NOAA's National Marine Fisheries Service
Endangered Species Act Section 7 Consultation

Biological Opinion

Agency: Permits, Conservation, and Education Division of the Office of Protected Resources, NOAA's National Marine Fisheries Service

Activity Considered: Biological Opinion on the proposal to issue permit amendment No. 10137-04 to the National Marine Fisheries Services' Pacific Islands Science Center Marine Mammal Research Program for studies of Hawaiian monk seals in the Hawaiian Archipelago and Johnston Atoll, pursuant to Section 10(a)(1)(A) of the Endangered Species Act of 1973

Consultation Conducted by: Endangered Species Division of the Office of Protected Resources, NOAA's National Marine Fisheries Service

Approved by: _____

Date: AUG 0 5 2010

Section 7(a)(2) of the Endangered Species Act (ESA) (16 U.S.C. 1536(a)(2)) requires that each federal agency shall ensure that any action authorized, funded, or carried out by such agency is not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of critical habitat of such species. When the action of a federal agency "may affect" a listed species or critical habitat designated for them, that agency is required to consult with either NOAA's National Marine Fisheries Service (NMFS) or the U.S. Fish and Wildlife Service, depending upon the listed resources that may be affected. For the action described in this document, the action agency is the NMFS' Office of Protected Resources – Permits, Conservation, and Education Division. The consulting agency is the NMFS' Office of Protected Resources – Endangered Species Division.

This document represents the NMFS' biological opinion (Opinion) of the effects of the proposed studies on endangered Hawaiian monk seals and their designated critical habitat, and has been prepared in accordance with Section 7 of the ESA. This Opinion is based on our review of the Permits, Conservation, and Education Division's draft Environmental Assessment, draft permit amendment 10137-04, the Marine Mammal Research Program's application, the most current marine mammal stock assessment reports, recovery plans for listed species, scientific and technical reports from government agencies, peer-reviewed literature, biological opinions on similar research, and other sources of information.

Consultation History

On September 22, 2007, the Permits Division received an application from the Marine Mammal Research Program for a permit to "take" endangered Hawaiian monk seals as part of a program to assess the status of the species and implement actions to promote its recovery from endangerment. Between March and April 2008, the Permits Division processed the proposed permit, solicited public comments on the proposed permit, and responded to those comments.

On February 3, 2009, the Endangered Species Division received a request for formal consultation from the Permits Division on the issuance of scientific research permit 10137 that would authorize studies of Hawaiian monk seals. The Endangered Species Division requested additional information and on April 20, 2009 initiated formal consultation. On June 30, 2009, the Endangered Species Division completed consultation on all originally proposed actions with the exception of translocation between subpopulations, and the Permit's Division issued Permit 10137 to the Marine Mammal Research Program.

As an amendment to scientific research permit 10137, and per an agreement between the Permits and Endangered Species Divisions, the proposed translocation of six weaned Hawaiian monk seals from French Frigate Shoals to Nihoa Island, to take place in August of 2009, was assessed in a separate consultation. This consultation was completed on August 14, 2009, and the translocation took place as proposed.

The Permits Division issued amendment 10137-02 in October 2009 to authorize the use of an intramuscular injection of the anti-parasitic drug, praziquantel, in place of the originally permitted oral administration of the same drug at the same dosage. The Permits Division requested consultation. The Endangered Species Division determined that any effects that could result from the use of this drug would be consistent with the effects previously assessed in the June 2009 Opinion, and that reinitiation of consultation was not required.

The Permits Division issued amendment 10137-03 in January 2010 to authorize the permit holders to take non-invasive ultrasound measurements. The Permits Division requested concurrence that this amendment would not adversely affect the Hawaiian monk seals beyond the effects previously assessed in the June 2009 Opinion. The Endangered Species Division concurred with the Permits Division via a memorandum.

On June 21, 2010, the Endangered Species Division received a request for formal consultation from the Permits Division on the issuance of scientific research permit amendment 10137-04 that would authorize the use of the broad-spectrum nematodicide ivermectin (injectable), to be used in place of the currently authorized broad-spectrum nematodicide fenbendazole (oral), during the de-worming project. Formal consultation was initiated.

