists on site that can monitor sea turtles throughout the operation for disturbance and exposure risk and provide recommendations to the project manager based on those observations. The minimization measures in place for the Proposed Action would reduce the likelihood that any rodenticide would enter the marine environment, (see Section 2.4). In addition, all project personnel on the ground would maintain a 100 ft. (30.5 m) buffer from any sea turtles during operations. During aerial bait broadcast, helicopters would avoid hovering near turtle basking areas. Ship strike avoidance measures would be in place to avoid impacting this species during the transport of materials and equipment (Section 2.4). These include reducing the vessel's speed to 5-10 knots in the presence of, and in known areas of, listed marine species, and maintaining a 656 ft. (200 m) buffer around marine species encountered at sea.

5.5 HAWKSBILL SEA TURTLE

5.5.1 RELEVANT BASELINE INFORMATION

Hawksbill sea turtles are not known to nest in the NWHI and have been infrequently observed in MANWR's lagoon and nearshore waters. "Infrequent" as used here is defined as happening or occurring at long intervals or rarely.

5.5.2 IMPACTS

5.5.2.1 Primary Exposure

Hawksbill sea turtles could potentially eat bait pellets that drift into the water and succumb to primary exposure. However, it would be very unlikely this would occur given the low probability of bait entering the water, the rapid decomposition of bait in water (see Section 2.2.3), and the amount that would have to be consumed for a lethal dose, as per preliminary findings of a USDA National Wildlife Research Center hazards study indicating turtles are unlikely to be negatively affected by brodifacoum consumption (see Section 5.4.2.1). Hawksbills are infrequent visitors to the refuge, which further reduces the probability of their exposure to bait pellets. Because exposure is unlikely, impacts are insignificant.

5.5.2.2 Secondary Exposure

Secondary exposure of the toxicant to Hawksbill sea turtles is very unlikely due to their diet. Hawksbill sea turtles appear to be specialist sponge carnivores, and therefore secondary exposure to the rodenticide is highly unlikely. Because secondary exposure is highly unlikely impacts are insignificant.

5.5.2.3 Operational Impacts

Operational impacts to hawksbill sea turtles during the Proposed Action are unlikely. Impacts include helicopter noise disturbance to loafing turtles. This species infrequently visits MANWR and has never been reported hauling out or nesting in the Action Area. Hawksbills that enter the lagoon may be disturbed by helicopters during the Proposed Action. Regardless, 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, nearshore 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 insignificant, especially given that the species has rarely been reported occurring in the lagoon (USFWS unpublished data).

5.5.2.4 Other Impacts

Hawksbill sea turtles may experience impacts from implementing monitoring and biosecurity measures. The impacts and results would be the same as discussed in Operational Impacts (Section 5.5.2.3).

5.5.2.5 Ship Strike

The marine aspects of this species is under jurisdiction of NMFS. Ships navigating through Refuge waters and entering MANWR's lagoon have the potential to accidentally strike sea turtles in the water and potentially causing injury or mortality. Hawksbill sea turtles are rarely observed in Refuge waters and within MANWR's lagoon. Adhering to mitigation measures that restrict a vessel's speed to 5 knots or less within lagoon waters and keeping a watchful eye for sea turtles when navigating Refuge waters would make the potential for ship strikes unlikely, and therefore, impacts are insignificant.

5.5.3 MITIGATION AND IMPACT MINIMIZATION STRATEGIES

If hawksbill sea turtles are observed in the Action Area, the same mitigation strategies in place for green sea turtles would apply to these individuals (see Sections 5.4.3 and 2.4).

5.6 OTHER MARINE SPECIES

Eleven species under the jurisdiction of NMFS and analyzed in this BA are only at risk from a ship strike and are unlikely to be affected by the project (see Table 5.2). Except for the false killer whale MHI Insular DPS, these marine species are rare to infrequent visitors to Hawaiian waters. Strike avoidance measures would be in place (Section 2.4) along with any additional measures recommended in the PMNM permit to avoid the risk of negative affects to endangered marine species. During transportation of supplies and materials, vessels would monitor and adjust speeds to no more than 10 knots in the presence of these protected marine species and ship captains would be mindful of maintaining a 656 ft. (200 m) buffer around species encountered at sea. Adhering to BMPs that restrict a vessel's speed and distance, and no known record of ship strikes with a marine protected species by any authorized vessel operator in the Monument, the potential for ship strikes unlikely and therefore, impacts are discountable.

Based on adherence to the BMPs, along with no known record of ship strikes with a marine protected species by any authorized vessel operator in the Monument; we expect the likelihood of a marine protected species being the victim of a ship strike to be discountable.

Table 5.2 Effects analysis for potential ship strike with marine species (n=11)

Common Name	*Effects Analysis for Potential Ship Strike*
Loggerhead sea turtle North Pacific Ocean DPS	Rare in Hawaiian waters; not likely to occur in the Action Area. Would be protected by mitigation measures (Section 2.4) if detected.
Olive ridley sea turtle	Rare in Hawaiian waters; not likely to occur in the Action Area. Would be protected by mitigation measures (Section 2.4) if detected.
Leatherback sea turtle	Rare in Hawaiian waters; not likely to occur in the Action Area. Would be protected by mitigation measures (Section 2.4) if detected.
False killer whale MHI Insular DPS	Present in MHI. Known to preferentially use habitat on the northern coast of Moloka‘i and Maui Islands, the north end of Hawai‘i Island, and a small region southwest of Lāna‘i Island. Marine areas used by this species are known and mitigation measures would be in place.
Blue whale	Infrequent in Hawaiian waters in winter; not present in summer. Would be protected by mitigation measures (Section 2.4) if detected.
Fin whale	Present but infrequent in Hawaiian waters. Can occur in any month. Detected in the NWHI, Hawaii EEZ, and MHI (O‘ahu, Kaua‘i, Lāna‘i, and Hawaii Islands). Marine areas used by this species are known and mitigation measures would be in place.
Sei whale	Rare in Hawaiian waters; not likely to occur in the Action Area. Would be protected by mitigation measures (Section 2.4) if detected.
Sperm whale	Rare in Hawaiian waters; not likely to occur in the Action Area. Would be protected by mitigation measures (Section 2.4) if detected.
North Pacific right whales	Present but infrequent in Hawaiian waters. Not present in summer. In Hawaii, known to associate with humpback whale pods. Detected off Maui, Kaho‘olawe, and Moloka‘i Islands. Marine areas used by this species are known. Would be protected by mitigation measures (Section 2.4) if detected.
Giant manta ray	Known to preferentially use habitat in French Frigate Shoals, NWHI. Marine areas used by this species are known. Would be protected by mitigation measures (Section 2.4) if detected.
Oceanic whitetip shark	Present but infrequent in Hawaiian waters. In Hawai‘i, known to associate with pilot whale pods. Would be protected by mitigation measures (Section 2.4) if detected.
Source: Hamer Environmental (2018)	

CHAPTER 6: CONCLUSION AND DETERMINATION

An effects determination is made for the Proposed Action regarding each listed species and designated critical habitat. The three possible effects determinations for each species are: (*i*) No Effect (NE); (*ii*) May Affect, but Not Likely to Adversely Affect (NLAA); and (*iii*) May Affect, and Likely to Adversely Affect (LAA).

- "No effect" means there will be no impacts, positive or negative, to listed or proposed resources. Generally, this means no listed resources will be exposed to action and its environmental consequences. Concurrence from the Service is not required.
- "May affect, but not likely to adversely affect" means that all effects are beneficial, insignificant, or discountable. Beneficial effects have contemporaneous positive effects without any adverse effects to the species or habitat. Insignificant effects relate to the size of the impact and include those effects that are undetectable, not measurable, or cannot be evaluated. Discountable effects are those extremely unlikely to occur. These determinations require written concurrence from the Service.
- "May affect and is likely to adversely affect" means that listed resources are likely to be exposed to the action or its environmental consequences and will respond in a negative manner to the exposure. These determinations require concurrence from the Service.

It has been determined that the Proposed Action is likely to adversely affect one ESA-listed species and may affect but not likely to adversely affect 16 other ESA-listed species and designated critical habitat. A "NLAA" effects determination requires a request for concurrence from the Service (informal consultation), and a "LAA" effects determination requires initiation of formal consultation with the Service (see Table 6.1).

Table 6.1 Summary of Effects Determination and Mitigation Measures for ESA-listed Species and Critical Habitat that May Occur in the Action Area.

Common Name	Effects Analysis	Impact[1]	Mitigation
Birds (USFWS)			
Laysan duck	LAA	P, S, OH, O	USFWS is consulting with Ecological Services Division under Section 7 of the Endangered Species Act to identify the best course of action to ensure protection of this species. For full details, see Laysan Duck Mitigation Strategy (Appendix C).
Plants (USFWS)			
Pōpolo	NLAA	OH, O	Locations known; Species proliferate. Train staff during ground operations to identify this species and avoid trampling (see Section 5.2.3).
Lo'ulu	NLAA	OH, O	Locations known, marked, and fenced for protection. Species proliferate. Train staff during ground operations to identify this species (see Section 5.2.3).
Marine Species (USFWS and NMFS)			
Hawaiian monk seal and Critical Habitat	NLAA	P, S, OH, O, SS	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 this species and its critical habitat. See current mitigation measures in place, including ship strike avoidance measures (BMP's) that will be in place (Section 2.4).
Hawaiian green sea turtle Central North Pacific DPS	NLAA	P, S, OH, O, SS	Mitigation and protection measures will be in place to protect nearshore environment during and after the Proposed Action (Section 2.2.3). Ship strike avoidance measures (BMP's) will be in place (Section 2.4).
Marine Species (NMFS)			
Hawksbill sea turtle	NLAA	P, OH, O, SS	Beach haul-out by this species has not been documented in the Action Area. Frequency of species occurrence in the Action Area is so rare that risk is considered negligible. Ship strike avoidance measures (BMP's) will be in place (Section 2.4).
Loggerhead sea turtle North Pacific Ocean DPS	NLAA	SS	Frequency of species occurrence in the Action Area is so rare that risk is considered negligible. Ship strike avoidance measures (BMP's) will be in place (Section 2.4).
Olive ridley sea turtle	NLAA	SS	Frequency of species occurrence in the Action Area is so rare that risk is considered negligible. Ship strike avoidance measures (BMP's) will be in place (Section 2.4).
Leatherback sea turtle	NLAA	SS	Frequency of species occurrence in the Action Area is so rare that risk is considered negligible. Ship strike avoidance measures (BMP's) will be in place (Section 2.4).
False killer whale MHI Insular DPS	NLAA	SS	Detected in MHI (Molokai, Hawaii, Maui and Lanai). Ship strike avoidance measures (BMP's) will be in place (Section 2.4).
Blue whale	NLAA	SS	Species occurrence in the Action Area is so infrequent that risk is considered negligible. Ship strike avoidance measures (BMP's) will be in place (Section 2.4).

Common Name	Effects Analysis	Impact[1]	Mitigation
Fin whale	NLAA	SS	Species occurrence in the Action Area is so infrequent that risk is considered negligible. Ship strike avoidance measures (BMP's) will be in place (Section 2.4).
Sei whale	NLAA	SS	Frequency of species occurrence in the Action Area is so rare that risk is considered negligible. Ship strike avoidance measures (BMP's) will be in place (Section 2.4).
Sperm whale	NLAA	SS	Frequency of species occurrence in the Action Area is so rare that risk is considered negligible. Ship strike avoidance measures (BMP's) will be in place (Section 2.4).
North Pacific right whales	NLAA	SS	Species occurrence in the Action Area is so infrequent that risk is considered negligible. Ship strike avoidance measures (BMP's) will be in place (Section 2.4).
Giant manta ray	NLAA	SS	Known to preferentially use habitat in French Frigate Shoals, NWHI. Species occurrence in the Action Area is so infrequent that risk is considered negligible. Ship strike avoidance measures (BMP's) will be in place (Section 2.4).
Oceanic whitetip shark	NLAA	SS	Species occurrence in the Action Area is so infrequent that risk is considered negligible. Ship strike avoidance measures (BMP's) will be in place (Section 2.4).
Impact is from: 1) P=Primary (primary exposure), 2) S=Secondary (secondary exposure), 3) OH=Operational Hazards (airstrike risk, helicopter noise, ground-based disturbances), 4) O=Other (implementing monitoring plan (Appendix B) and MANWR's biosecurity rapid response measures (Appendix A), and SS=Ship Strike.			
Source: Hamer Environmental (2018)			

6.1 LAYSAN DUCK

LAA – The Proposed Action may affect, and is likely to adversely affect, the Laysan duck. The Laysan duck population on MANWR is of global significance. Take could occur during all phases of the project (Table 5.1). Without minimization and mitigation efforts it is expected that mortality would occur among most, if not all, of the Sand Island duck population (adults, subadults, ducklings, and eggs). Implementation of the Laysan Duck Mitigation Strategy (Appendix C) would minimizing this species' exposure to brodifacoum during and post-operation and mitigate spatial and temporal risks resulting from the proposed action.

6.2 PŌPOLO AND LOʻULU

NLAA – The project may affect, but is not likely to adversely affect, pōpolo and loʻulu. Out-plantings of pōpolo thrive at MANWR under management efforts that focus to restore native plant communities. Cultivation of loʻulu in locations outside of Nihoa Island, such as MANWR, safeguard this rare plant against extinction. Known locations of pōpolo will be marked and avoided by ground personnel to prevent accidental trampling. Known locations of the five loʻulu will be marked, fenced, and avoided by ground personnel to prevent accidental trampling. It is improbable that the Proposed Action will impact pōpolo and loʻulu. Therefore, the potential effects are insignificant. Because effects are insignificant, the proposed project may affect, but is not likely to adversely affect pōpolo and loʻulu.

6.3 HAWAIIAN MONK SEAL AND CRITICAL HABITAT

NLAA – The project may affect, but is not likely to adversely affect, Hawaiian monk seal and its critical habitat. The refuge provides essential features of habitat for foraging, pupping, and nursing Hawaiian monk seals and is mapped as Critical Habitat and monitored regularly. A buffer of 100 ft. (30.5 m) from basking seals will be maintained by ground personnel. Helicopters will not hover over basking seals and will use a deflector to minimize drift in the nearshore waters. Ship strike avoidance measures will be implemented that restricts vessel speed to no more than 10 knots and distance to no less than 656 ft. (200 m). Therefore, the potential effects are insignificant. Because effects are insignificant, the proposed project may affect, but is not likely to adversely affect Hawaiian monk seals or their critical habitat.

6.4 GREEN SEA TURTLE

NLAA – The project may affect, but is not likely to adversely affect, the Central North Pacific Distinct Population Segment green sea turtle. The Refuge’s lagoon provides protected waters for green sea turtles that are frequently observed swimming in the area. Green sea turtles infrequently nest at the Refuge. A buffer of 100 ft. (30.5 m) from loafing turtles will be maintained by ground personnel. Helicopters will not hover over loafing turtles and will use a deflector to minimize drift in the nearshore waters. Ship strike avoidance measures will be implemented that restricts vessel speed to no more than 10 knots and distance to no less than 656 ft. (200 m). Therefore, the potential effects are insignificant. Because effects are insignificant, the proposed project may affect, but is not likely to adversely affect green sea turtles.

6.5 HAWKSBILL SEA TURTLE

NLAA – The project may affect, but is not likely to adversely affect, the hawksbill sea turtle, an infrequent visitor to the Refuge. Hawksbill sea turtles are unlikely to be present during the Proposed Action. Should this species be detected in the Action Area, the same minimization measures for green sea turtles will be implemented. It is improbable that the project will impact hawksbill sea turtles, and therefore the potential effects are insignificant. Because effects are insignificant, the proposed project may affect, but is not likely to adversely affect this species.

6.6 OTHER MARINE SPECIES (NMFS)

NLAA – The project may affect, but is not likely to adversely affect, the marine species that are solely at risk of ship strike during the transport of gear and equipment to and from Honolulu to Midway Atoll. At least one whale, the false killer whale MHI Insular DPS, might be encountered during ship transport. This whale species is known to occur in waters of the MHI, but primarily around the islands south of O‘ahu (Honolulu). Ship strike avoidance measures will be implemented that restricts vessel speed to no more than 10 knots and distance to no less than 656 ft. (200 m). Therefore, the potential effects of a ship strike are insignificant for false killer whale MHI Insular DPS, and negligible for the other ten marine species. Because effects are insignificant and negligible, the proposed project may affect, but is not likely to adversely affect these marine species.

CHAPTER 7: REFERENCES

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CHAPTER 8: LIST OF CONTACTS MADE AND PREPARERS

8.1 PREPARERS

Table 8.1 below identifies the principal agencies, organizations, and individuals that participated in the preparation of this report.

Table 8.1 Principal Preparers of this Biological Assessment

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Source: Compiled by Hamer Environmental (2018)	

8.2 CONTRIBUTORS

Table 8.2 below identifies the agencies, organizations, and individuals that contributed critical information for the development of this report.

Table 8.2 Contributors to this Biological Assessment

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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.

Bait Bucket - a piece of equipment used in many types of industry to discharge products at a steady rate.

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.

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.

Epipelagic - the oceanic zone extending from the surface to about 656 ft. (200 m) where enough light penetrates to allow photosynthesis

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.

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.

Invasive - a non-native species whose introduction causes or is likely to cause economic or environmental harm, or harm to human health.

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.

Mitigation - steps taken to reduce or avoid negative environmental impacts.

Native - a species that occurs naturally (without human agency) in an area.

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.

Pica - displaying an indiscriminate preference for eating non-food items; such as chicks pecking and eating rocks, sticks and other foreign objects.

Potable - safe to drink; drinkable.

Predation - the act of one organism killing and eating other organisms; can refer to both animals and plants.

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.

Threshold - the magnitude or intensity that must be exceeded for a certain reaction, phenomenon, result, or condition to occur or be manifested.

Appendix A. MIDWAY ATOLL NATIONAL WILDLIFE REFUGE BIOSECURITY 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.

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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 to rodent 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 20 m 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 (also, see Appendix C),** for which we will monitor population size, reproductive performance, and behavior. We will quantify direct and indirect impacts of mice on duck population using 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 when bait pellets are no longer available to be consumed or biological samples

collected post-application indicate little to no risk (Appendix C). Monitoring will also include recapture of ducks demonstrating signs of toxicosis.

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 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. Monitoring populations of fish, birds, and plants and controlling populations of invasive species currently takes place on MANWR for management purposes. The refuge staff and personnel from coordinating external agencies will follow established protocols that have been enhanced in scope for surveying and sample-collecting during pre- and post-eradication. While we are still working out details, we currently plan to work with a qualified lab off-site to test for brodifacoum residue in non-target carcasses, prey species, and in the environment over time. Sampling and analysis will be done at appropriate intervals. Surveys of the beaches, coastal waters, and terrestrial areas will be conducted to monitor various aspects of the operation. These surveys will include assessing bait persistence, removing mouse carcasses, retrieving sick or injured wildlife, and collecting samples (including non-target fatalities) for pesticide testing. Every precaution will be taken to avoid impacting non-target species while maximizing the chance of project success. We will use adaptive management techniques to adjust the project if we experience any significant unintended consequences to non-target organisms.

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 primary focus of sampling, with diminishment of brodifacoum levels to be confirmed before ducks are returned to Midway Island (see Appendix C).

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 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 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 5 and details of the Laysan duck protection plan in Appendix C.

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Appendix C. LAYSAN DUCK PROTECTION STRATEGY

Laysan Duck Protection and Mitigation Strategy
Protection Plan for Midway Atoll Mouse Eradication Campaign

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TABLE OF CONTENT

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1: PROJECT INTRODUCTION

Midway Atoll National Wildlife Refuge (MANWR) is part of the Northwest Hawaiian Islands (NWHI) archipelago, and located approximately 1,250 mi (2,000 km) west-northwest of Honolulu, Hawai`i. The refuge lies within the Papahānaumokuākea Marine National Monument (PMNM) and has also been designated the Battle of Midway National Memorial. Midway Atoll hosts shallow lagoons and three low-lying islands (Sand, Eastern, and Spit Islands) that are encompassed by a nearly circular fringing coral reef. This isolated refuge in the Pacific Ocean is the breeding grounds for millions of seabirds, a haven for thousands of migratory shorebirds, and one of only three locations that harbor populations of the Federally endangered Laysan duck (*Anas laysanensis*).

MANWR is rodent-free except for Sand Island, where house mouse (*Mus musculus*) populations and their negative impacts to native species and habitats continue to occur despite on-going rodent control and management efforts. The Proposed Action by the USFWS to eradicate the mice at MANWR involves aerial and ground applications of bait pellets containing rodenticide (Brodifacoum-25D) into all potential mouse territories on Sand Island, including hand-broadcasting of bait in sensitive areas (e.g., narrow shorelines) and placing bait stations in commensal areas.

The impacts from invasive predatory mammals, including mice and rats (*Mus musculus* and *Rattus* spp.), are one of the leading causes of species extinction on islands (Blackburn et al. 2004, Duncan and Blackburn 2007). Over three million birds, of 25 different species, can be found at MANWR and all of them are potentially susceptible to predation by mice. Predation of vulnerable populations of native seabirds is a real and ongoing threat on Sand Island that demands an immediate and effective response. Eradication of the house mouse would also facilitate the protection and restoration of all native species and habitats present in the refuge, including federally listed species and their habitats.

1.1 SUMMARY OF RISKS TO LAYSAN DUCKS

MANWR supports the federally endangered Laysan duck, a rare, non-migratory, year-round resident of the refuge (Table 1). The Laysan duck persists in the wild only on Laysan Island and at Midway and Kure Atolls. Globally, there are fewer than 1,100 Laysan ducks occurring at these 3 sites and approximately half of this population occurs on Eastern and Sand Islands of MANWR (SWCA 2017).

Current threats to Laysan ducks are made more significant by a small population size and extremely limited distribution which make this species highly vulnerable to demographic fluctuation and the chance of adverse environmental influences from droughts, severe storms, epizootics, predators, and invasive species. Non-native invasive species (mice, weeds, and possibly predatory insects such as some ant species) can alter the Laysan duck's habitat. Habitat degradation and loss within PMNM may be intensified by increased storm severity and sea level rise associated with global climate change.

As mouse predatory behavior is likely to spread on Sand Island, the negative impacts to Laysan ducks could be significant to the global population. If mice are tenacious enough to attack and cause mortality to the Laysan albatross, one of the largest ground-nesting seabirds at MANWR, then it is likely that mice are having similar negative effects on other ground nesting birds, including the Laysan duck. In addition, mice could be competing with ducks for invertebrate food resources. Mice are known to be a seed predator on *Eragrostis variabilis*, an important grass providing cover for Laysan ducks. The proposed mouse eradication would allow recruitment of native grasses useful for Laysan ducks as shelter, nesting, and foraging habitat (VanderWerf 2012).

Laysan ducks are non-migratory, year-round residents at MANWR, and those on Sand Island would be exposed to rodenticide bait pellets during and after the eradication action. 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. Therefore, Laysan ducks would likely ingest Brodifacoum-25D rodenticide bait pellets if they encounter them. Bait pellets would remain accessible on the ground until they are all consumed by mice or terrestrial invertebrates, or until environmental factors cause the grain-based pellet matrix to disintegrate. If bait pellets are consumed, primary poisoning is likely unless an affected duck is administered vitamin K immediately. Secondary poisoning is possible as long as the toxicant remains available in the ecosystem, or there are invertebrates with brodifacoum residue in their bodies (possibly up to 6 months). Human disturbances also pose a risk; impacts can occur during capture and captive holding, hand-broadcasting of bait pellets, and post-project monitoring efforts. Impacts could include trampling of vegetation and nests and inducing stress.

Thus, there is a clear primary route of exposure to the rodenticide as it is assumed that ducks would consume bait. For primary exposure to the rodenticide, rodenticide resulting in illness or mortality, the calculated threshold whole body ED_5 is 0.47-1.8 µg total intake of brodifacoum for an average Laysan Duck (Mineau 2018). In addition, the primary food source of Laysan ducks is invertebrates and thus ducks are likely to sustain secondary or tertiary exposure to rodenticides after ingesting these smaller organisms that previously consumed bait. Therefore, secondary exposure to the rodenticide is likely. Without mitigation, a large portion of the population of ducks present on MANWR would very likely succumb to the toxic effects of the rodenticide through primary or secondary exposure. Mitigation measures for Laysan ducks during and following the proposed mouse eradication would ensure that, at minimum, a viable portion of the population is protected for later release back on Sand Island. Based on the life history characteristics of the Laysan duck, the best time to conduct a mouse eradication would be during the non-breeding season (October through February) (SWCA 2017).

Table 1. Laysan ducks and shorebirds occur in moderate to high abundance at MANWR (n = 6 species. MBTA = protected under the U.S. Migratory Bird Treaty Act of 1918, US ESA = U.S. Endangered Species Act, IUCN Red List = International Union for Conservation of Nature Red List of Threatened Species).

Common Name	Scientific Name	Federal Status	IUCN-list
Laysan duck	*Anas laysanensis*	ESA Endangered	Critically endangered
ruddy turnstone	*Arenaria interpres*	MBTA	Least concern
wandering tattler	*Tringa incana*	MBTA	Least concern
Pacific golden plover	*Pluvialis fulva*	MBTA	Least concern
bristle-thighed curlew	*Numenius tahitiensis*	MBTA	Vulnerable
sanderling	*Calidris alba*	MBTA	Least concern

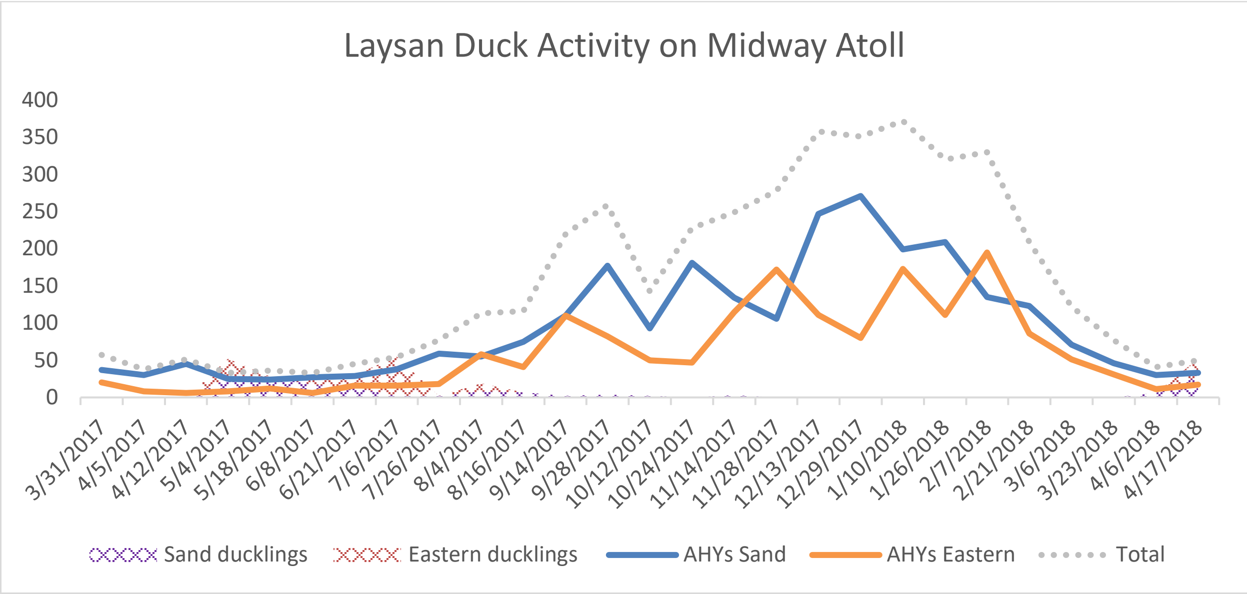
Source: USFWS (2017)

1.2 EFFECTS OF TIMING OF ERADICATION ON NON-TARGET ORGANISMS

The optimum time to apply rodenticide is informed by several considerations having to do with the effects on efficacy, human safety, and effects on non-target organisms. The best timing for each consideration does not always align with that for the others. Some deviations from the best time for any particular consideration can be managed by changing other parameters. At Midway the best time to do the work with respect to Laysan Ducks would be between October and February when the fewest birds are breeding or molting. The best time to do the application for ensuring that every mouse has access to and interest in taking the bait would be when food resources are declining in abundance and mouse populations have peaked and are starting downward. This part of the regular cycle of mouse population size happens at different times during different years but is most typically during the summer and early fall at Midway. Other factors that can affect success of bait applications include timing of rainfall and wind velocity. The constraint most relevant to human safety and thus the one that will put bounds on the range of times that can be considered is the number of adult albatrosses flying into the colony. This colony is the largest in the world and any at particular time may have as many as 500,000 breeding albatrosses that each weigh between 5 and 6 pounds coming and going as they bring food to their chicks. For reduction of bird airstrike hazard to the helicopters spreading the rodenticide, the window chosen to do this work should start in July when many of the chicks have fledged and extend until mid-October, when the earliest breeders start showing up for a new season.

Given the window dictated by human safety during flight operations (July to mid-October) the choices for the other efficacy and non-target considerations become more difficult. Figure 1 shows results of Laysan duck counts at Midway Atoll and supports the idea that waiting until mid-September to apply bait would allow more ducks to be captured because they are less cryptic (more detectable) after breeding and molting is completed and would not need to be held in captivity for as long because the team would not need to start capturing early in the year before the breeding season starts.

Figure 1. Duck detectability increased mid-August and decreased dramatically mid- to late February. Ducklings are first seen late March to early April with highest numbers between April and July. However, they can still be seen through October and November (rare). Eastern Island: During the winter months, we typically saw 111-195 ducks. From this survey, we can estimate Midway's population to be approximately 600 with a range of 526-686 (95% CI).



Optimal timing for bait application to minimize shorebird impacts is during late May as soon as the adult birds have departed the wintering grounds to travel North to breed. As discussed earlier, this time falls outside the flight safety window of late July to mid–October. The later window that is best for Laysan Duck capture (late September start) falls during a period less desirable for shorebird protection both because most winter resident shorebirds will have returned and because there may even be a pulse of birds stopping by on their way further south to other wintering sites (Figure 1) based on observations of particularly high counts during this period. These shorebird numbers do not persist later in the winter.

Results from recent trials to compare bait uptake rates in July and September indicate faster bait disappearance in September 2018 than in July of 2018 arguing for the earlier application period from an efficacy standpoint because even at the highest labelled application rate we couldn't maintain bait on the ground for more than 2 days in amounts sufficient to ensure bait availability to all mice. In 2018 ducks continued to breed during the month of September with young broods still appearing so the advantage of waiting till ducks were no longer breeding to improve detection and capture probabilities was not evident this year.

The proposed date for first bait application is July 1, 2019. Non-target species protection activities will be timed to reflect this starting time. We will start capturing Laysan ducks in February and continue throughout the spring and summer. We will start capturing migratory shorebirds in June as soon as all birds that are going to migrate North have done so. Captive ducks and shorebirds will be kept in aviaries on Sand Island until immediately before the July application period. Then they will be moved to corresponding aviaries on Eastern Island where they will be kept until it is deemed safe to release them using a four-step process described later in this report.

We will also capture and hold in captivity on Sand Island canaries and common mynas. These birds will be released in test groups after there are no more pellets visible and residue testing indicates levels of Brodifacoum residue in invertebrates have declined sufficiently. We will track released passerines carefully and also observe the health of returning migratory shorebirds for signs that they are being exposed including lethargy and bleeding. Ducks will not be released until all these other indicators of Brodifacoum toxicity are no longer being seen. Staffing and infrastructure requirements of each of the non-target organisms to be held in captivity will be discussed in detail below. The total number of non-target care personnel needed are shown in Table 2.

Table 2. The 2019 staffing schedule for non-target species management for capture and captive care of birds. V = Wildlife veterinarian, A = Aviculturist, C = Capture specialist and, P = Protection team members. Protection team members will assist with captive care tasks including food preparation, feeding aviary birds, cleaning aviaries, observation of marked birds on Eastern, supplemental feeding on Eastern, Guzzler cleaning, surveillance on Sand, and other duties.

First Bait application										Last Bait application				
	Jan	Feb	Mar	Apl	May	June		July		Aug	Sep	Oct	Nov	Dec
All captive care		V A	V A	V A	V A	V A		V A		V A	V A	V A	V A	V A
Laysan Duck		C - 3 P - 3	C-3 P-3	C-4 P-4	C-4 P-4	C-4 P-4		C-4 P-4		C-4 P-4	C-3 P-4	C-2 P-4	C-2 P-4	C-2 P-4
Shorebirds					C-2 P-2	C-2 P-2		C-2 P-2		C-2 P-2	C-2 P-2	C-2 P-2	P-2	P-2
Sentinel Passerines				C-2 P	C-2 P	C-2 P		P		P	P	P	P	
Total NT staff		8	8	13	17	17		15		15	14	13	11	10

CHAPTER 2: BENEFITS OF MOUSE ERADICATION TO LAYSAN DUCKS

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 in the Northwestern Hawaiian Islands include non-native, invasive species (e.g., mice, and plants) that can alter the Laysan duck's habitat. Since the Laysan duck is also a ground nesting species, the removal of mice is expected to contribute to successfully maintaining Laysan ducks on MANWR. 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. Without eradication, introduced mice would continue to prey on ground nesting birds 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 populations. Mice could also be competing with ducks for invertebrate and plant food resources. Mice are known to be a seed predator on *Eragrostis variabilis* an important food source and plant cover for Laysan ducks. Therefore, it is possible that food will be less limiting for Laysan ducks and that an increase in nesting cover could occur after mice are eradicated from Sand Island. Diet overlap of Laysan ducks with mice is currently being studied on Midway using DNA barcoding techniques.

CHAPTER 3: SUMMARY OF AVIAN CAPTURE METHODS

This section addresses trapping methods that can be, and have been used for, capturing ducks and shorebirds. Specific details on trapping Laysan ducks found in each species' section. Capture of passerine birds (canaries and mynas) involves some of the same techniques as well.

Noose Carpet: A noose carpet at least 30 x 30 cm (Bub 1991) can be made of 0.24 x 0.24 in. (0.6 x 0.6 cm) hardware cloth and 20 lbs. (9 kg) monofilament nooses. A clinch knot can be used to secure each noose to the hardware cloth. Birds are coaxed to walk across the noose carpet by herding them towards it (Figure 2). Noose carpets are designed to typically catch one bird at a time. Traps set near wetlands must be weighted or anchored to prevent captured ducks from dragging the noose carpet into a deep wetland and diving to the bottom where they could drown.

Figure 2. USGS biologist Michelle Reynolds herds ducks towards a noose carpet, a trap used to catch many of the 28 ducks translocated from Midway Atoll National Wildlife Refuge to Kure Atoll State Wildlife Sanctuary within Papahānaumokuākea Marine National Monument on September 3, 2014.

Walk-in Trap: A walk-in trap such as those using a funnel fence of net walls with a tapering lead where herded ducks enter traps (or transport boxes) (Bub 1991). Decoys placed on the outside with bait on the inside is used to attract birds. A mist net can also be set up as a walk-in trap (SWCA 2017). This method is effective and may cause less stress than some of the other techniques. This kind of trap can be pre-baited and left open to allow birds to habituate to its presence and to learn to come for food there.

Mist Net: Mist nets can be made with black polyester shelves 8.5 ft. high and 19.7-29.5 ft. wide (2.6 m high and 6-9 m wide) for capturing birds. Net poles can be made from 1 x 118 in. (0.0254 x 3 m) PVC-pipe or obtained from Avinet and sized 0.63 x 118 in. (0.016 x 3 m). Attempts to attract birds can be with audio playback of vocalization, herding, bait, and decoys. Mist nets can also be setup in a triangular formation to act as a walk-in trap.

Net Gun: A CO_2-powered Super Talon net gun with a 49 ft. (15 m) range can be used to capture birds. Each net gun can have four heads, each loaded with a 9.8 ft. (3 m) diameter net. Three types of nets are available: removable weights, permanent weights, and permanent weights with grappling hooks. A Crossman CO_2 cartridge is used to propel the net. To capture birds with the net gun, a blind should be set up with decoys and a lure to attract birds to the blind.

Whoosh Net: A whoosh net uses four pieces of 0.63 x 24 in. (0.016 x 0.6 m) rebar to anchor a net and bungee cords, two pieces 0.34 x 59 in. (0.01 x 1.5 m) rebar with 1 x 59 in. (0.0254 x 1.5 m) PVC-pipe slid over the top for the lead poles, 1.3 x 36 in. (3.2 x 91 cm) punched angle for securing the trigger, and a pull cord made of parachute cord tied to a 0.24 x 1 in. (0.6 x 2.54 cm) metal pin. Decoys can be placed to attract birds to the path of the whoosh net.