Description of the proposed action

The National Marine Fisheries Service's Permits, Conservation, and Education Division proposes to amend an existing permit to the Marine Mammal Research Program of the National Marine Fisheries Service's Pacific Islands Science Center pursuant to the ESA and Marine Mammal Protection Act of 1972, as amended (MMPA; 16 U.S.C. 1361 *et seq*., Section 104).

The current permit authorizes the Marine Mammal Research Program to continue population monitoring; health, disease, and foraging research; and relocations and disentanglements to enhance survival of the species over a five-year period beginning in 2009. Specifically, the earlier permit authorized the Marine Mammal Research Program to engage in activities that would be used to (1) assess survivorship, reproductive rates, pup production, condition, abundance, movements among subpopulations, and incidence and causes of injury or mortality of Hawaiian monk seals; (2) diagnose disease, monitor exposure to disease, and develop normal baseline hematology and biochemistry parameters in monk seals; (3) conduct activities to increase the survival of monk seals; (4) investigate foraging ecology to determine foraging locations of monk seals, variables related to the diving behavior, characteristics of foraging substrate, and prey identification and foraging behaviors; and (5) enhance the survival of weaned pups and juveniles using de-worming agents. A complete description of those earlier activities appears in Appendix A of this Opinion.

The Permits Division's proposed permit amendment would authorize the Marine Mammal Research Program to administer to certain Hawaiian monk seals the broad-spectrum nematodicide ivermectin (injectable) in place of the currently authorized broad-spectrum nematodicide fenbendazole (oral).

De-worming study

Seals included in this study are weaned pups at least 120 days post-weaning and juveniles aged 1 to 2 years. Seals are identified during standard ground surveys and their health status and body conditions are assessed by visual inspection and examination of digital photos. Emaciated seals too compromised to treat without high risk of mortality are excluded. Seals of these ages are randomly assigned to a treatment or control group, or alternated systematically, with the goal to have equal numbers in each group, matched in age, sex, body condition, and location.

All study subjects are captured by hand and net, feces collected for subsequent determination of parasite burden/presence (voided feces or fecal sample collected via fecal loop or digital extraction; stored in 10 % formalin), measured and weighed, flipper tagged if necessary, and given an intramuscular dose of praziquantal at 5 mg/kg and an oral dose of fenbendazole (Panacur) at 10mg/kg, and released. The proposed amendment would replace the use of oral fenbendazole with a subcutaneous injection of ivermectin (dose of 0.2 mg/kg).

Blubber depth measurements using a SonoSite portable imaging ultrasound (SonoSite, Bothell, WA) would be collected by applying light pressure to the skin to obtain images along the lateral side and dorsum of the animal. Images would be collected in wild seals from both the de-wormed and control.

Control seals are handled exactly as the dosed seals minus the drug administration. No sedation is used for treatment or control seals. Seals are also handled for a follow up assessment (sampling and weighing) approximately 4 weeks post-dosing. Seals are treated at intervals of spring, summer, autumn, and winter.

Post treatment body condition and fecal egg counts are determined by observing the seals, collecting scat from known individuals during MMRP monitoring patrols, and capturing and weighing seals. Parasite load is determined from fecal egg count data, treated as a categorical covariate. Visual assessment of condition is recorded on an ongoing basis throughout the study, using standard MMRP subjective body condition scoring and feces would be preserved for detection of parasites. Subsequent survival is determined through visual re-identification during population assessment field research, supplemented by observations made during additional field sessions.