Dip Net and spotlight: Both shorebirds and ducks can be captured at night by dazzling them with a bright light and gently putting a dip net over them.

A variety of traps have been used to catch mynas, some relying on the birds' attraction to baits of various kinds (called 'foraging traps' in Australia) and others using live decoy birds. In practice, baited multi-catch traps become decoy traps as soon as the first myna is caught (https://www.cabi.org/ISC/search?q=Acridotheres%20tristis). At present not enough is known to predict which traps will be most successful in a given area. Different trap designs seem to vary in efficiency in different places, including different islands within the same group (Feare 2010) and different habitats on the same island (Feare, unpublished). On North Island, Seychelles, commercially available multiple catch traps failed to catch mynas feeding on the island's grassland but were successful close to the island's organic waste site, while locally-made decoy traps, each with four catching compartments with a drop door triggered on entry, were most efficient on the grassland (Feare, unpublished). Common mynas can sometimes be trapped on the nest using nooses inside the nest or in the nest entrance. Where this has been used the number caught has been very small compared with the numbers caught by more traditional trapping away from the nest (Millet et al. 2004, Tideman et al. 2007). Canaries can be caught using food-baited walk in traps, sparrow traps with live decoys, and mist nets. All nets and traps that are set would be monitored continuously when deployed.

CHAPTER 4: LAYSAN DUCK

4.1 LAYSAN DUCK MITIGATION PLAN

The Laysan duck is endemic to Hawai`i and is considered the rarest native waterfowl species in the United States. It currently has the most restricted range of any duck in the world (USFWS 2009). In 2004 and 2005, a total of 42 ducks were translocated from Laysan Island to the 1,128 ac. (456 ha) Sand Island, MANWR, following extensive habitat restoration efforts (Reynolds and Klavitter 2006). This population peaked in 2010 at 661 adult and juvenile birds (95% CI 608–714), before the botulism outbreaks that caused population declines in 2012 and 2015 of 38 percent and 37 percent, respectively. In 2015, using a statistical model developed from a radio-telemetry study (Reynolds et al. 2014), Reynolds estimated there were between 314 and 435 Laysan ducks (95% CI for population estimate). The point estimate was 375 individuals (Reynolds et al. 2017). 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 same statistical model developed by Reynolds was then used to estimate the population of Laysan ducks on MANWR using data from March 2017 to March 2018 that included numbers from the non-breeding season (October-February). Using a maximum count of 372 ducks, the model returned a population estimate of 600 ducks with a range of 526-685 (95% CI) individuals (K. Goodale, Pers. Comm.). Laysan ducks fly between Eastern and Sand Island but it is unknown how often birds move back and forth or whether there are birds that do not cross the water barrier and stay on one island of the other.

The Laysan duck (*Anas laysanensis*) is currently on the Federal Endangered Species List due to its restricted distribution and small wild population. It is a small-sized duck, largely nocturnal and sedentary. Adults are approximately 15-17 in. (38-43 cm) in length and weigh around 15-18 oz. (420-500 g). Overall, it is a chocolate-colored bird with contrasting bi-colored body feathers, an iridescent purplish-green speculum (wing patch), and a prominent white eye ring (USFWS 2009, Moulton and Marshall 1996). Legs and feet are pale dull orange and usually brighter in males.

On Laysan Island, courtship behaviors occur most of the year and adult pairing is established by September or October. The nesting season on Laysan generally runs from April through July, but reproductive response is flexible according to habitat conditions (Moulton and Marshall 1996). Laysan ducks can produce clutches averaging 3.8 eggs; the start and duration of egg-laying is highly variable from year to year depending upon stochastic factors like climatic events. Egg-laying typically occurs from April to August and incubation is 28-29 days. Duckling activities are concentrated near sources of fresh water with nearby food and cover.

At MANWR, the peak nesting season is March through September. Males start molting in June. Most adult females start molting in August and September. Wing molt takes approximately 3-4 weeks, a pattern typical of mainland ducks (Moulton and Weller 1984). Broods receive female-only parental care (Moulton and Weller 1984, Reynolds and Kozar 2000). If the timing of the Proposed Action occurs in July, it will overlap with the Laysan duck breeding season (March through September). The only effective mitigation strategy is to prevent the exposure of the ducks to rodenticide.

4.2 PROPOSED LAYSAN DUCK PROTECTION PLAN

Captive care facilities (aviaries) with a minimum capacity of 200 Laysan ducks and the capability to separate smaller groups of animals in ways that minimizes aggression will be built both on Sand and on Eastern Islands. Two hundred ducks will be held in the Sand Island aviaries from their date of capture until immediately before the bait application when they will be transferred to the Eastern Island aviaries. There will also be clinic space inside a building on Sand Island allocated for more intensive care of ducks that need veterinary care and aviary space for holding ducks for at least 10 days in order to administer a vaccine for botulism and a booster shot 10 days later for all ducks whether they are held or just captured and subsequently released on Eastern Island. Capture operations will commence in February and the first set of actions would include the capture of 200 Laysan ducks (40% males and 60% females, and 60% adults). Ducks in excess of 200 will be held for 10 days for 2 doses of botulism vaccine, have their flight feathers clipped, and then released on Eastern Island where they will have access to supplementary water at pre-placed guzzlers, supplementary food spread broadly to eliminate excessive food guarding, and artificial cover structures for shade and rain protection. For a July bait application, capture operations would start in February and continue until all pellets have disappeared. If hens and ducklings are detected we will attempt to capture them together and keep them in a separate compartment. If a hen on a clutch of eggs is located we will place her in an individual compartment and see if she will incubate the displaced clutch. If not, we will use an incubator for duck eggs and raise the ducklings by hand. As before, ducks captured after the first 200 will be vaccinated twice 10 days apart and then released on Eastern Island and provided supplemental food, water, and shelter. The 200 captive birds on Sand will be held until immediately before the bait application when they will be moved to the Eastern Island aviaries to minimize the chance of them accidentally ingesting pellets or insects that have fed on the bait and to reduce the risk of compromising the eradication operation by allowing access to alternate food sources for the mice. Previous food trials indicated that conversion of Laysan ducks to a captive diet on commercial feed is possible (SWCA 2017).

Based on a habitat assessment, Eastern Island has a carrying capacity to currently support about 85 to 102 Laysan ducks (SWCA 2017). To increase the carrying capacity of Eastern Island, Laysan duck habitat on Eastern Island will be enhanced by adding vegetative and artificial cover, guzzlers for freshwater resources (Figure 3), and supplemental feeding stations, spread widely enough to preclude exclusion of subordinate ducks by more assertive individuals. These enhancements would increase the carrying capacity of Eastern Islands to approximately 400 ducks. The proposed action thus involves two redundant levels of protection (ducks held in aviaries and ducks released on Eastern Island) to ensure the survival of as many healthy individuals (~600) as possible. By maintaining the capacity to care for ducks both in an aviary setting and by clipping flight feathers and releasing birds on Eastern, the team can respond to situations in which birds are doing poorly in captivity by wing-clipping them and releasing them on Eastern or bring birds into the aviaries that aren’t competing well out on Eastern Island for more intensive care in captivity. As stated, we plan to have the capacity to hold a minimum of 200 ducks in aviaries along with an avian care facility with room for 25 sick or injured birds needing more individualized treatment.

Figure 3. Guzzler and surrounding vegetative cover at Green Island, Kure Atoll

4.3 INFRASTRUCTURE DEVELOPMENT AND PERSONNEL

4.3.1 INFRASTRUCTURE DEVELOPMENT

The infrastructure needed to safely hold wild Laysan ducks in captivity for an extended period (>5 months) is extensive. Eastern Island has the habitat capacity to support about 85-102 Laysan ducks that would be wing-clipped, brought from Sand Island, and released wild. However, with the additional water guzzlers, cover and shade structures, and food that will be provided on Eastern (see Section 4.3.1.2 below), the habitat capacity will be much higher (~400), and the remaining population of ducks not kept in aviaries can be supported for the duration of the eradication action. Further, ducks released on Eastern Island would have to be monitored and recaptured for a second wing-clipping, if needed, to prevent them from flying back to Sand Island. Infrastructure needed on Eastern Island for the additional translocated ducks would include shade structures and supplemental feeding stations and water sources. While aviaries can be built on Eastern Island, the island can only be accessed by boat and has limited resources. Therefore, any infrastructure built and maintained on Eastern Island needs to consider conducting operations in terms of weather conditions and shuttling efforts by boat across the channel, in addition to all supplies (e.g., freshwater, food, and equipment) being brought over on a regular basis or stored on-island. Bird care specialists will need to camp on a rotating basis at Eastern to ensure that weather and sea conditions don't prevent access for personnel to the birds in captive care. Other infrastructure is necessary to support captive holding of birds. Work areas will be needed for administering veterinary care, preparing food, storing food items and utensils, and storing cleaning supplies.

In general, aviary sites on both islands will be located where there is adequate air flow, shade, and a low amount of noise. In addition to adequate aviary space, each aviary will be fitted with 5mm thick rubber flooring that prevents ducks from developing foot and leg issues (see Section 4.4.1). Aviaries will be located on cement pads to avoid problems with burrowing birds. Eastern Island aviaries will have fewer burrowing bird problems but will also be placed on available concrete pads. Further, visual barriers (see Section 4.4.1), and rodent control efforts are also important aspects to address in terms of aviary design and maintenance. With Laysan ducks, the aggressive behavior displayed among captive ducks over food might be reduced if aviaries are built to compartmentalize ducks into smaller groups (Warner 1963, SWCA 2017). We plan to compartmentalize ducks into groups of 10 birds. If our groupings of 10 ducks prove to be too large, we will have materials on hand to further subdivide the compartments on Sand Island.

4.3.1.1 Sand Island

Infrastructure on Sand Island will include:

- Aviary structures to house at least 200 ducks (100 males and 100 females): The large shade house on Sand Island (52 x 96 ft [15.8 x 29 m]) will be partitioned into 16 compartments for 10 ducks each to hold 160 ducks with 31.2 ft^2 (2.9 m^2) per duck. An additional aviary with 10 compartments of 100 ft^2 (9.3 m^2) each will hold the remaining 40 ducks in groups of 5 with 25 ft^2 (2.3 m^2) per duck and have extra compartments for any hens with ducklings to be isolated. We will keep males and females separate to avoid aggression and breeding. Total aviary area for ducks will need to be at least 5,000 ft^2 (464 m^2) on each island (Sand and Eastern) and there will be enough compartments so there are not more than 10 ducks in any particular section to reduce chances for food guarding. Visual barriers made of 80% shade will be installed. Aluminum flashing will be used around aviaries to prevent mice from chewing into shade cloth and entering aviaries. All ducks will be moved to Eastern Island before the rodenticide drop.
- Work areas for duck food prep and storage and cleaning supplies.
- Avian care facility with room for 25 birds needing more individualized treatment, for sick or injured birds and those suspected of being exposed to rodenticide bait.

4.3.1.2 Eastern Island

Ducks with clipped flight feathers will have access to 11 water guzzlers distributed around the island and feeding stations adequate to allow access for even the most timid birds. There will also be additional cover stations established. Four aviaries, each with a capacity of at least 50 ducks will be constructed (Figure 4) on existing concrete pads near the pier and boat access, making aviary construction and captive husbandry of birds convenient. Rubber matting will be installed in 4 aviaries of 30 x 50 ft (9.1 x 15.2 m) each that have 10 compartments each.

Figure 4. Views from inside and outside one of the 8x14 ft aviary compartments that was used to hold ducks during the 2004 and 2005 translocation. The compartment had a sand floor, natural cover, and artificial cover structures.

In summary, infrastructure on Eastern Island will include:

- Aviary structures to house at least 200 ducks
- 11 water guzzlers total (3 already in place)
- 11 shade structures
- Seawater pump system to have additional water available for cleaning aviaries
- Camping facilities for up to 10 aviculturists and duck monitors when bad weather precludes traveling between Sand and Eastern Islands
- Work areas for duck food prep and storage and cleaning supplies

4.3.1.3 Eastern Island Freshwater Infrastructure

On Eastern Island, three 500 gal. (1,893 L) water guzzlers are currently placed close to freshwater wetlands (seeps) and installed on top of revetment mounds to prevent potential overflow from tsunamis. These water guzzlers are kept close to the existing wetland seeps to reduce the amount of time taken to search for ducks with botulism. Soil on the revetment mounds are loosely compact and can easily be dug by hand without the need to land heavy machinery on Eastern Island. Areas where water guzzlers are installed should have adequate cover habitat for Laysan ducks and therefore, some additional vegetation may need to be planted. The guzzlers and cover plantings will be installed as early as possible to allow catchment reservoirs to fill during the winter and plants to establish during rainier weather.

For Sand Island ducks released on Eastern Island, 8 additional guzzlers to the three already in place will be installed. Given the current suitable habitat on the island, it is highly probable that ducks will congregate around freshwater sources. Crowding around freshwater sources increases the risk of potential disease outbreak, with botulism being the primary concern, and increases the likelihood of female mortality from forced copulations and duckling mortality from aggressive adults. The three existing seep ponds on Eastern will be filled with sand or covered with shade cloth to prevent ducks from accessing the water to reduce conditions that foster botulism outbreaks.

Fresh water for captive ducks and camping duck caretakers will be brought from Sand Island Periodically.

4.3.2 PERSONNEL

People are needed for infrastructure development, bird capture and captive care, bird health and veterinary care, behavioral monitoring, food preparations, aviary construction, maintenance and cleaning, and post-project monitoring. Personnel needs vary from construction and maintenance of aviaries to specifically-trained (and federally permitted) ornithologists, avian rehabilitators, aviculturists, and licensed veterinarians. A veterinarian will be on site for the duration of the capture period, bait application period, and post application holding period and staff will be ready to handle botulism outbreaks and accidental rodenticide poisonings. Details of how ducks with botulism will be treated and cared for are outlined in Appendix 1. Table 2 summarizes staffing needs for the care of each of 3 groups of birds.

4.3.3 CAPTURE METHODS AND MATERIALS

This species becomes secretive and difficult to locate during the breeding season and capturing birds during the non-breeding season is preferred. Capture during the non-breeding season will also reduce risk to eggs and ducklings. For a July rodenticide application capturing Laysan ducks on Sand Island should start in February of the implementation year. For the bait drop to proceed, we will need to capture a minimum of 200 ducks for captive care and a minimum of 200 ducks for translocation to Eastern Island. Capture efforts will continue throughout the bait application and continue through implementation and as long as brodifacoum remains accessible in the ecosystem in harmful concentrations. Any ducks not captured for holding that are 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. Those ducks showing signs of exposure would be held in temporary holding pens under observation and any decision-making would occur based on the duck’s on-going health prognosis. In the event that nests or very young broods are found, we would capture the adult, and place the nest and eggs into a dog pet carrier (twice the size of a cat carrier) and place them inside one of the aviary compartments. If ducks with small ducklings are found, we will capture adult and young ducklings which can’t thermoregulate, and then place them inside a smaller, private aviary compartment.

SWCA (2017) tested methods on Sand Island to increase capture efficiency of Laysan ducks. Trials were conducted to develop alternative trapping techniques for capturing multiple ducks at one time. For trials, construction fencing was used to make a drift fence, chute, and holding pen. The height of the trap was approximately 16 in. (41 cm), the drift fence was 6 ft. (1.8 m) long, and the chute was 8 ft. (2.4 m) long. The holding area was “V”-shaped and 5 ft. (1.5 m) long with an entrance of 5 ft. (1.5 m) wide and end width of 5 ft. (1.5 m) (Figure 5). The holding area was covered with a black plastic tarp and had a capture box (also known as a transport box) attached (Figure 6). The transport boxes were the same boxes used to transport Laysan duck during the 2004-2005 translocations (Figure 7).

Figure 5. Layout of Laysan duck trap. The covering for the holding area is not included to show the design

Figure 6. Laysan duck trap with the covering on

During the trials, Laysan ducks did not hesitate when herded into the trap. The ducks were reluctant to enter pet carriers, which did not allow light through, but they did enter the transport boxes, which allowed light to pass thorough (Figure 7). These traps could be built to scale and could be used to catch up to 10 to 15 ducks at one time by attaching multiple transport boxes to the trap.

This trapping method has the potential to be dangerous to ducks if experienced duck handlers are not present during trapping operations. Duck trappers should have experience handling endangered species, identifying signs of avian stress, capture myopathy, and injury and capturing 10 or more waterfowl at one time. Trauma and injury to individual ducks by trampling may occur if the holding area is not large enough to support the number of ducks being herded into it.

Figure 7. The transport box allows light to enter through both sides.

4.4 CAPTIVE HOLDING AND TRANSPORT

4.4.1 AVIARY STRUCTURES

Aviaries will be built at least one month prior to the capturing of ducks and sites prepared by excluding albatrosses from nesting there prior to when albatross nesting begins (to avoid having to move albatross nests to erect aviaries). To hold at least 200 ducks comfortably, with room for an additional 25 animals if there is a botulism outbreak, 10 aviaries will be constructed each on Sand Island and Eastern Island. An additional aviary would be constructed for ducklings too small to compete well in aviaries holding adults. Aviaries, each measuring ~500 ft^2 (46.5 m^2) with five, 100 ft^2 (9.3 m^2) compartments, will be built using galvanized steel poles and shade cloth.

Substrate or flooring that discourages burrowing seabirds and crabs from digging under and into the aviary and prevents ducks from developing foot and leg issues will be used. This will entail siting the aviaries on cement pads. Ducks will be housed in aviaries on 0.2 in (5 mm) thick rubber floor pads with localized feeding stations that can be easily cleaned. A-frame hutches will be provided for cover as needed and aviaries will have shade cloth. Bathing tub, water bowls, and food bowls will be placed in each aviary compartment (Figure 8). Outdoor aviaries in well ventilated areas (not inside buildings) will prevent fungal respiratory diseases. Automated weighing platforms will be installed in each section of the aviaries to allow for close monitoring of nutritional status without the disturbance of handling the birds to weigh them. For both the Sand Island and Eastern Island aviary facilities we will have sufficient running water to clean feeding stations, watering devices, and floors daily. Visual Barriers will be installed and the aviary facility designed to aid in behavior management. Two layers of 80% shade cloth (24 in. [61 cm] height) will be attached to each aviary compartment divider wall to serve as a visual barrier to reduce stress between ducks held in each compartment. Closed–circuit cameras will be installed to monitor behavior of the ducks without humans being visible. Aviaries will be designed to keep group size small enough to be able to detect food exclusion and fighting problems.