Permit conditions

The proposed permit lists general and special conditions to be followed as part of the proposed research activities. These conditions are intended to minimize the potential adverse effects of the research activities on targeted Hawaiian monk seals and include the following that are relevant to the proposed permit:

- Researchers would suspend permitted activities in the event of serious injury or mortality of a protected species other than that specifically authorized or if authorized take is exceeded. The Permit Holder would contact the Chief of the Permits Division by phone within two business days and submit a written incident report within two weeks. Research may recommence upon review of that information and authorization by the Chief of the Permits Division.
- All research activities must be suspended if annual reports are not received by the Permits Division by March 31 of each year for which the permit is valid, beginning in 2010. If research is suspended, authorization to resume permitted activities requires written permission from the Permits Division following receipt and evaluation of the annual report. Reauthorization of this permit may be denied or delayed if the annual report has not been received or approved. This report must describe activities conducted from January 1 to December 31 of the prior year, including:
    - unforeseen problems/effects on individuals and in general
    - measures to mitigate and enhance the effectiveness of permitted activities
    - circumstances under which individuals were killed or injured and their disposition
    - physical condition of individuals taken
    - effects of permitted activities on individuals
    - coordination of activities with other permit holders
    - preliminary findings
    - listing and copies of reports/publications resulting from permitted activities or approximate time when they would be available
    - non-permitted species caught, harassed, or otherwise taken and the effects of such taking

- incidental (non-research related) use of photographs, film, or other images (e.g., on websites, in commercial publications or documentaries)
- any additional findings, results, or information

- In addition, a final report would be submitted within 180 days of permit expiration to the Permits Division and would summarize similar information as previously described over the duration of the permit.
- In the event a seal(s) dies, is seriously injured, or experiences health problems during the translocation process, a written incident report would be submitted.
- To minimize impacts of disturbance during research and enhancement activities, researchers would minimize the total time on the beach or haul out; do not retrieve carcasses or samples if other seals are in the immediate vicinity; move carcasses to a secure area during necropsies to avoid disturbance to seals; and only target animals when no other individual seals are in the immediate vicinity, particularly mother/pup pairs.
- To minimize impacts of capture, handling, sedation, transport, tagging, bleach marking, and sampling activities, researchers would use biologists experienced in capture techniques to complete the activities as quickly as possible, monitor seal's responsiveness, and immediately terminate efforts to handle a particular animal if there was any evidence that the activity might be life-threatening or interfering with the animals' vital functions including but not limited to, a seal showing signs of acute stress or protracted alarm reaction (*e.g.*, abnormal respiration or heart rate, diminished eye responsiveness, muscle tremors/spasms) that may lead to serious injury, capture myopathy, other disease conditions, or death. In the event of an adverse reaction during handling, emergency procedures would be initiated as determined by and under the advice of an on-site veterinarian. Only personnel highly experienced or trained in the use of veterinary techniques would perform intrusive procedures (including tagging, blood sampling, biopsy sampling, etc.).
- Researchers would use sterile disposable needles, biopsy punches, etc. to the maximum extent possible (always use disposable needles for blood sampling and injections of drugs or other approved substances). Researchers would thoroughly disinfect (with a bactericidal/virucidal agent) all biopsy punches, etc. between animals and immediately prior to each use. No antibiotics would be administered to wild seals.
- No lactating females with pups would be handled or restrained for any purpose. However, in the rare event a pup is orphaned as a result of any authorized activities authorized, the orphaned pup would be humanely provided for (i.e. salvaged [placed in a stranding facility for rehabilitation and eventual release], or if salvage is not possible, humanely euthanized). Pups that are euthanized would count against the total number of animals authorized for accidental mortality.