Figure 8. Natural cover, artificial cover, food bowls, bath tubs, and waterer inside a 2004 Laysan duck aviary compartment.

4.4.2 PREDATOR CONTROL NEAR SAND ISLAND AVIARIES

To reduce the risk of predation by mice, bait stations containing peanut butter flavored sticky traps and multi-catch live traps will be placed every 10 feet (3 m) around the perimeter of each aviary. Sticky traps will be checked several times a week and sticky traps replaced as needed. The bottom outside edge of the aviary will be covered with a 2-ft tall (0.61 m) aluminum sheeting to prevent mice from chewing through the shade cloth to enter the aviary. Biosecurity measures for transport of gear, supplies, and personnel between Sand and Eastern will be stringent to prevent the accidental introduction of mice to Eastern Island. Protocols will include mouse-proof containers, rigorous inspections, bait stations at both boat landings, and mouse detection gear deployed on Eastern Island.

4.4.3 HOLDING AND TRANSPORT BOXES

Commercially available cat carriers 19 x 12 x 10 in. (48 x 30 x 25 cm [LxWxH]) will be used to hold sick birds receiving veterinary care or rehabilitating as well as to transport ducks during initial capture attempts and to shuttle them (Figure 9 and Figure 10) to Eastern Island aviaries.

Figure 9. Example of Duck Transportation Equipment

Note: USGS Biologist Michelle Reynolds on Kure Atoll during a major translocation to move 28 Laysan ducks from Midway Atoll National Wildlife Refuge to Kure Atoll State Wildlife Sanctuary within Papahanaumokuakea Marine National Monument September 2014. Photo by: John Klaviteer/USFWS.

Figure 10. Example of Duck Transport Box Use

Note: USCG ENS Kane holds the door of a transport box open as USFWS John Klavitter places a duck inside its transport cage in preparation for translocating 28 Laysan ducks from Midway Atoll National Wildlife Refuge to Kure Atoll State Wildlife Sanctuary in 2014. Photo by: Eric Dale/FWS Volunteer.

4.5 CAPTIVE CARE

4.5.1 EXAMINATION AND TREATMENT

Each duck brought into captive care will be examined for signs of botulism or other conditions and birds needing extra care or treatment assigned to the clinic. Laysan ducks are susceptible to avian botulism, and a prevention plan involving botulism vaccine and a response plan will be in place to care for sick ducks and management of outbreaks (Appendix E). Botulism antitoxin will be kept on-site under refrigeration for administering to sick ducks exhibiting symptoms of botulism toxicity including:

- Inability to fly or poor flight

- Depressed behavior, weakness
- Labored breathing
- Diarrhea and soiled vent
- Paralysis of nictitating membrane
- Inability to walk
- Inability to hold up neck

A captive care protocol for treating ducks affected with botulism can be found in Appendix 1. A botulism vaccine will be administered to all captured ducks to prevent a major outbreak among the captive flock. Enough captive care facilities sufficient to keep all ducks handled in captivity long enough for 2 doses of vaccine 10 days apart will be constructed. Then, birds will join the captive flock of 200 birds that will be housed on Sand Island until July 1 or go immediately to Eastern Island with flight feathers clipped. Once rodenticide applications have commenced, Vitamin K will also be kept in ample amounts with trained staff on-site to administer at first signs of poisoning from brodifacoum. Ducks exposed to brodifacoum will display a hunched posture, puffed up wings, be moribund, or show blood from nares. The vaccine, anti-toxin, and vitamin K will be stored in the work areas built near the clinic aviary. If duck mortality (take) exceed thresholds determined by formal consultation, we will reopen consultation to discuss and determine a best course of action.

4.5.2 FEEDING AND MANAGING SOCIAL INTERACTIONS

When kept together, food aggression and food guarding behavior amongst Laysan ducks was the leading cause of starvation-related mortality (Warner 1963). Measures to reduce this behavior will include supplying the group with multiple food containers and larger food containers or troughs, putting up visual barriers between food containers, and designing the aviary to house groups in low numbers together (SWCA 2017). Captive animals will be monitored using closed-circuit cameras to detect dangerous interactions so animal groupings can be adjusted. Automated weighing perches will also be installed to detect weight loss in birds suspected of not getting adequate access to food. Likewise, for the higher than normal densities of ducks living freely on Eastern Island after clipping of their flight feathers, extra food distribution will be managed to minimize the possibility of dominant individuals precluding access to food or water for subordinate individuals. In addition, during the breeding season, holding ducks in all male and all female groupings and separating out first year birds may reduce negative interactions and prevent males from competing for females.

Reynolds and Klavitter (2006) used commercial duck mash during the 2004-2005 translocation effort and noted that mash used to feed captive ducks in aviaries should be very fresh and should not be stored for more than one month, as birds find older mash less appealing. To increase the caloric input of the mash, dry cat feed may also be added. In feeding trials conducted by SWCA (2017), the combination of fly larvae, cooked white rice and duck feed was the most successful in encouraging food-take from a container and was also the most consumed in the vicinity of the container. Food presented in water was much more likely to be consumed by ducks than food presented without water. Adults without ducklings seemed to display more foraging behavior and showed more interest in the food items than adults with ducklings. Ducks already displaying foraging behavior before encountering the food items were more likely to consume food. Freeze-dried mealworms are taken well by some ducks and captive ducks are more easily converted to accepting food if there is live food incorporated in the ration. All potential live food sources will be carefully evaluated with reference to biosecurity.

4.6 RELEASE

4.6.1 CARCASS AND BAIT MONITORING BEFORE AND AFTER RELEASE

Island-wide monitoring of bait presence, mouse sign, and carcasses will be conducted, and starting 2 months before the first bait drop, known duck resting and foraging sites will be searched for signs of any ducks until no visible bait pellets remain after the final application of the bait. Sites will be searched daily. All carcasses found are to be recorded, and carcasses suitable for necropsy will be collected, labeled, frozen and submitted to U.S. Department of Agriculture for analysis. Resting and foraging sites will be monitored before the first bait application, during and up to 42 days after the last aerial broadcast of bait or until 30 days after bait no longer persists in the environment, whichever is longer. To quantify bait persistence post-eradication, a sample of 82 x 3.3 ft. (25 x 1 m) transects will be surveyed throughout the island. No ducks will be returned to Sand Island while there is any bait detectable anywhere that is accessible to ducks. In the event of a mouse detection more than 42 days after the last bait drop a localized eradication response may be undertaken and duck protection measures will be integrated into any actions.

4.6.2 RELEASE METHOD

Ducks that have had their flight feathers clipped will remain on Eastern until they molt again. There is a possibility that some of these birds could molt early and have the ability to fly back to Sand Island. If they return to Sand Island and they become sick from brodifacoum toxicity, we will re-capture these birds, treat them with vitamin K, and when healthy again, return them to Eastern Island. Birds being held in the aviaries on Eastern will be kept there until there is confirmation through a four-step process to determine when it is safe to release ducks back to Sand Island. These four steps include: 1) there are no pellets remaining; 2) brodifacoum residue levels measured in selected invertebrates reach levels deemed safe; 3) migratory shore-birds returning from their northern breeding grounds appear to be staying healthy upon arrival, and; 4) sentinel canaries and Indian mynahs are released on Sand Island and show no ill effects. All birds on Sand will be observed for any signs of mortality or other signs of anticoagulant exposure (hunched posture, puffed up wings, blood from nares, moribund). Monitoring of released birds will include radio-tagging sentinel mynahs.

4.6.2.1 Pre- and Post-Project Monitoring

We will monitor Laysan duck 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 of the mouse eradication effort. Diet overlap of Laysan ducks with mice is currently being studied using DNA barcoding techniques. After live-capture and holding ducks on Eastern Island during the operation, birds will be released after confirmation through a four-step process described above to determine when it is safe to release ducks back to Sand Island as outlined above. We are exploring the possibility of having an analytical lab set up on Sand Island to ensure quick feedback about samples. Monitoring will be done daily at all known duck aggregation sites and throughout the island. We will recapture all ducks if any are found demonstrating signs of toxicosis.

Radio-transmitters will be attached to a sample of Indian Mynah birds (sentinels) to monitor their movements, behavior, breeding and survival when they are released. The birds will also be observed at a distance using spotting scopes to prevent disturbance.

Invertebrate prey species of Laysan Ducks on Sand Island to be chosen after diet studies are complete (DNA barcoding) will be collected at weekly intervals after the final bait application in areas favored by foraging ducks and brodifacoum residues will be measured to assess when those residues go below values calculated to be dangerous to feeding ducks. To determine these residue levels, we used an approached proposed by Thomas et al. (2011) and improved on by Mineau (2014). This approach provides a relationship between brodifacoum liver residues and the probability of evident coagulopathy at necropsy (Thomas 2011) and uses data on the proportion of a single dose that is retained in the liver over time (Mineau 2014). These two sets of information allow for a calculation of a "field-derived LD_{50}" or more accurately ED_{50} (dose at which half of the test population will show an effect – but not necessarily death) (Mineau 2018).

However, to be protective at the individual level for a rare or threatened species like the Laysan duck, ED_{50} is not appropriate, and for this analysis we used an ED_5 (5% of the exposed population will be affected by coagulopathy – not necessarily death). If we assume a 500g Laysan duck, its liver weight will be approximately 11g (after relationships in broiler chickens – Deaton et al. 1969). Using the approach described above, the calculated threshold whole body ED_5 is 0.47-1.8 µg total intake of brodifacoum for an average Laysan Duck (Mineau 2018).

Because Brodifacoum can bio-accumulate through multiple exposures, expressing the risk as a proportion of daily food intake is not appropriate (Mineau 2018). Instead, we used an 'accumulation window' of about 200 days (the mid-point estimate for the half-life of brodifacoum in rat liver tissue) (Horak et al. 2018).

Pitt et al. (2015) found that residues in cockroaches averaged 2.3 µg/g 10-15 days after bait drop, and 0.9 µg/g about 45 days later. It is reasonable to assume that, over time, a certain amount of brodifacoum will 'escape' the insect food chain to be lost to soil and the abiotic environment more generally. Fitting these two points to an exponential curve (a common curve type when describing residue degradation or loss from a system) and defining the peak residues as day 1[1] (even though it took 10-15 days for the residues to maximally contaminate the cockroaches) yields the following:

$$\text{Residue level } (\mu g/g) = 2.3496 * \exp(-0.0213 * \text{days after peak residue})$$

Predicting forward, cockroach residues at 200 days (our chosen period of residue accumulation) post peak would be approximately 0.03 µg/g. We calculated the cumulative residue intake over a 200-day period which produces a recommended prolonged withholding time for the ducks of 13-15 months needed to drop the risk level below an ED_5.

[1] We are only interested in the declining phase of residues after peak

It is important to note that we are being very protective by choosing an ED_5 when the outcome is coagulopathy rather than mortality, representing a conservative approach. It is also reasonable to assume that an increasing part of the duck's diet over time will be made up of unexposed cockroaches and other invertebrates, so the suggested holding times described above may be over-estimated. Therefore, a prudent, and conservative, first release of Laysan ducks may be at the 4-6-months post bait application (after monitoring of other avian sentinels also indicates the environment is safe), with continued surveillance and monitoring of the ducks (i.e. if any negative effects are detected, adaptive management can be enacted to revert it).

Furthermore, field application of this proposed model will require real time estimates of remaining residue levels in the Midway ecosystem. Sentinel diet sampling and analysis would be performed at intervals appropriate to inform the mitigation strategy. It will be important to look at the overall loss rate of residues from the food-chain in the early days, weeks and months following the bait application as to characterise and document the residue decline curves for Sand Island.

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Appendix D. SEEP CHECKS PROTOCOL

LAYSAN DUCK GUZZLER and ARTIFICIAL POND CHECKS

(Revised August 2018, Kelly Goodale, Wildlife Biologist USFWS)

1. Overview

GOAL

To effectively and efficiently manage the risk of large-scale avian botulism type C epizootics at Midway Atoll

OBJECTIVE

Water and surrounding vegetation adjacent to artificial ponds (aka "seeps"), guzzlers, ephemeral wetlands with a history of botulism, and other manmade water-holding structures that have a history of botulism are patrolled in order to detect and remove sickened or dead ducks and other sources of animal protein (such as dead seabird eggs/chicks or mice) that could contribute to or escalate an outbreak of avian botulism type C.

The secondary goal is to get an accurate assessment and movement of the population. This will be done in conjunction with seep checks on a weekly basis. In order to get the most accurate assessment of the population and movement of ducks, at least one person will be deployed to one of four locations. By checking these areas at the same time, it reduces the chances of double counting and will give us the most accurate population assessment and movement.

For the sake of brevity and established Midway nomenclature, patrols of Laysan duck habitat will hereafter be referred to as "seep checks."

LOCATIONS TO BE CHECKED

- On Sand Island, there are currently 8 artificial ponds, 4 guzzlers, and 5 low areas that become temporarily flooded after heavy rains. Though the likelihood of botulism being present at each site is highly variable, each location can attract ducks. Additionally, with the exception of guzzlers, all of these locations have at least some history of botulism and support widely variable water levels. There are four ponds that were dug to create Laysan duck habitat prior to the 2004 translocation: Big and Little Ballfield Ponds and Radar Hill East and West Ponds. Brackish Pond is a permanent pond consisting of brackish water in a former sand/gravel borrow pit. Catchment is a large, shallow concrete basin that was part of the water collection infrastructure for the Naval Air Facility at Midway. R2 Ditch is a small but relatively deep drainage ditch that is a part of the operating runway infrastructure. In addition to the artificial ponds, there are four guzzlers (plastic water basins with sloped floors and a rain catching roof that are intended to provide additional water sources for ducks) installed on the island. Guzzlers are found near the FWS Office, in Parade Field, and at two sites formerly supporting constructed ponds, named Communications and Sunrise Seeps, respectively. These are now called Communications Guzzler and Sunrise Guzzler. Additionally, there are five major ephemeral ponds that pose a potential botulism risk after heavy rains: Mauka-Makai (a former artificial pond that was back-filled in 2013), a drainage ditch adjacent to the former Mauka-Makai pond, Sunrise East and the low area adjacent to Brackish Pond.

- There are three constructed ponds and three guzzlers on Eastern Island. The three ponds are named Monument, Sunset, and Rolando. Each pond has one guzzler installed in its vicinity.

EQUIPMENT NEEDED

- Binoculars
- Stick or golf club for turning vegetation
- Duck kit (includes: zip lock bags, nitrile gloves, a small towel, and a holding bag that cinches closed).
- Radio (**essential for your safety and for timely notification and treatment of a sick duck).**

2. Methods

GENERAL GUIDELINES:

- When conducting a seep check, finding dead or sick ducks is the first priority. Other activities such as band re-sights, duck counts, or vagrant sightings are always secondary.
- In general, it is preferable to check the seeps in the morning. However, during cooler weather the importance of morning seep checks is reduced. The primary reasons to perform seep checks before other work takes place are to get the disruption of seep checks out the way as soon as possible and to detect and remove carcasses before maggots have a chance to develop, especially during hot weather months. Maggot formation typically takes approximately 24 hours.
- When more than one refuge staff is available to check seeps, rotate weekly or bi-weekly visits so that a new set of eyes checks each seep as often as possible. Don't check a seep the same way each time; go clockwise one day and counter-clockwise the next. Also, alternate high then low or rotate who checks which seep.

DETAILED PROTOCOL:

1. When first approaching a seep, note any LADU immediately fleeing the area, particularly if they are having difficulties moving. Assess these birds for botulism symptoms (see below, #3).

2. Visually survey the water surface, the edge of the water, and the vegetation surrounding the water's edge out to 15 feet. At many locations, it will be necessary to enter the water in order the check under vegetation along the water edge. Some ponds have duck-attracting vegetation features outside of the 15 ft. search area. Because sick or dead ducks have been found in these areas in the past, it is essential that these spots are checked during patrols of these locations. The specific locations and vegetation features are as follows:

- Radar Ponds: Look under naupaka shrubs near the edges of each seep, scan hillsides above both seeps.
- Catchment Basin: Check under seagrape trees and in duck trails through the tall grass.
- Mauka-Makai Ditch: Spot check vegetation throughout ditch when there is standing water. Check perimeter of the former seep to the north (now filled in) when it is flooded.
- Brackish Pond: Check the perimeter of any ephemeral ponds created during rains.
- Rolando Pond: Check under naupaka shrubs east of the seep.

3. Observe LADU on land and in the water for behavior that may indicate early signs of botulism, including:
   - Squinty eyes
   - Weak, slow walking or swimming (may "wing-walk" if legs are paralyzed)
   - Inability to hold head erect
   - Inability to fly away

   ****Note: Laysan ducks on Midway are extremely habituated to humans due to the near daily presence of people in the artificial habitat. Do not use the fact that a duck is not fleeing from you as singular indicator of botulism.****

4. Walk completely around each seep. Use binoculars to scan the shoreline from different locations.

5. Thoroughly check dense vegetation and surrounding areas by moving leaves aside with a stick (ducks will try to hide when they become sick). Also check under trees where they may seek shade.

6. During duckling season, walk from the outside of the vegetation in towards the seep, so that if you flush any broods you will not be blocking their access to the water. Be careful when females with broods are present. Keep your distance and give them time to scurry away. Avoid separating the mothers from their broods.

7. Listen and look for flies. This may be an indication of a dead duck. Sense of smell is also important, however, the amount of dead albatross chicks (particularly during peak botulism season) makes smell a less obvious indicator.

8. Remove any other protein sources (such as seabird carcasses and eggs) from the water and along embankments to prevent a build-up of substrate on which the botulism bacteria can grow. Deposit them on high ground at least 20’ from seeps where they will not drain back into the seep if it rains.

IF YOU FIND A SICK LADU

- Contact the Refuge Biologist via radio so they can meet you in the field with the antitoxin.

- Approach a sick LADU quietly. Even lethargic LADU can make a last ditch effort to fly, so consider using a net. Anticipate its movement and avoid hitting the LADU with the net rim.

- Handle a sick LADU gently. Minimize talking and use quiet voices.

- Bring the sick LADU back to USFWS office for treatment. Use a pet carrier if possible, but a duck bag (cinched tight to prevent escape) works if this is the only thing available.
    - Note: There is a pet carrier with other supplies stored in the shed on Eastern Island.

- Don’t forget to finish checking the rest of the seep after ensuring the sick LADU is being attended to.