- Researchers would conduct post-handling monitoring of seals for signs of stress and recovery. Researchers would also monitor haul outs following any disturbance to determine if any pups have been injured or abandoned. Any observed serious injury to, death, or abandonment of a pup would be recorded and counted against the total takes allowed.
- Caution would be exercised to minimize disturbance when approaching all seals at any time, particularly mother/pup pairs, and an approach or research or enhancement activity would be stopped if there is any evidence that the activity may be interfering with the mother/pup behavior, nursing, or other vital functions of any animal.
- For the de-worming trial, upon completing the first few de-worming treatments using injectable ivermectin and praziquantel (i.e., six seals treated or three weeks into trial, whichever occurs first), the Permit Holder must provide the following information to the Permits Division: a description of how the treatments proceeded; any logistical problems encountered; observed short-term effects of administering the drugs (immediately after and up to 48 hours post-treatment) such as signs of lethargy, vomiting, diarrhea, etc.; any follow-up observations made within two weeks after treatments; and any observed impacts to non-target species. This may be in the form of field notes or other informal documentation.
- No inter-island/atoll translocation and/or temporary captivity of pup or juvenile monk seals would occur until prior approval is received from the Office of Protected Resources, Permits, Conservation, and Education Division.
- The following are conditions for monk seal researchers working in Northwest Hawaiian Islands National Wildlife Refuge (NWR) from the USFWS Pacific Remote Islands NWR Complex:
  - Walking is prohibited on all beaches, from dusk to dawn, where adult turtles rest.
  - All field camps must use maximum light control (shading, minimum wattage, etc.). All field camps must avoid disorienting hatchling turtles.
- Researchers must comply with the following conditions related to methods of captive care and transportation:
  - Hawaiian monk seals would be maintained in captivity and transported in compliance with the provisions of the Animal Welfare Act (AWA) and AWA implementing regulations "Specifications for the Humane Handling, Care, Treatment, and Transportation of Marine Mammals" (9 CFR Part 3, Subpart E)
  - Satisfactory measures and contingency plans would be in place to prevent escape from temporary pens (*e.g.*, during extreme weather events) and to respond to escape (*e.g.*, search surveys, health assessment upon recapture)
  - An emergency kit would accompany animals during transport in the event an animal is injured or otherwise needs medical treatment

Approach to the assessment

The NMFS approaches its Section 7 analyses of agency actions through a series of steps. The first step identifies those aspects of proposed actions that are likely to have direct and indirect physical, chemical, and biotic effects on listed species or on the physical, chemical, and biotic environment of an action area. As part of this step, we identify the spatial extent of these direct and indirect effects, including changes in that spatial extent over time. The result of this step includes defining the *Action area* for the consultation. The second step of our analyses identifies the listed resources that are likely to co-occur with these effects in space and time and the nature of that co-occurrence (these represent our *Exposure analyses*). In this step of our analyses, we try to identify the number, age (or life stage), and gender of the individuals that are likely to be exposed to an action's effects and the populations or subpopulations those individuals represent. Once we identify which listed resources are likely to be exposed to an action's effects and the nature of that exposure, we examine the scientific and commercial data available to determine whether and how those listed resources are likely to respond given their exposure (these represent our *Response analyses*).

The final steps of our analyses – establishing the risks those responses pose to listed resources – are different for listed species and designated critical habitat (these represent our *Risk analyses*). Our jeopardy determinations must be based on an action's effects on the continued existence of threatened or endangered species as those "species" have been listed, which can include true biological species, subspecies, or distinct population segments of vertebrate species. The continued existence of these "species" depends on the fate of the populations that comprise them. Similarly, the continued existence of populations are determined by the fate of the individuals that comprise them – populations grow or decline as the individuals that comprise the population live, die, grow, mature, migrate, and reproduce (or fail to do so).

Our risk analyses reflect these relationships between listed species, the populations that comprise that species, and the individuals that comprise those populations. Our risk analyses begin by identifying the probable risks actions pose to listed individuals that are likely to be exposed to an action's effects. Our analyses then integrate those individual risks to identify consequences to the populations those individuals represent. Our analyses conclude by determining the consequences of those population-level risks to the species those populations comprise.

We measure risks to listed individuals using the individual's "fitness," or the individual's growth, survival, annual reproductive success, and lifetime reproductive success. In particular, we examine the scientific and commercial data available to determine if an individual's probable lethal, sub-lethal, or behavioral responses to an action's effect on the environment (which we identify during our *Response analyses*) are likely to have consequences for the individual's fitness.