IF YOU FIND A DEAD LADU OR OTHER WATERBIRD NEAR A SEEP

9. Remove carcasses of any waterfowl or shorebird species using gloves and Ziploc bags provided in your duck kit.

10. **Be sure to include all maggots and eviscerates in the Ziploc when collecting dead ducks**. This is important because a single maggot can contain enough toxin to sicken or kill a duck.

11. Bring all dead ducks back to the office and place in the appropriate section in the duck freezer. Put older, rotting carcasses in the receptacle designated for incineration. Put fresh carcasses (no maggots or odors) into the one designated for necropsy candidates.

12. If you haven’t already, inform Refuge Biologist of any dead LADU. Record the appropriate information on the LADU Intake Log in the lab (be sure to assign LADU carcasses a new log #). Record log #, species, location, band number if applicable, date, time, and your name on the Ziploc.

13. Do not remove bands from freshly dead LADU as they may be sent off for examination and it is important that the band remain on the bird for this process.

Seep check Safety and Ecological Integrity Issues

- Do not risk personal injury or injury to the animal when trying to capture a sick duck. Many ponds (particularly Brackish Pond and all the Eastern Island ponds) contain thick layers of pond muck several feet deep. Getting mired in the muck while doing a seep check alone poses a serious safety risk. If you must enter interior sections of the seep, proceed with extreme caution or avoid this altogether by using a long-handled net to retrieve a duck or other dead item. Ask for additional help if needed.

- Many ponds also have sharp objects such as branches, nohu thorns, metal or plastic debris, or buried military waste that may not be visible from above. Never enter a pond barefoot. The minimum footwear to enter a pond are sandals with straps around the toes and heel. Slippers are not suitable.

- Destruction or degradation of native plants is an adverse effect of seep checks. Repeated ground disturbance in some of the most intact native plant areas of the Refuge, such as Brackish, Monument, and Sunset Ponds set back Refuge habitat restoration efforts by trampling or otherwise destroying desirable plants and opening habitat for aggressive weeds. Be careful where you walk and be as gentle as possible on the plants, particularly in the sensitive areas mentioned above. *Sesuvium portulacastrum* is one species in particular that is relatively rare at Midway Atoll and is being out-planted or encouraged at certain constructed ponds. As much as possible, please avoid stepping on this sensitive plant.

- The spread of invasive weeds is an additional serious, adverse effect of seep checks. While a few ponds have native-dominated plant communities, most of the seeps are densely infested with some of the most aggressive and difficult to control weeds on the Refuge. Many of these weeds, such as *Phylla nodiflora* began their spread across the Refuge starting in 2008, when botulism patrols in the artificial duck habitat were first initiated. Since then, many of these plants have become deeply entrenched and widespread across the Refuge. When conducting a seep check, take care to ensure that you are not transporting seeds or any other plant material from the pond or guzzler to other locations on the Refuge.

3. Determining seep check frequency

DEFINITIONS (for the purposes of determining seep check frequency)

Emaciated: Body condition score of 1.0 or less. Refer to laminated chart taped to wall in duck lab.

Poor body condition: score of 1.0-2.0

Good body condition: score of 2.0-4.0
Trauma: any broken bone (leg, wing, skull, other) or open wound. Large patches of missing feathers (with or without broken skin) are also considered a sign of trauma
Other disease/illness: non-traumatic condition asymptomatic of botulism, including severe dehydration, as described in the Midway Botulism Captive Care intake exam protocol)
Botulism suspected: The duck is in moderate to good body condition, there are no signs of trauma or other disease, and it exhibits signs of botulism including: squinty eyes, slow walking or swimming (may "wing-walk" if legs are paralyzed), inability to hold head erect, inability to fly away
Duckling: a duck age 1-60 days old (see Table 2. Plumage development and age classification of ducklings for further information)
Hatch-year: Fully feathered duck, less than one year of age
Botulism season: The period of year when botulism conditions are most consistently present at Midway and when, based on historical data (2007-2015) of confirmed and suspected botulism cases, there is the highest risk of epizootics. Botulism season is June-September at Midway. August is historically the peak botulism season (see Table 1).
Non-botulism season: Though there has been at least one botulism case every month of the year at Midway, there is a distinct, off-peak season during the fall, winter, and early spring months, when ambient temperatures are cooler, water temperatures in the ponds are lower, and when ducks are more concentrated in terrestrial areas away from water (see Table 1). When this season overlaps with periods of resource scarcity (i.e. winter at Midway), the naturally elevated level of duck mortality can lead to significant amounts of crew time spent patrolling for botulism when there are, in fact, few to no actual botulism cases.

BASELINE FREQUENCY OF SEEP CHECKS

WEEKLY: Patrols of every constructed pond and guzzler once per week is the default schedule during non-botulism season, when environmental conditions favorable to botulism are not present. Based on verified and suspected botulism detections at Midway from 2007-present, weekly checks are sufficient manage the risk of botulism epizootics.

BI-WEEKLY: During botulism season from June through September, two patrols per week are warranted due to the preponderance of ideal habitat for botulism and increasing frequency of environmental conditions conducive to bacterial production.

Seep checks on Eastern Island are subject to weather, equipment availability, and availability of certified and qualified boat operators. When conditions are safe enough and all other requirements met, seep checks on Eastern may be conducted, as scheduled.

Seep check frequency above the baseline is determined according to conditions specific to each detection of a sick or dead duck. Refuge biological staff, in consultation with the Refuge Manager, will use the **Situation-based Seep Check Frequency Decision-support Tool** to evaluate each carcass or sick duck detection individually and determine at what spatial scale and frequency any elevated patrols will occur. Search intensity may also be limited by available staffing resources, safety considerations, and competing Refuge priorities.

INTENSE: If more than two sick or dead ducks are found within a 24-hour period in a given area, it *may* be warranted to conduct an intensive search centered on that "hotspot" because of the possibility of an undetected carcass supporting growth of potentially toxic maggots. The exact search perimeter depends on site-specific conditions and staff time available to dedicate to carcass searches. During an intense search effort, approximately doubling the search radius to 30' from the current water line is recommended. Detailed checks around each bunch of grass or sedge at the waterline and within the 30' radius may be required, however***, removal of native plants to enhance carcass searches should be considered a last ditch effort***.

Situation-based seep check frequency decision-support tool

Situation	**Time of year**	**Location**	**No action**	**Island-wide daily checks for 4 days**	**Intense check at detection site(s)**
ENCOUNTERS OF SINGLE DEAD DUCKS					
Dead duck: trauma	ANY	ANY	X		
Dead duck: other disease/illness	ANY	ANY	X		
Dead adult duck, body condition ≥1.0, no obvious cause of death	Non-botulism season	>15' from pond or guzzler or in town	X		
Dead adult duck or hatch year duck, body condition ≥1.0, no obvious cause of death	Botulism season	ANY		X	
Dead adult or hatch year duck, body condition ≤1.0	ANY	ANY	X		
Dead adult or hatch year duck, body condition ≥1.0	Non-botulism season	Constructed pond or guzzler		X	
Dead duckling 1-60 days old (Class IA to Class III)	ANY	ANY	X		
Carcass with maggots, any age	ANY	Constructed pond or guzzler		X	
ENCOUNTERS OF LIVE, SICK DUCKS					
Fully feathered hatch year or adult duck showing signs of botulism	ANY	ANY		X	

ENCOUNTERS OF MULTIPLE DEAD OR SICK DUCKS					
Two botulism suspected adult ducks found within 3 day check period at same site	ANY	ANY		**X**	**X**
Botulism suspected adult duck found at second location on same island during island-wide checks initiated above	ANY	ANY		**X**	
>1 botulism suspected adult duck found at one site on same day	ANY	Constructed pond or guzzler		**X**	**X**

Table 1. All botulism suspected and confirmed Laysan ducks found at Midway Atoll NWR 2007-2016

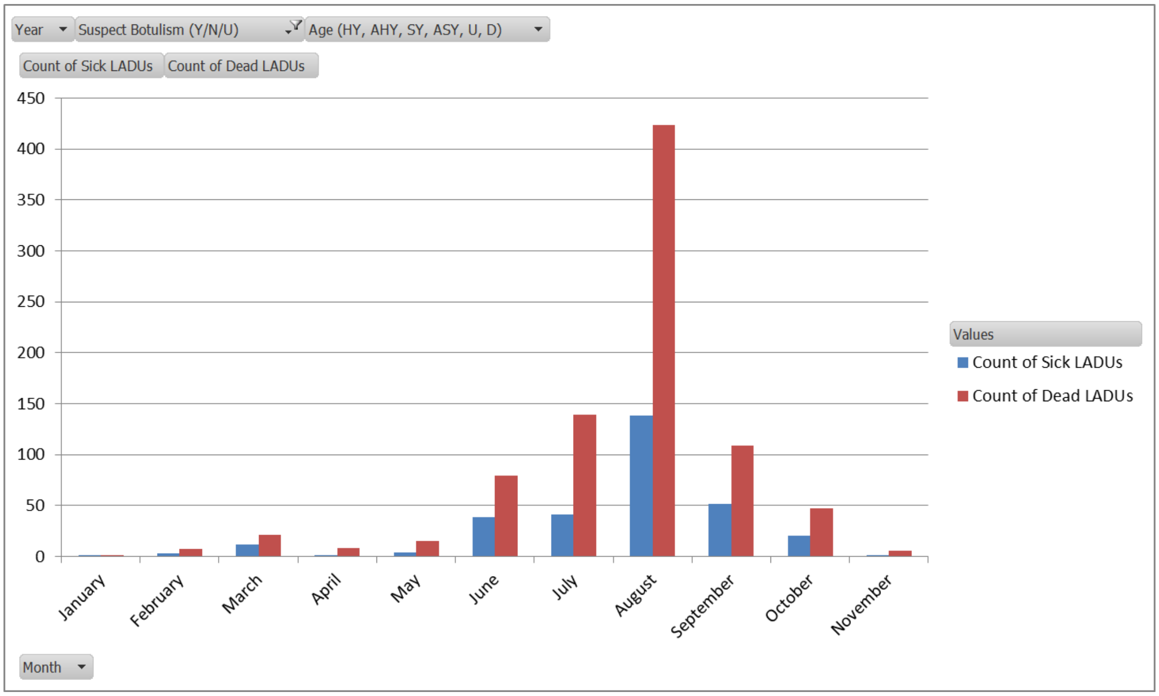
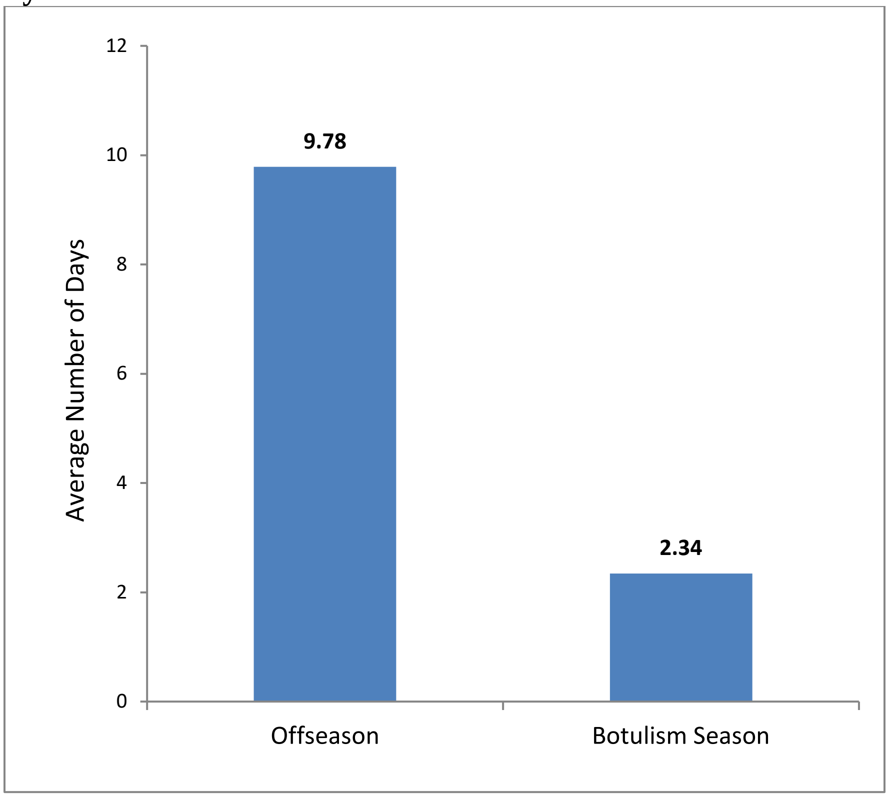
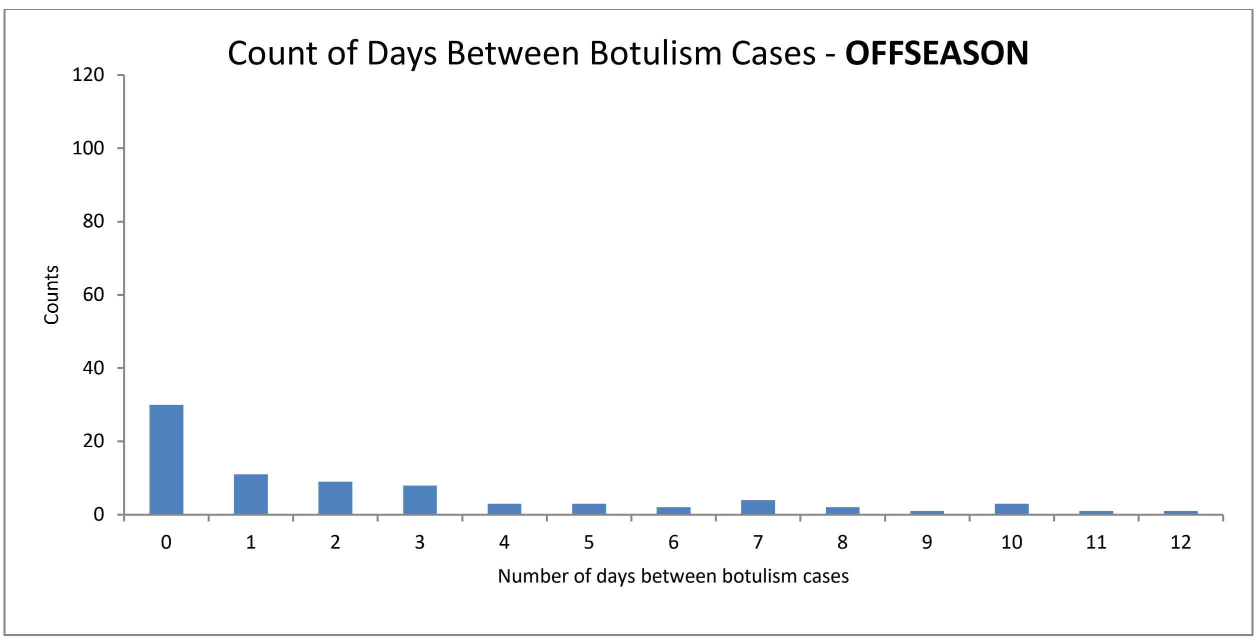
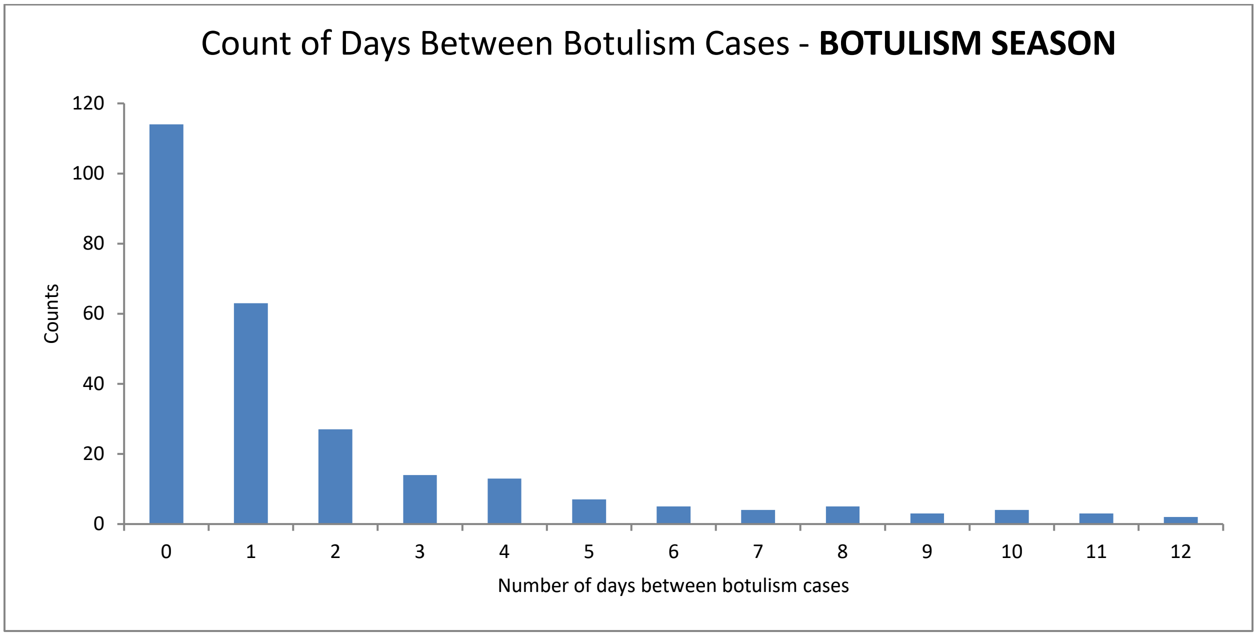


Table 2. Average number of days between confirmed or suspected botulism case adult LADU by season.







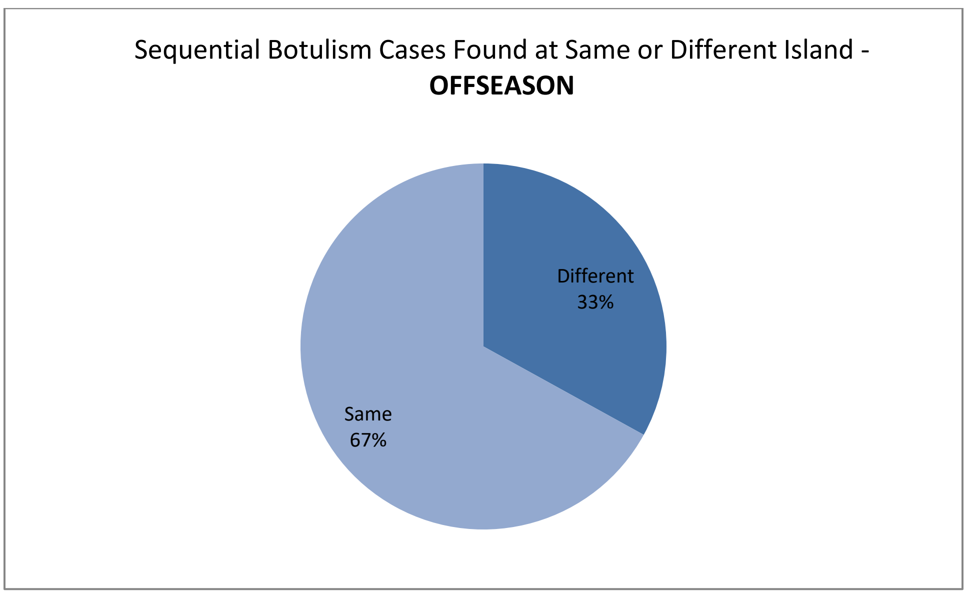


Figure 5. This graph shows whether a sequential, subsequent botulism case was discovered on the same island or different island as the most recent case outside of the botulism season.

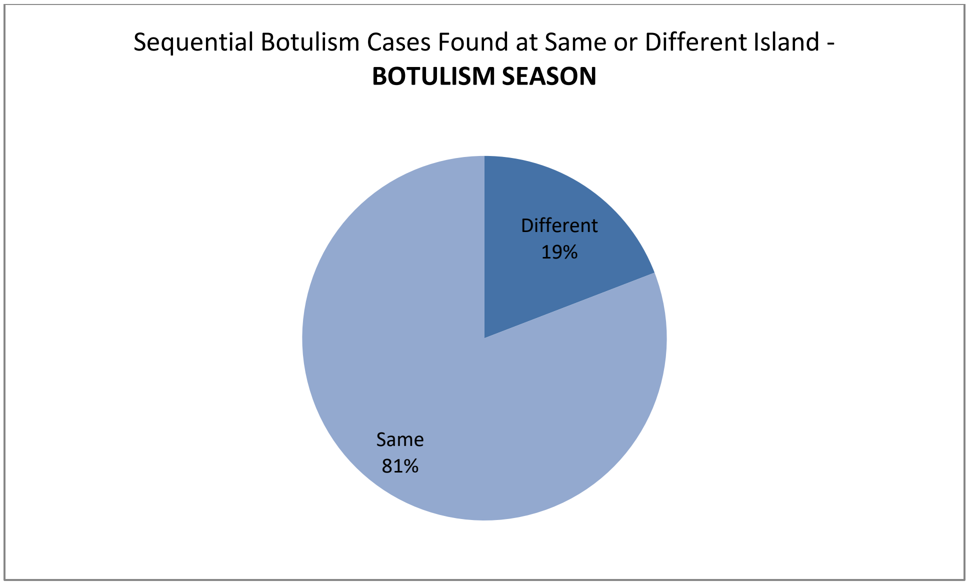
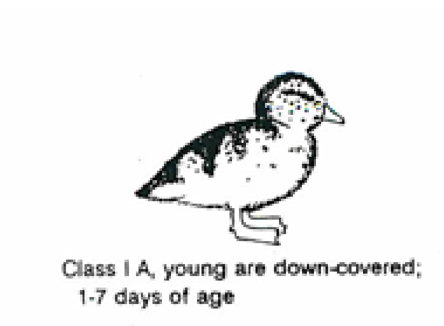
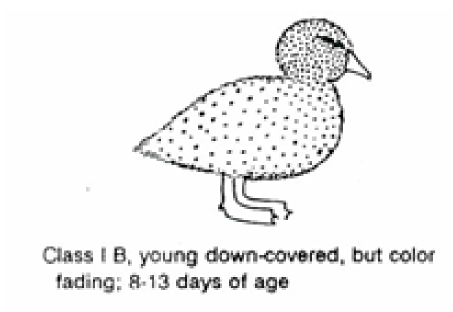
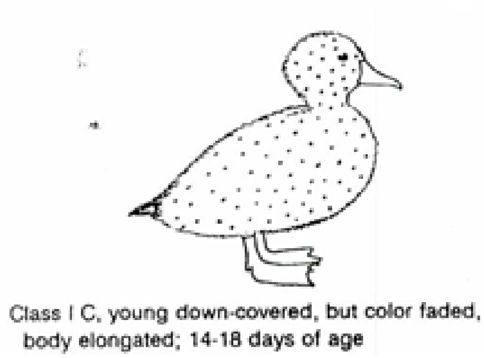


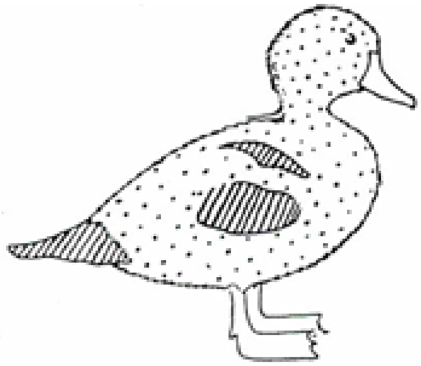
Figure 6. This graph shows whether a sequential, subsequent botulism case was discovered on the same island or different island as the most recent case during botulism season.

Table 2. Plumage development and age classification of ducklings (Wildlife Management Institute)

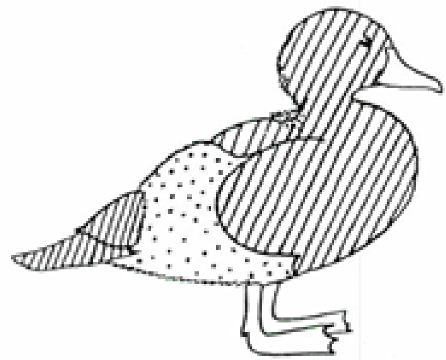




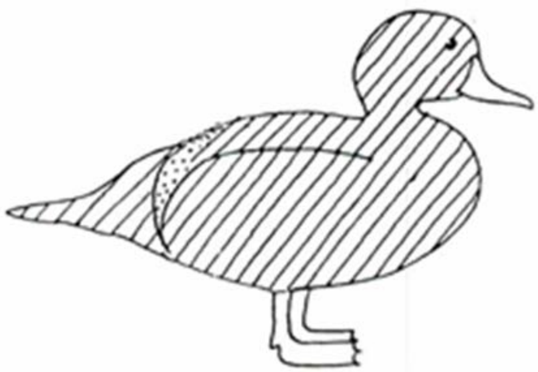




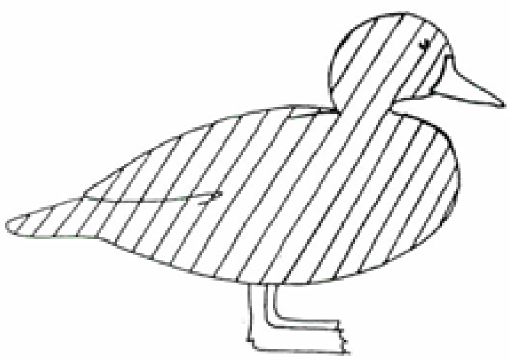
Class II A, first feathers appear, replacing down on sides and tail; 19-27 days of age



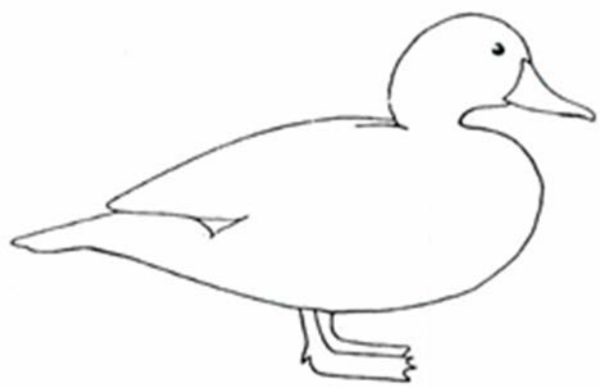
Class II B, over half of body covered with feathers; 28-36 days of age



Class II C, small amount of down remains, among feathers of back; 37-42 days of age



Class III, fully feathered but incapable of flight; 43-55 days of age, flying at 56-60 days



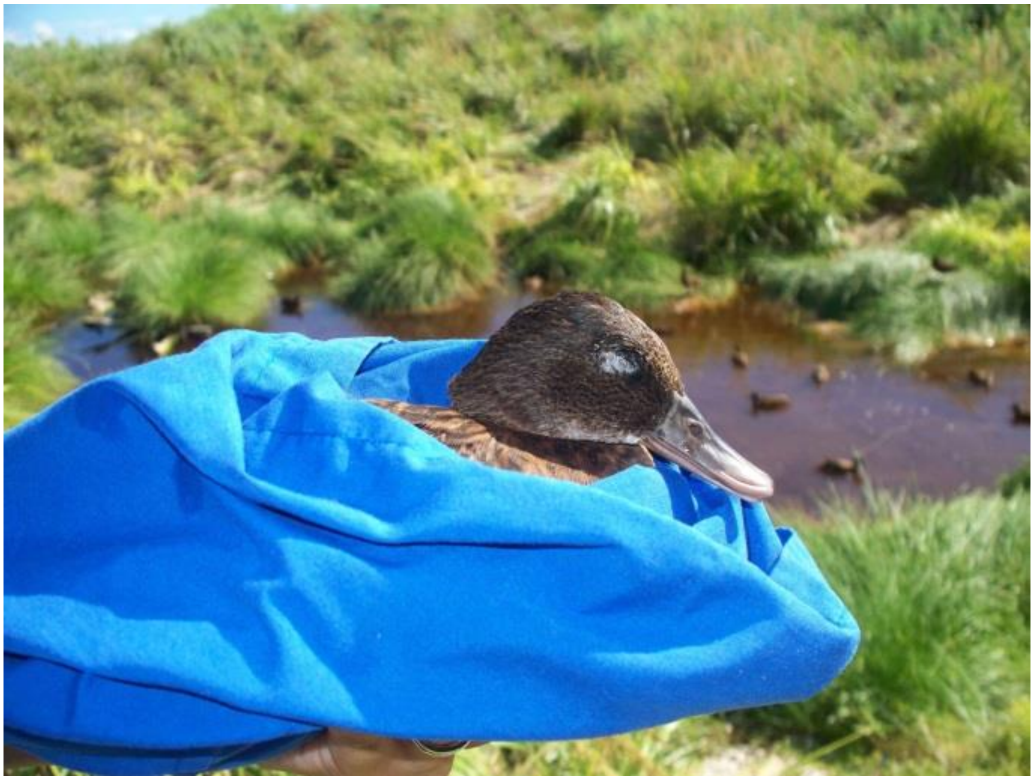
Adult Dabbling Duck

Appendix E. CAPTIVE CARE PROTOCOL FOR LAYSAN DUCKS AFFECTED WITH AVIAN BOTULISM

CAPTIVE CARE PROTOCOL

For Laysan Ducks Affected with Avian Botulism (Updated August 2018)

For trained and qualified personnel only.



CONTENTS

1. GENERAL GUIDELINES

- Before handling a bird, wash your hands thoroughly since sunscreen and hand lotions can affect the bird's natural waterproofing.

- When handling a duck, work in a team of two: one person to restrain the bird and the other to administer injections or tube-feedings.

- Never leave ducks unattended, even if they appear weak.

- To minimize the bird's stress level, use quiet voices and limit the bird's vision (for example, place towels over the pet carrier for a visual barrier).

- Any injections need to be administered with a new, sterile needle and syringe – do not reuse.

- Keep the work area clean and the equipment sanitized.

- Record all information pertaining to captive duck care on the appropriate datasheets.

- Hawaii Wildlife Center is available and willing to provide guidance on any compromised Laysan Duck. Feel free to call them for advice.

    - Phone: 808-345-8421
    - Email: birdhelp@hawaiiwildlifecenter.org

2. COLLECTION

Do not risk personal health and safety in an attempt to capture affected birds.

1. Prior to beginning collection efforts, check in with the Refuge Biologist. Ask for assistance to capture bird(s) if needed.

2. If the bird is immobile, pick it up by hand. If the bird is still able to move, work in teams of two or more individuals to herd it away from the water and towards a person holding a net or a towel.

3. If possible and depending on location, a qualified FWS staff or Kupu member will meet you in the field to administer the antitoxin, provide a pet carrier, and transport to FWS office.
    a. For responder: Retrieve one 0.5 cc syringe of antitoxin from wildlife freezer in duck lab and thaw in hand to body temperature.
        i. Find thickest part of breast muscle, moisten area with a few drops of alcohol, separate feathers with sterile swab to expose skin, and insert needle bevel up into breast muscle (one finger's width away from keel for ducks). Retract needle to ensure needle not in a vein. If in a vein, you will see blood at base of needle. Pull needle out and re-insert, repeat retraction. If no blood, inject antitoxin intramuscularly into breast muscle.
4. Transport the bird to the duck lab at the FWS office. Use a pet carrier if available, with a towel over it to minimize visual stress. If a carrier is not available, secure the bird in a duck bag for transport, cinching the bag up tight, being *extra* careful not to drop or injure the bird.

3. INTAKE EXAM

1. Prepare a pet carrier, water bath, fluids, and antitoxin (if not administered in the field) in the FWS duck lab.
2. Administer 0.5cc antitoxin if not administered in the field. Find thickest part of breast muscle, moisten area with a few drops of alcohol, separate feathers with sterile swab to expose skin, and insert needle bevel up into breast muscle (one finger's width away from keel for ducks). Retract needle to ensure needle not in a vein. If in a vein, you will see blood at base of needle. Pull needle out and re-insert, repeat retraction. If no blood, inject antitoxin intramuscularly into breast muscle.
3. Record weight, body condition, temperature, and dehydration level in *Captive Care Notes* datasheet (Appendix 9).
    a. <u>Weight</u>: Using the pesola spring-scale, weigh and record the weight of the duck bag by itself. Then weigh the duck in the bag ([weight of duck in bag] – [bag weight] = duck weight). Be sure the bag is cinched tight to prevent escape. Adults typically range from 400-600 g.
    b. <u>Body condition score</u>: Locate the keel (sternum) on the bird and feel its level of prominence relative to the muscle mass on either side. Use the figure in Appendix 3 to assign the bird a score from 1-3.
    c. <u>Temperature</u>: Gently insert the digital thermometer into the cloaca to get the internal temperature. A normal temperature for a duck is 102°-106° F.
        i. If less than 102°F, place a heating pad with a towel between the bird and the pad in the pet carrier after the intake exam is completed. Set the heating pad on the low setting. Situate the pad so that only half of it is inside the carrier. Monitor very closely and adjust or remove heat as necessary. Caution must be used, as it is easy to overheat the duck so check on the bird frequently.
        ii. If greater than 106° F, wipe the feet with alcohol swabs to aid in cooling. Place the bird in the pet carrier and put the carrier in a cool, shaded, well-ventilated area away from human disturbance.
    d. <u>Dehydration</u>: To assess the level of dehydration, examine the eyes, inside of the mouth and skin of the feet. Determine whether the dehydration level is slight, moderate or severe.
        i. Well hydrated – bright, glistening eyes, the inside of the mouth will be a pinkish-red color and moist, and the skin of the feet will be smooth and supple.
        ii. Severely dehydrated – sunken eyes, the tongue and membranes inside the mouth will be white or pale pink with ropy and tacky mucous strands, and the skin of the feet will be dry/flaky. Another sign will be if you pinch the skin near the cloaca and it holds a tent shape relatively long before smoothing out.
4. Administer fluids: Obtain a bag of Lactated Ringers Solution (LRS) or 0.9% Sodium Chloride solution (NaCl).
    a. Subcutaneous administration (SQ) – Fill a syringe with 20 cc using a sterile 18-gauge needle. Replace the 18-gauge needle with a sterile 25-gauge butterfly needle. Put the

syringe and needle in a warm water bath for ~ 5 minutes. The fluid should be around the duck's body temperature. Be careful not to overheat the fluid or administer fluid that is too cool. Find loose skin on the inner thigh (see Figure 1) and moisten with an alcohol wipe to clean the area. Insert bevel up just under skin, the needle doesn't need to go in beyond the bevel. Retract the needle to ensure the needle not in a vein. If in a vein, you will see blood at base of needle. Pull needle out and re-insert, repeat retraction. If no blood, slowly inject LRS subcutaneously. Attempt to give 20 cc of fluids, if it is too much; insert the needle in the inguinal fold of the other leg.

Figure 1. On the left, the arrow is pointing at the general region of a duck's right inguinal fold. On the right is a closer look at the loose skin at the inguinal fold where you want to inject SQ fluids.

b. Oral administration (PO) – Oral fluids can be given only when the bird is able to hold its head up and protect its airway. Cut a corner of the LRS or NaCl bag and empty the contents into a container with a lid. Draw up 20 mL of solution into a 35 mL catheter syringe. Always draw up 5 – 10 mL more than required for tubing since at least 5 mL will be lost in the gavage tube. Remove any air bubbles by pointing the syringe upwards and depressing the plunger to move any air out through the tip. Firmly attach the gavage tube to the syringe tip. Place the syringe with the attached gavage tube in the hot water bath for ~5 minutes to heat the solution. Once heated, prime the tube by filling the entire length with solution. This prevents air from being pushed into the bird's stomach. Continue to depress the plunger until the amount in the syringe equals 15 mL, which is the maximum amount the bird should receive upon intake. Have one person restrain the bird while the other gavages. The restrainer should hold the bird on the table or at waist level. The person gavaging should obtain firm control of the bird's head. Gently extend the bird's neck and use your thumb and index finger to open its mouth. Locate the glottis, which is the opening to a bird's trachea. It lies directly behind the tongue and will open and close as the bird breathes. AVOID inserting the tube in the glottis as this will send the fluids into the lungs or the air sacs, causing pneumonia or death. Insert the gavage tube to either side of the glottis (Figure 2). Fully extend the bird's neck up and out. Insert the tube on either side of the glottis and slowly slide it down the esophagus. On a duck it is tough to visually check the tube's placement due to the small size of its mouth, so you can double check your tube placement by gently feeling the ventral area of the bird's neck. You should be able to feel two distinct tubes: the gavage tube and the trachea. The gavage tube will feel larger and sturdier. If you only feel one tube, the gavage tube may be in the trachea, remove and try again. Once in the esophagus, allow the bird to partly close its mouth. This will be more comfortable for the bird and it will struggle less. Continue to advance the gavage tube gently down the esophagus until the sharpie mark for length is reached. Depress the plunger at a moderately slow, even pace. Tube feed in 5 mL increments while watching for regurgitation. Give no more than 10 mL for the bird's first PO fluid administration, and no more than 15 mL for any subsequent administrations. Make sure to hold the top of the tube where it meets the syringe since pressure can cause the tube to come off and spray the contents over the bird and handler. Once the syringe is empty, pinch off the tube and slowly pull it out. Pinching off the tube creates a vacuum along the length of the tube and stops any liquid from dripping into the bird's trachea. Return the duck to its carrier immediately. The stress of restraint may cause it to regurgitate.