When individual listed plants or animals are expected to experience reductions in fitness in response to an action, those fitness reductions are likely to reduce the abundance, reproduction, or growth rates (or increase the variance in these measures) of the populations those individuals represent (see Stearns 1992). Reductions in at least one of these variables (or one of the variables we derive from them) is a necessary condition for

reductions in a population's viability, which is itself a necessary condition for reductions in a species' viability. As a result, when listed plants or animals exposed to an action's effects are not expected to experience reductions in fitness, we would not expect the action to have adverse consequences on the viability of the populations those individuals represent or the species those populations comprise (e.g., Brandon 1978, Mills and Beatty 1979, Stearns 1992, Anderson 2000). As a result, if we conclude that listed plants or animals are not likely to experience reductions in their fitness, we would conclude our assessment.

Although reductions in fitness of individuals is a necessary condition for reductions in a population's viability, reducing the fitness of individuals in a population is not always sufficient to reduce the viability of the population(s) those individuals represent. Therefore, if we conclude that listed plants or animals are likely to experience reductions in their fitness, we determine whether those fitness reductions are likely to reduce the viability of the populations the individuals represent (measured using changes in the populations' abundance, reproduction, spatial structure and connectivity, growth rates, variance in these measures, or measures of extinction risk). In this step of our analysis, we use the population's base condition (established in the *Environmental baseline* and *Status of listed resources* sections of this Opinion) as our point of reference. If we conclude that reductions in individual fitness are not likely to reduce the viability of the populations those individuals represent, we would conclude our assessment.

Reducing the viability of a population is not always sufficient to reduce the viability of the species those populations comprise. Therefore, in the final step of our analyses, we determine if reductions in a population's viability are likely to reduce the viability of the species those populations comprise using changes in a species' reproduction, numbers, distribution, estimates of extinction risk, or probability of being conserved. In this step of our analyses, we use the species' status (established in the *Status of listed resources* section of this Opinion) as our point of reference. Our final determinations are based on whether threatened or endangered species are likely to experience reductions in their viability and whether such reductions are likely to be appreciable.

To conduct these analyses, we rely on all of the evidence available to us. This evidence consists of

- monitoring reports submitted by past and present permit holders
- reports from the NMFS Science Centers
- reports prepared by natural resource agencies in States and other countries
- reports from non-governmental organizations involved in marine conservation issues
- the information provided by the NMFS Permits Division when it initiates formal consultation
- the general scientific literature

We supplement this evidence with reports and other documents – environmental assessments, environmental impact statements, and monitoring reports – prepared by other federal and state agencies.

During the consultation, we conducted electronic searches of the general scientific literature. We supplemented these searches with electronic searches of doctoral

dissertations and master's theses. These searches specifically tried to identify data or other information that supports a particular conclusion as well as data that do not support that conclusion. When data were equivocal or when faced with substantial uncertainty, our decisions are designed to avoid the risks of incorrectly concluding that an action would not have an adverse effect on listed species when, in fact, such adverse effects are likely (i.e., Type II error).

Action Area

Research would occur in the North Pacific Ocean on and along islands of the Hawaiian Archipelago, most likely Northwestern Hawaiian Islands, but possibly in the main Hawaiian Islands and Johnston Atoll. Past de-worming trials have been conducted on Laysan Atoll.

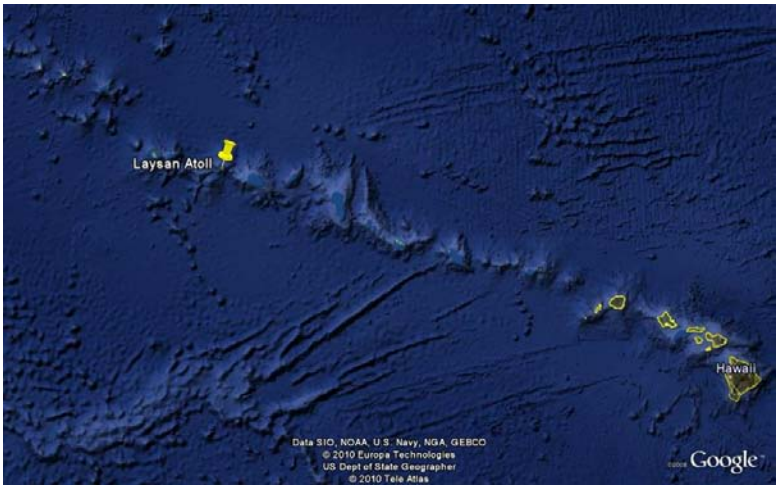

Figure 1. Hawaiian Archipelago.

Status of listed resources

NMFS has concluded that the actions being considered in this biological opinion *may affect* the following species and critical habitat, under NMFS' jurisdiction, that are protected under the Endangered Species Act of 1973 (16 U.S.C. 1531 et seq.; ESA):

Hawaiian monk seal	*Monachus schauinslandi*	Endangered
Blue whale	*Balaenoptera musculus*	Endangered
Fin whale	*Balaenoptera physalus*	Endangered
Gray whale (Western Pacific population)	*Eschrichtius robustus*	Endangered
Humpback whales	*Megaptera novaeangliae*	Endangered
North Pacific right whale	*Eubalaena japonica*	Endangered
Sei whale	*Balaenoptera borealis*	Endangered
Sperm whale	*Physeter macrocephalus*	Endangered
Green sea turtle	*Chelonia mydas*	Threatened Endangered
Leatherback sea turtle	*Dermochelys coriacea*	Endangered
Loggerhead sea turtle	*Caretta caretta*	Threatened
Olive ridley sea turtle	*Lepidochelys olivacea*	Threatened Endangered

In addition to these species, critical habitat that has been designated for Hawaiian monk seals also occurs in the action area. In May 1988, NMFS designated critical habitat for the Hawaiian monk seal out from shore to 20 fathoms in 10 areas of the northwestern Hawaiian Islands. Critical habitat for monk seals includes all beach areas, sand spits and islets, including all beach crest vegetation to its deepest extent inland, lagoon waters, inner reef waters, and ocean waters out to a depth of 20 fathoms around the following: Kure Atoll, Midway Islands, except Sand Island and its harbor, Lisianski Island, Laysan Island, Maro Reef, Gardner Pinnacles, French Frigate Shoals, Necker Island, and Nihoa Island (50 CFR 226.201).

Species not considered further in this opinion

To refine the scope of this Opinion, NMFS used two criteria (risk factors) to determine whether any endangered or threatened species or critical habitat are not likely to be adversely affected by vessel traffic, aircraft traffic, or human disturbance associated with the proposed actions. The first criterion was *exposure*: if we conclude that particular endangered or threatened species or designated critical habitat are not likely to be exposed to vessel traffic, aircraft traffic, or human disturbance, we must also conclude that those listed species or designated critical habitat are not likely to be adversely affected by the proposed action. The second criterion is *susceptibility* upon exposure: species or critical habitat may be exposed to vessel traffic, aircraft traffic, or human disturbance, but may not be unaffected by those activities—either because of the circumstances associated with the exposure or the intensity of the exposure-- are also not likely to be adversely affected by the vessel traffic, aircraft traffic, or human disturbance. This section summarizes the results of our evaluations.

Blue, fin, gray (Western population), humpback, North Pacific right, sei, and sperm whales as well as green, leatherback, loggerhead, and olive ridley sea turtles also occur in the action area. If the investigators encounter the whale species by boat, they would maintain a distance of 300 feet to eliminate the probability of adversely affecting the species; we would not expect endangered or threatened sea turtles to be adversely affected by small vessel traffic. Because of these mitigation measures, we conclude that the proposed action may affect but is not likely to adversely affect these species, so they will not be considered further in this Opinion.