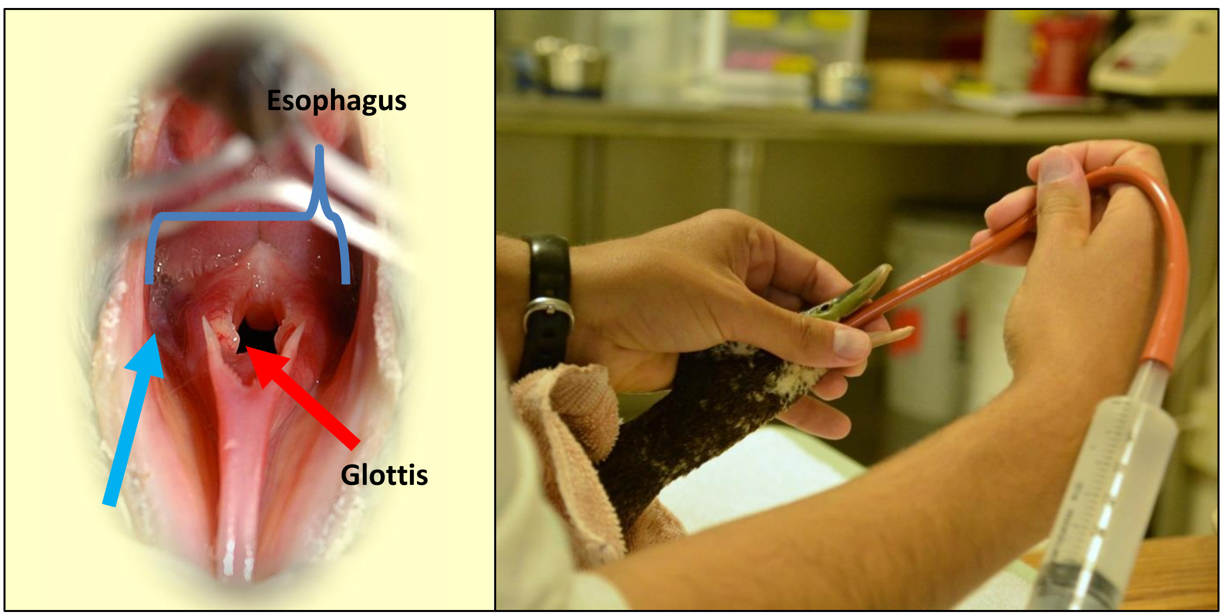


Figure 2. On the left is a picture of a bird's mouth, when open. The glottis is indicated by the red arrow. This is where you want to avoid inserting the tube, instead aiming for the esophagus (blue) on either side of the glottis. Photo: Hawaii Wildlife Center. On the right is an example of a duck being gavaged. Photo: Greg Joder.

Potential problems encountered when gavage feeding:

- Resistance while advancing the tube. STOP if you feel resistance. Never force the tube as it can rupture the wall of the esophagus and be fatal to the bird. Reevaluate several things at this point:

  - Is the bird's neck straight? A crooked, twisted or L-shaped neck can cause the tube to hit the esophageal wall or the thoracic inlet. It may become stopped by the clavicle.

  - Is the stomach full with food? Withdraw the tube and check the tip to see if there are remnants of food there. If this is the case, wait a few more hours for the bird to digest the food before trying to tube feed again.

  - Is the tube adequately lubricated? If the tube and bird are positioned correctly, express a small amount of tubing fluid (2-3 mL) into the esophagus to help with lubrication.

  - Is the tube clamped in the bird's bill? This will stop the normal advancement of the gavage tube.

- Regurgitation. If the bird begins to regurgitate, immediately pinch and remove the gavage tube. Do not hold the bird upside down, but gently hold the bird and let it shake out the fluid by itself. Cotton swabs may be necessary to clear food from the bird's trachea. **Never** try to keep a bird from regurgitating by holding its head up or keeping its mouth closed. This will cause aspiration that can lead to pneumonia.

  - Emaciated, hypothermic birds, newly admitted birds, or those that are severely stressed are prone to regurgitation.

  - A sign that the bird has aspirated a significant amount of fluids is a gurgling or a clicking sound when they breathe.

6. Place the bird in the pet carrier, cover it with a large towel, and relocate the carrier to a quiet place where it will not be disturbed by human noise or movement. If it is hot outside, find a shady, well-ventilated place. If it is cool outside, consider leaving the carrier inside.

7. Clean and disinfect the work station. See Appendix 5 for cleaning protocols.

8. Enter the duck on the *Sick and Dead LADU Intake Log* (Appendix 9) and assign it a log number.

4. CONTINUING CARE

There is not a standard hydration and feeding schedule that works for every bird, as it depends on the severity of the symptoms and the individual's body condition. Assess the bird each morning and create a hydration and feeding schedule according to the following guidelines.

Just as in the intake exam, take and record the duck's temperature, weight, dehydration level, and body condition score every morning in a quick and thorough manner. Create a hydration and feeding schedule based on the bird's current condition.

<u>SITUATION 1 – Bird is unable to hold its head up</u>:

- Do not administer fluids orally; birds at this stage are very likely to aspirate.
- Give 10 mL sterile LRS or NaCl solution SQ in the inguinal fold of each leg (for a total of 20 cc per administration).
- You can give SQ fluids at 3 to 4 hour intervals for debilitated birds.
- Check if the bird has absorbed the fluids (by seeing if the bolus has disappeared) before giving any more.
- If the bird has not absorbed the fluids, make sure it is within its normal temperature range (102°-106° F); a cold bird will not be able to absorb fluids. If necessary, offer a heating pad (Instructions, p. 11).
- Continue to offer a rolled-up towel on which the bird can support its head.
- The duck's fecals will be runny– this is normal.
- Do not give dishes of food and water in the carrier. With no control over their head, it is possible they can drown in their own water dish.
- Do not give a second dose of anti-toxin; one dose is the maximum.
- Never inject non-sterile fluids or fluids not approved for SQ treatment.

<u>SITUATION 2 – Bird is able to hold its head up, and is not emaciated (has a body condition score of 1+ or higher)</u>:

- Try administering fluids PO. Tube-feed in 5 mL increments while watching closely for regurgitation and give no more than 10-15 mL.

- Later, if the status of the bird is the same or improved, the next tube-feeding can be up to 15 mL of Ensure followed by another administration of LRS/NaCl at least four hours later.

- At this time, examine the fecal matter in the carrier. If it looks exactly like it appeared before going into the duck, the bird is not digesting it. In this case, keep administering LRS/NaCl one or two more times before trying Ensure again. Only after the duck shows that it can digest it properly should you transition to feeding Cat Food Slurry.

- Offer a small food and water dish in the pet carrier to see if the bird will self-feed. If the bird is eating on its own, you can minimize tube-feedings unless the bird is losing weight or getting dehydrated. This is ideal since it saves the bird the stress of multiple handlings. However, Laysan Ducks are often too stressed in captivity to self-feed so this is not always an option.

SITUATION 2A. Bird is able to hold its head up, is digesting properly and is thin:

- Tube-feed the bird Cat Food Slurry up to 3 times a day, as long as you think the bird is getting enough water from the water dish on its own (assess hydration). If not, replace one of these tube-feedings with LRS or NaCl. Wait a minimum of 2 hours after LRS/NaCl feedings and 4 hours between slurry feedings.

SITUATION 2B. Bird is able to hold its head up, is digesting properly and is in moderate or good body condition:

- Tube-feed the bird Cat Food Slurry 2 times a day, as long as you think the bird is getting enough water from the water dish on its own (assess hydration). If not, add in a LRS or NaCl tube-feeding. Wait a minimum of 2 hours after LRS/NaCl feedings and 4 hours between slurry feedings.

SITUATION 3. Bird is able to hold its head up, and is emaciated (has a body condition score 1 or less):

- Before feeding a starving or emaciated seabird, ensure that the bird's temperature is above 100°F before continuing. If the bird's temperature is dangerously low, place a heating pad underneath the pet carrier (follow instructions on p. 11). Monitor the bird closely by visually watching the bird as well as taking its temperature often.

- Follow one of the suggested protocols from Lafeber:

Treatment Protocol 1 – Starvation
Quantity per tube feeding – 7% of body weight

For instance a 200-gram bird could be gavaged up to 14 ml of fluid. Administer the fluid very slowly, and stop if fluid begins to well up in the back of the throat. If the bird is unable to hold 7%, then gradually work up to this volume.

Administer hydrating fluids (LRS or NaCL) PO or SQ
1 hour later: 25% dilution of Emeraid Omnivore
2 hours later: LRS/NaCl (PO or SQ)
1 hour later: 35% dilution Emeraid Omnivore
2 hours later: LRS/NaCl (PO or SQ)
1 hour later: 45% dilution Emeraid Omnivore
2nd Day* LRS/NaCl (PO or SQ)
1 hour later: 55% dilution Emeraid Omnivore
2 hours later: 65% dilution Emeraid Omnivore
2 hours later: 75% dilution Emeraid Omnivore
2 hours later: 85% dilution Emeraid Omnivore
2 hours later: 100% Emeraid Omnivore, made as directed per label instructions
2 hours later: LRS/NaCl (PO or SQ)
NOTE: If bird is still dehydrated, you may add another LRS mid-day replacing one Emeraid tube feeding.

Treatment Protocol 2- Severe Starvation
Quantity per tube feeding – 7% of body weight (kg)
For instance a 200-gram bird could be gavaged up to 14 ml of fluid. Administer the fluid very slowly, and stop if fluid begins to well up in the back of the throat. If the bird is unable to hold 7%, then gradually work up to this volume.

Administer hydrating fluids (LRS or NaCL) PO or SQ
1 hour later: 10% Emeraid Omnivore
2 hours later: LRS/NaCl (PO or SQ)
1 hour later: 20% Emeraid Omnivore
2 hours later: LRS/NaCl (PO or SQ)
1 hour later: 30% Emeraid Omnivore
2 hours later: LRS/NaCl (PO or SQ)
2nd Day* LRS/NaCl (PO or SQ)
Same as Day 1, except give one LRS tubing first, and then give 40% Emeraid Omnivore feedings all day.
3rd Day* Assess bird's overall condition
Same as Day 2, except give one LRS tubing first, and then give 50% Emeraid Omnivore feedings all day.
In rare cases, it may take up to 4-5 days for a severely emaciated bird to tolerate Emeraid Omnivore as directed on the label, and possibly 5-6 days to eat solid food.

GENERAL CAPTIVE CARE GUIDELINES:

- When opening the carrier door to bring out the duck, always be inside a contained room such as the duck lab or the outside aviary in case the duck escapes. To prevent escapes, open the door slowly and block the opening with one hand while you reach in with the other hand.

- Keep the plumage clean by using the wire mesh “poop guards” in the pet carrier to keep the bird from sitting in its feces.

  - Also, periodically check the vent area. If it is dirty, put the duck in the “bird burrito” (Figure 2), bring it to the duck lab sink, hold it upside down and run water over the cloaca while wiping off the feces. Towel off the excess water near the vent and tail.

- If the bird is weak and immobile, you can help the duck by manually expelling its feces. You can do this on each handling prior to SQ or PO administrations. Put the duck in the “bird burrito,” place it on its back, and press gently on the area anterior to the cloaca to expel any fecal matter present. Clean the bird’s feathers off. Pat yourself on the back, you just helped a duck poop.

- Replace dirty pet carriers, “poop guards,” and absorbent pads with clean ones every morning and evening. Change out food and water dishes at least once a day unless otherwise soiled.

- Examine the bird’s fecals and note on the captive care datasheet the color and consistency to help you keep track of its digestive health.

- Do not keep birds loose in the aviary since they tend to lose weight quickly that way. Continue to keep them in a pet carrier in a quiet, undisturbed place.

- If the bird is improving and you anticipate releasing it soon, give the bird the **Botumink vaccine**. The bottle of Botumink is kept in the fridge. The dose is 1cc and is given SQ in the inguinal fold. Wipe the top of the vaccine bottle with alcohol before introducing the sterile single-use needle.

  Remember: The botulism anti-toxin is given IM (p. 4) while the botulism vaccine is given SQ; it is easy to confuse the two.

- If the bird is improving and at a good weight, consider release. See Appendix 5 for release criteria.

- If the bird is losing weight and/or not improving within a few days, report to Refuge Biologist with any other symptoms and seek guidance as appropriate.

5. REFERENCES

This protocol drew heavily from existing written protocols and personal communication with Hawaii Wildlife Center, which were extremely helpful in this attempt at creating a tailored procedure for Midway Atoll NWR. Many thanks go to Linda Elliott, Judi Ellal, Tracy Anderson, Dan Clark, Bret Wolfe, Greg Schubert, Meg Duhr-Schultz, and Ann Humphrey for their support and guidance.

Avian Botulism Management at Midway Atoll NWR. John Klavitter and Bret Wolfe, 2014.

Hawaii Avian Botulism Guidelines. Hawaii Wildlife Center in partnership with Hawaii Division of Forestry and Wildlife.

Laysan Duck Avian Botulism Bird Collection, Stabilization, Transportation, and Rehabilitation, Standard Operating Procedures. Hawaii Wildlife Center, 2014.

APPENDIX 1 – Intake Exam: Condensed Version

This simplified version is designed to help you remember the steps as you perform the intake exam. However, it is not a replacement for reading the full version (Section 2 and Appendix 1). It is essential that you are familiar with the details of each step before attempting them.

Materials Needed:

Pet carrier, absorbent pads, poop guard, towel
Hot water bath
Appropriate syringes with gavage tubes or sterile needles
Thermometer
Duck bag, pesola spring scale
Captive Care datasheet
Defrosted anti-toxin, if appropriate

Intake Exam:

1. Prepare pet carrier.

2. If not administered in the field, defrost an anti-toxin syringe in your hand and administer 0.5 cc of it to the duck intramuscularly (IM) in the breast muscle.

3. Prepare and warm fluids.
   I. Draw up 20 cc in a sterile luer-lok syringe with a sterile 23 or 25 gauge needle to give subcutaneously (SQ).
   II. Place syringe in hot water bath to warm.

4. Take and record <u>temperature, weight, body condition score and dehydration</u> level.
   - Is the bird's temperature lower than 102° F? If yes, consider placing bird on a heating pad after the exam (important instructions on page 10).
   - Is the bird's temperature higher than 106° F? If yes, wipe feet down with alcohol pads and place in a shady, well-ventilated place after the exam.

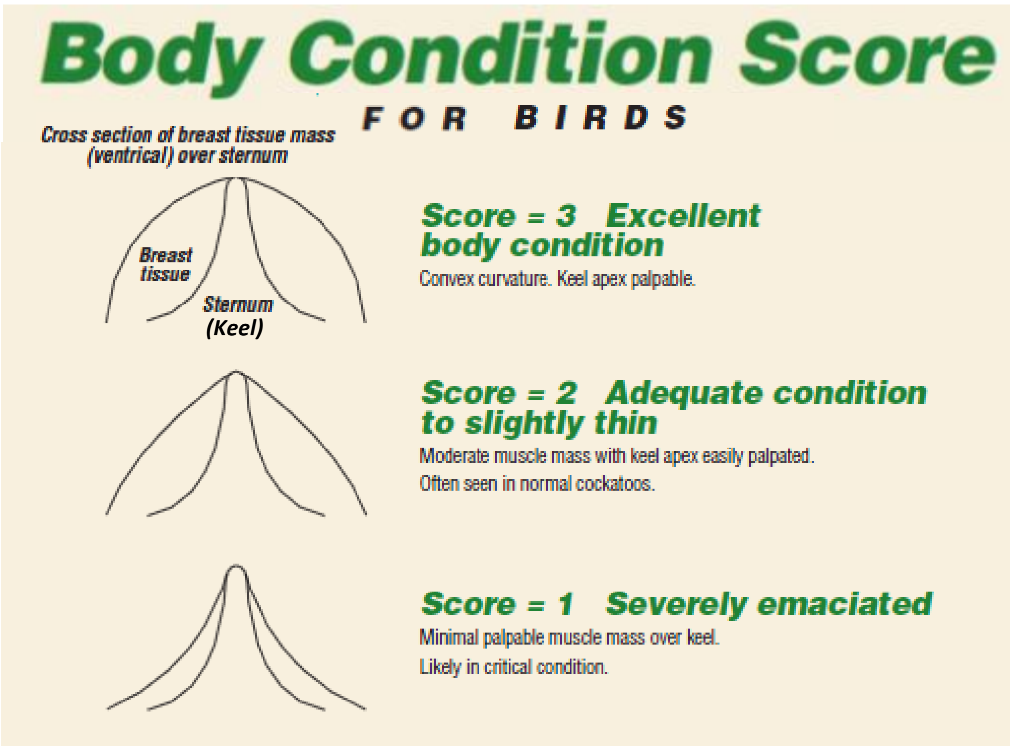
5. Administer SQ fluids to the bird by injecting 10 cc into the inguinal fold of each leg with a sterile 23 or 25 gauge needle.

6. Place bird in pet carrier and relocate to a quiet place and make sure the ambient temperature is appropriate.

7. Clean and disinfect equipment and work station.

APPENDIX 2 – Body Condition Score

The body condition score is a useful tool for assessing a bird's overall health. Note a patient's score on the captive care datasheet and use it to help determine when to release a bird.



NOTE: If the body condition scores in between two numbers on the scale, you can use "+" and "-" to convey this. For example, if the score is in between a 1 and 2 and is closer to a 1, use 1+.

Source: Kaytee Diets (http://www.kaytee.com/assets/014/27187.pdf)

APPENDIX 3 – Diet preparation and storage

It is important for the duck to be well hydrated and maintaining or gaining weight while in care. Use the following diets when caring for a duck. Refer to the Continuing Care section to determine which diet to use.

A. Lactated Ringers Solution or 0.9% Sodium Chloride Solution – These are rehydrating solutions that can be given PO or SQ. Either solution will work; use what is available. Give 15 cc maximum for PO, and 20 cc maximum for SQ. See Appendix 1 for more information on administration.