Status of species considered in this opinion

The species narrative that follow focus on attributes of life history and distribution that influence the manner and likelihood that these species may be exposed to the proposed action, as well as the potential response and risk when exposure occurs. Consequently, the species' narrative is a summary of a larger body of information on localized movements, population structure, feeding, diving, and social behaviors. Summaries of the status and trends of the listed Hawaiian monk seal is presented to provide a foundation for the analysis of the species as a whole. We also provide a brief summary of the species' status and trends as a point of reference for the jeopardy determination, made later in this Opinion. That is, we rely on a species' status and trend to determine whether an action's direct or indirect effects are likely to increase the species' probability of becoming extinct. Similarly, the species narrative is followed by a description of its

critical habitat with particular emphasis on any essential features of the habitat that may be exposed to the proposed action and may warrant special attention.

Biogeography of Hawaiian Monk Seals

Hawaiian monk seals are found primarily in the Northwest Hawaiian Islands, which extend more than 2,000 km miles northwest of the Main Hawaiian Islands. Major breeding subpopulations occur at French Frigate Shoals, Laysan Island, Lisianski Island, Pearl and Hermes Reef, Midway Atoll, and Kure Atoll (Carretta *et al.* 2001). Smaller groups are found at Nihoa and Necker Islands, seals have been observed at Gardner Pinnacles, Maro Reef, and Johnston Atoll, and several dozen seals are distributed throughout Main Hawaiian Islands (Carretta *et al.* 2001, NMFS 2007b). Midway was an important breeding rookery at one time, but is no longer used (Reeves et al. 1992). However, all Hawaiian monk seals represent a single population. Reported sightings on each of the eight Main Hawaiian Islands have become increasingly common, and births have been reported on all of the Main Hawaiian Islands except Lanai and Hawaii.

Sightings of Hawaiian monk seals have occurred on at least three occasions at the remote Pacific location of Johnston Atoll (excluding nine adult males relocated there from Laysan Island in 1984).

Habitat and feeding

Virtually all terrestrial substrates, including emergent reefs and shipwrecks, are used by monk seals. Sandy beaches with shallow protected water near shore are the primary haul-out areas, for pupping, nursing, and resting, although pups are born on a variety of substrates (Gilmartin 1983). Seals use vegetation behind beaches as shelter from wind and rain.

Pinniped movements are generally based on foraging. Oceanographic features, such as thermal changes that might concentrate prey densities, can affect individual seal foraging behavior (Field *et al.* 2001). Hawaiian monk seal distribution, destinations, routes, food sources, and causes of movements when not traveling between islands are not well known. Approximately 10-15% of Hawaiian monk seals migrate among the breeding populations (Johnson and Kridler 1983). Inter-island movement appears to be more likely when the islands are close together. For example, movement between Kure Atoll, Midway Atoll, Pearl and Hermes Reef appear to be fairly common, while movement between French Frigate Shoals and Kure Atoll (a distance of 2,000 km) is not known to occur. The western subpopulations (Pearl and Hermes Reef, Midway Islands, and Kure Atoll) exhibit a higher degree of migration compared to the more isolated subpopulations at Laysan, Lisianski, and French Frigate Shoals (NMFS 2007b; Table 1).

At the breeding islands, monk seals feed on octopus, spiny lobster, eels, and bottom-dwelling and reef fish (Gilmartin 1983; Goodman-Lowe 1998; Rice 1960). Considered foraging generalists, monk seals exhibit significant differences in diet between islands, age, and sex groups (NMFS 2007b). No research or monitoring effort has been identified that will effectively measure or index monk seal prey abundance at the major breeding atolls (NMFS 2007b).

Monk seals forage within the barrier reefs of the atolls and on the leeward slopes of reefs and islands, as well as nearby seamounts and submerged reefs and banks (Littnan et al. 2006). Several recent studies of the foraging patterns of Hawaiian monk seals near rookeries in the Northwest Hawaiian Islands provide insight into their diving behavior. Dive depths appear to differ slightly between rookeries as well as between age and sex classes. Stewart *et al.* (2006) found that throughout the six Northwest Hawaiian Islands breeding colonies, most dives were less than 150 meters, but found some dives exceeding 550 meters. At Pearl and Hermes Reef, most dives reach 8-40 meters, with some dives to three- to four-fold greater depths (Stewart 2004). At Kure Atoll, males tended to dive deeper than females (Stewart and Yochem 2004a). However, at Laysan Island, this trend was reversed and dives were much deeper (800 to 1,150 feet; Stewart and Yochem 2004b). Most dives at French Frigate Shoals were to depths of 4-40 meters, but some dives exceeded 500 meters (Abernathy 1999). Parrish *et al.* (2002) noted a tendency towards night diving at French Frigate Shoals.