- Storage:
    - For bags that have been cut open for oral administration, pour the contents into a container with a lid and refrigerate. Label the container with the open date and throw out the contents after one week.
    - For SQ fluid bags that have only been entered by sterile needles via the port at the bottom with the yellow stopper, store the bag in the fridge. Label the bag with the date of first use and throw out after one week.
    - For intravenous (IV) administration, the contents in the bag are only good for 24 hours. However, fluid administration via IV is not part of this protocol so you will not have to worry about this.
    - **NOTE**: If you observe tiny particles or floating material in these solutions (even if they have never been opened), they are no longer good. Throw these out.

B. Ensure Nutrition Shake, plain or vanilla flavor, 8 oz bottle – This is given PO. It provides some nutrition in addition to hydration and is a good transition between a diet of fluids only to a diet of fluids and Cat Food Slurry. Gavage up to 15 cc of Ensure per feeding.

- Storage: Label the bottle with the open date, refrigerate after opening, and dispose of after 24 hours.

C. Cat Food Slurry – Before transitioning to slurry, make sure the duck is digesting the Ensure properly. Use potable water and approved cat kibble (Evo or Taste of the Wild brands) to make the slurry. Gavage up to 15 cc of slurry per feeding.

- Store the bag of cat food in the freezer to prevent it from going bad.
- Preparation instructions:

- Using the coffee grinder, grind approximately 1 cup of cat kibble as fine as possible without causing it to become heated in the process (this affects the nutrients). The coffee grinder should do a good job of grinding it into a fine powder. However, if there are any large chunks of kibble, sift these out as these can clog the tube when gavaging.

- Combine equal amounts of water and cat food together. For example, add 3 TB ground cat food to 45 mL water. Mix in the blender. You may have to double the amounts of both ingredients if the blender cannot mix a smaller amount. Blend well, but do not allow the slurry to heat up. Add more water if the slurry is too thick to draw into the syringe and blend again.

    - ♦ Note: If you are extra careful to mix the slurry thoroughly and break apart any clumps, you can mix by hand with a syringe plunger or spoon in lieu of using the blender. The goal is to not plug up the tube with solid clumps when you are gavaging the duck.

- Draw slurry in to the feeding syringe, attach the gavage tube and remove air and excess amounts of slurry. Warm in hot water bath. Feed as soon as possible after the slurry has warmed since it will swell/solidify with time. Hold the feeding tube onto the syringe when dispensing into the bird so that it does not pop off.

- Leftover slurry should be discarded at the end of each feeding.

<u>D. Self-feeding diet</u> – If the bird is holding its head up, place a small dish of food and a small dish of water in its carrier. Offer a combination of Trip-l duty poultry feed, cat food kibble moistened with water, and dried mealworms. You can also supplement this with Bunchgrass (*Eragrostis variabilis*) or Goose Grass (*Eleusine indica*) seeds if you have time to collect them. All the dry food is stored in the biology freezer located in the duck lab. Dishes of food and water can be left in the carrier the entire day unless they become soiled.

- If the bird is stressed, it may not self-feed and will require tube-feedings of slurry to maintain its weight.

- **NOTE**: Be aware that mice can be attracted to the duck food. To prevent them from gaining access to it, place the pet carrier on a sturdy structure that is more than one foot off the ground, is not touching any walls or cords, and is slick on the surface (to prevent the mice from climbing the sides). A metal table or other similar structure is ideal.

E. Emeraid Omnivore/Psittacine – This is a critical care diet meant for critically ill or emaciated birds (birds with a body condition score of 1 or less). It is easy to assimilate because it is in a form that does not require the patient's valuable energy stores in order to digest. This allows the debilitated animal to quickly get the essential nutrients for survival.

- Storage: Upon arrival, store Emeraid in a cool, dry space, and refrigerate powder after opening package. Emeraid has an 18-month shelf life from the time of production, and should be used within 9 months after opening. Handle product carefully and avoid contamination, which can lead to bacterial overgrowth; specifically, remember to keep the Emeraid dry, use a clean, dry spoon whenever using the product, and do not cross-contaminate with scoops used for non-Emeraid foods.

- Preparation:
    - Fully concentrated Emeraid Omnivore is essentially a 3:2 powder to water ratio. Therefore, for smaller volumes of Emeraid, measure 6 teaspoons (and blend with 20 ml of water) or, for larger volumes, measure 6 tablespoons (and blend with 60 ml of water) to get a 100% concentration. You can prepare however much you need as long as it works out to a 3 part powder to 2 part water ratio. You can then dilute it down to the appropriate concentration or you can also simply follow the amounts given in Table 1, which will give you the dilutions for commonly used amounts when gavaging. Refer to the Emeraid Protocols on p. 7-8 for instructions.

Desired Emeraid Concentration	# Scoops of Powder (1 scoop = 1 tsp)	Amount Water (mL)	Appx. End Amount (mL)
25%	1.5	26	27
50%	3	25	28
75%	6	30	33
100%	6	20	30

Table 1. Amounts of Emeraid Omnivore powder and water to use for different concentrations.

    - Measure level scoops; do not pack the powder. Mix the powder with hot (not boiling) water to help it dissolve. When mixing the Emeraid and water, shake or stir the mixture vigorously to avoid any danger of hot spots. Shaking dry powder in the mixing container will facilitate mixing; shaking helps to break up the clumps and lumps prior to adding the water. Make sure all lumps and clumps are blended.

    - Keep the gavage tube and syringe in very warm water until ready to feed. The temperature of the Emeraid mixture should be on the hotter side of warm, but not too hot; if you can dip the tip of your pinky finger in the mixture and it feels comfortably warm, that is good. The hot water also warms up the gavage tube and makes it more supple to work with.

- When ready to feed, fill the syringe with the Emeraid mixture and ensure that the duck is ready to feed immediately. To minimize any risk of the tube plugging, do not load the feeding or gavage needle with formula until immediately before feeding. When feeding, always watch for regurgitation. Prepare fresh food if more than 30 minutes passes. Discard any leftover formula. Make fresh Emeraid for each feeding; do not feed birds Emeraid Omnivore for more than 7 days.

APPENDIX 4 – Release criteria and banding procedure

After the effects of the botulism toxin have resolved, the most important factors to consider when releasing a bird are body condition, weight, and stress level.

The duck in care should meet the following criteria as closely as possible before release:

1. Able to hold its head up, stand, and walk.

2. Holds wings in the correct position.

3. Able to function nictitating membrane (the bird's third eyelid).

4. Properly hydrated; eyes are no longer squinting.

5. Good body condition (with ideally a minimum of 2- for the body condition score) and is within the normal weight range according to its gender and age. **NOTE**: Mass fluctuates significantly with season and reproductive status.

    - Average weight ranges for this species are:
        - Male – 450 g
        - Female, non-ovulating – 460 g
        - Female, ovulating – 550 to 600 g
        - Female with brood – 377 g
        - Hatch-years and young second-years can be below 350 g

6. Vaccinated with Botumink (instructions on p. 9).

7. Banded with the band combination being recorded on the *Captive Care Notes* datasheet.

    - If the Refuge Biologist is available, an aluminum USGS band and an auxiliary band can be put on the bird. Each of the bands should have directions on which leg they need to be placed on. Record the new band combination and numbers on the banding datasheet.

    - If the Refuge Biologist is not available, temporary band(s) can be placed on the bird instead. Double check the resight reference file so that you do not duplicate an existing color combination. If the bird has received the botulism vaccine, secure the temporary bands with super glue so that survival can be tracked.

    - Upon release, be sure to update the Sick and Dead LADU Intake Log, the Sick and Date LADU database (excel database), and the resight reference file to ensure that the data have been accounted for.

APPENDIX 5 – Cleaning and disinfecting

Keeping the duck lab clean and disinfected is important in minimizing risk to human and bird health. It also helps prevent insect infestations of ants, roaches and mice.

- Wash hands frequently.

- Spray and wipe the bench and any other soiled surfaces with 10% bleach solution.

- After an injection, dispose of the needle in the sharps container and the syringe in the garbage can. Neither of these objects should be reused.

- Wipe the top of the Botumink vaccine bottle with alcohol before introducing each sterile needle.

- After an oral administration of fluids or slurry, wash the syringe and gavage tube with dish soap and water to remove all food and oily residues. Rinse thoroughly. Make sure remnants of slurry do not remain stuck in the tube; you may have to use the syringe to clear it out. Use chlorhexidine or vercon solutions to disinfect. Completely submerge each object in the solution for at least 10 minutes and rinse with water. Draw solution into gavage tubes to make sure the disinfectant makes contact inside the tube.

  - Chlorhexidine solution: 2 Tablespoons per gallon of water. Avoid contact with eyes, ears and mucous membranes. Replace solution every few days.

  - Vercon solution: One tablet per pint of water. Use gloves when reconstituting: while the solution is non-toxic and non-irritating, direct contact with the tablet can irritate skin, mucous membranes, and eyes. Replace solution after one week.

  - If neither of these are available you can use a 10% bleach solution, although the bleach will shorten the life of the plastic syringes and feeding tubes.

- Never use the same gavage tube twice without cleaning and disinfecting it first.

- Allow clean syringes and tubes to dry thoroughly before putting them away. Trapped moisture can encourage bacterial growth.

- Syringe plungers will become more difficult to depress over time. Throw out ones that take a lot of effort to push.

- Replace any food and water bowls as they become soiled. Clean and disinfect these as well.

- ❖ Bring dirty pet carriers outside and use the hose, 10% bleach solution and scrub brush to clean. Let the bleach solution sit for at least 10 minutes before rinsing. Let the carriers dry thoroughly. Throw away the used absorbent pads.

- ❖ For poop guards covered with fabric, don’t use bleach to clean them as this will shorten the life of the fabric. Let them soak in a tub with chlorhexidine or vercon solution instead.

- ❖ Use the washing machine in the store room to clean the dirty duck bags and towels. There is a limited supply of clean duck towels so make sure you have enough clean ones for the next day.

APPENDIX 6 – Disposition of Carcasses

Laysan Duck carcasses are periodically sent to the USGS National Wildlife Center – Honolulu Field Station for necropsy at the discretion of the Refuge Biologist (Midway Atoll NWR) and Thierry Work (USGS). All other collected LADU and other waterbird carcasses are stored in the freezer and incinerated at a later date.

Place carcasses in the respective designated containers inside the LADU freezer. There is a container for carcasses to be incinerated and a container for carcasses to be sent for necropsy.

Good candidates for necropsies:

- ❖ Were found freshly dead. If carcass is soft and mushy, has skin discoloration, feathers or skin that easily rub off, or if maggots are present then it is too decomposed for most lab tests.

- ❖ May have died from causes other than botulism. We are interested in other causes of mortality besides avian botulism.

A few fresh carcasses suspected to have died from botulism should be saved each year for testing and confirmation that botulism is present on Midway. These should be placed in the designated container with the other necropsy candidates.

APPENDIX 7 – Resources

- For any rehabilitation support and questions:

  Hawaii Wildlife Center
  Phone: 808-884-5000
  Email: birdhelp@hawaiiwildlifecenter.org,
  judi@hawaiiwildlifecenter.org or
  linda@hawaiiwildlifecenter.org

- For disease and carcass related questions:

  USGS – National Wildlife Health Center, Honolulu Field Office
  Phone: 808 792-9520
  Email: thierry_work@usgs.gov or
  bob_rameyer@usgs.gov

- For general Laysan Duck species and monitoring questions:

  USGS – Kilauea Field Office
  Phone: 808-985-6416
  Email: mreynolds@usgs.gov or
  kcourtot@usgs.gov

APPENDIX 8 – Datasheets

Sick and Dead LADU (and other waterfowl) Intake Log - MIDWAY ATOLL

Log # (assigned to LADU only)	Date	Time	Obs.	Species	Location Found	Status	Age	Sex (M, F, U)	Right Leg Band	Left Leg Band	Suspect Botulism (Y/N)	Botulism Anti-toxin (Y/N)	Botulism Vaccine (Y/N)	Disposition	Disposition Date & Location	Notes

APPENDIX 8 – Datasheets

Sick and Dead LADU (and other waterfowl) Intake Log - CODING SHEET

Log #:	A unique number given to any live LADU brought in to the lab or dead LADU collected. Format: Year-sequential number (e.g., 15-01 for the first bird of 2015). Birds other than LADU do not get assigned numbers.
Date:	Date of capture or collection.
Time:	Time of capture or collection.
Obs.:	Observer's initials.
Species:	The four letter species code of bird. Common species include: LADU - Laysan Duck NOPI - Northern Pintail AMWI - American Wigeon GRSC - Greater Scaup For other species, refer to Alpha Code document in 'Vagrant' folder in the Volunteer Drive
Location Found:	General location where duck was found, e.g. seep name, building name or sector number
Status:	The condition of the bird when found. Use codes: D - Dead S - Sick I - Injured E - Entangled (e.g. with plastic debris around head or feet) O - Other (explain in notes)
Age:	Approximate age of bird. Use codes: D - Duckling (still downy) HY - Hatch Year (a young bird hatched earlier in the year that is independent and capable of flight). SY - Second Year AHY - After Hatch Year (includes SY and ASY ages, use AHY if cannot specify) ASY - After Second Year (adult bird) U - Unknown See LADU ageing/sex guide for details on age-specific plumage.
Sex:	Male, Female or Unknown. Refer to LADU ageing/sex guide for details.
Right Leg Band:	If bird is banded, record the band for the right leg. This may include the color and symbol for a plastic auxiliary band or simply AL for an aluminum band. Record the aluminum band number in the note column.
Left Leg Band:	If bird is banded, record the band for the left leg. This may include the color and symbol for a plastic auxiliary band or simply AL for an aluminum band. Record the aluminum band number in the note column.

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Sick and Dead LADU (and other waterfowl) Intake Log - CODING SHEET

Suspect Botulism (Y/N):	For live birds: write 'Y' if bird is exhibiting symptoms typical of botulism (drooping wings, squinty eyes, paralysis). Write 'N' if unsure, or if another cause is obvious. For dead birds: write 'Y' if bird was found in an area that has been a hotspot for botulism within the past few weeks. Write 'N' for if unsure, or if another cause is obvious.
Botulism Anti-toxin (Y/N):	Applicable only for birds found alive. Write 'Y' if this bird received the botulism anti-toxin (IM injection). For birds that later die in care, this can eliminate them from being considered for necropsy.
Botulism Vaccine (Y/N):	Applicable only for birds found alive. Write 'Y' if this bird received Botumink, the botulism vaccine (SQ injection).
Disposition:	Ultimate fate of live bird or carcass. Use codes: 1 - Found dead, kept carcass in freezer for incineration. 2 - Found dead or died in care and is a candidate for necropsy. Note: if given anti-toxin, the bird is not eligible for necropsy. Carcasses qualifying for necropsy include ones that: ◦ Are relatively freshly dead (no maggots). ◦ Were not given botulism anti-toxin while alive. 3 - Held for treatment, was released. 4 - Held for treatment, died in care, put in freezer for incineration. 5 - Other (explain in notes). 6- Sent to USGS for necropsy.
Disposition Date and Location:	Ultimate location of bird and accompanying date. For example, "Date: 9/1/2014, Location: Office Guzzler" for a released duck, or "Date: 10/5/2014, Location: LADU Freezer" for a carcass kept for incineration, or "Date: 11/5/2014, Location: LADU Freezer for USGS" for carcasses to be sent for necropsy. For carcasses that have been sent for necropsy, change location to "USGS."
Notes:	Include any noteworthy details such as bird behavior, presence or absence of maggots, condition/freshness of carcass, keel score of carcass if fresh (refer to sheet on the wall in the lab for scoring), where the carcass was found, band condition and aluminum band number if applicable.

LADU CAPTIVE CARE NOTES

Page ____ of _____

Log #________________ Intake Date/Time/Location ____

Sex _______ Age _______ Band Combination RL/LL ______/_______ USGS Band # ________________

Obs.	Date	Time	Temp.	Weight (bird in bag)	Weight (bird only)	Body Condition Score	Dehydr-ation Level	Fluids or Nutrition Given	Notes

Release Date/Time/Location____

APPENDIX 9 – LADU Initial Intake Flowchart

Intake Exam for Laysan Ducks Suspected to have Botulism

This is designed to be a quick reference. Please consult the LADU Captive Care Protocol (Appendix 1) for full instructions. It is essential that you are familiar with the details for each step before attempting them.

MATERIALS NEEDED:

- **Pet carrier** (prepped with absorbent pad, poop guard, and rolled up, U-shaped towel [for duck to rest its head on if it cannot hold head up])
- **Sterile 20 mL luer-lok syringe with sterile needle (23G or 25G)**
- **Lactated Ringers Solution (LRS) or 0.9% NaCl Solution (NaCl)**
- **Hot water bath for syringe**
- **Thermometer**
- **Duck bag & pesola spring-scale**
- **Defrosted anti-toxin**
- **Captive care data sheet**

PREPARE AND WARM FLUIDS

Draw up **20 mL of sterile LRS or 0.9% NaCl** in a sterile syringe with a sterile needle for administration of subcutaneous (SQ) fluids.

Fill hot water bath and heat up in microwave for appx. 2 minutes. Place syringe with capped needle in bath to warm.

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INTAKE EXAMINATION

Take the following in a quick but thorough manner: **temperature**, **weight**, **body condition score**, and **dehydration level**. Record on the captive care data sheet.

If the vent is caked with feces, clean it by holding the duck upside down (wrapped in a towel) and running tap water over it.

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Is the duck severely dehydrated?

- **YES** → **Hydrate** the duck **before** administering the botulism anti-toxin. Its dehydration level should be slight to moderate before receiving the anti-toxin.
- **NO** → Administer the botulism **anti-toxin**: defrost one of the aliquoted syringes by warming it in your hand, and administer it intramuscularly (IM) in the breast.

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Administer **SQ fluids**: Inject 10 mL of LRS or NaCl into the inguinal fold of each leg. Test temperature of fluids against your skin before administering.

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Is the duck's temperature lower than 102° or higher than 106°?

- **YES** → If its temperature is **lower than 102°**, follow the instructions on p.11 of the protocol for using a heating pad. Monitor closely!

  If the duck's temperature is **higher than 106°**, wipe down its feet with alcohol pads, place in pet carrier and put in a shady, well-ventilated place.
- **NO** → Place duck in pet carrier, relocate to a quiet place, and make sure the ambient temperature is appropriate.

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Clean and disinfect the equipment and work station. **Assess** duck's condition in 3—4 hours; refer to the Laysan Duck Captive Care Protocol for instructions on continuing care.