Table 1. Migration rates per Hawaiian monk seal among subpopulations per year. Data are from 1995-2008, excluding translocations (NMFS 2007b).

From/To	Nihoa	Necker	FFS	Laysan	Lisianski	PHR	Midway	Kure
Nihoa	0.7727	0	0.2273	0	0	0	0	0
Necker	0	0.4259	0.5741	0	0	0	0	0
FFS	0.0027	0.0065	0.9888	0.0019	0	0	0	0
Laysan	0	0	0.0043	0.9610	0.0334	0.0013	0	0
Lisianski	0	0	0.0011	0.0484	0.9434	0.0057	0.0007	0.0007
PHR	0	0	0.0004	0.003	0.0082	0.9450	0.0305	0.0130
Midway	0	0	0	0.0013	0	0.0707	0.7639	0.1641
Kure	0	0	0	0	0.0011	0.0168	0.0786	0.9035

Hawaiian monk seals tend to dive within the water column, rather than to the sea floor, regardless of site (Littnan et al. 2006). Some work using Crittercams on seals at French Frigate Shoals indicates that most time spent underwater was for resting and socializing, not feeding. Despite the reef fishes of the coral shallows, adult seals forage on the slopes of the atoll and neighboring banks (Parrish et al. 2000). This is corroborated by the comparison between the diet composition of tagged seals and the composition of fish in each of four ecological zones (defined by depth) (Parrish and Abernathy 2006). Foraging has been shown to vary by age, with older juveniles (years 2 and 3) focusing on shallow atoll depths (10-30 meters) and yearlings feeding in sand fields at 50-100 meters. It is possible that the shift in foraging behavior with age is dependent on the physical strength to flip small rocks to find prey, rather than increasing dive duration or depth (Parrish *et al.* 2005).

Reproduction

Hawaiian monk seals do not form breeding colonies or harems (Johanos *et al.* 1994; Kenyon and Rice 1959). Mating, which occurs in water and is rarely observed, is inferred from male-female association patterns and from mounting injuries (Johanos *et al.* 1994). Breeding is asynchronous, lasting from February through September (Johanos *et al.* 1994). In recent years, fewer than 200 individuals are born annually (NMFS 2007b).

Females typically give birth for the first time between ages of 5 and 10 (Antonelis *et al.* 2006). Pupping patterns vary greatly and not all females give birth in consecutive years (Johanos *et al.* 1994; Kenyon and Rice 1959). Females that do give birth in consecutive years pup later each season, while females that skip a year or more give birth earlier the

next season. The mean interval for births in consecutive years was found to be 381 days (Johanos *et al.* 1994). Birth rates vary depending on breeding location and year, with approximately 30-70% of all adult females giving birth in any given year (Harting et al. 2007)(Johanos *et al.* 1994; Ragen and Lavigne 1999). Females give birth from February to August, peaking in late March/early April (Johanos *et al.* 1994), although pupping has been recorded year round. They prefer to give birth on beaches near shallow water and coral reefs surrounding the area, apparently to afford protection to the pup (Westlake and Gilmartin 1990).

Newborn pups weigh 16-17 kg and measure 95-100 cm long (Kenyon and Rice 1959). Pups are black at birth and undergo a post-natal molt late in the nursing period. Nursing lasts, on average, 39 days (Johanos *et al.* 1994), during which time the mother remains constantly near her pup in and out of water (Kenyon and Rice 1959). The mother does not eat during nursing and rapidly loses weight (Gerrodette and DeMaster 1990). After weaning, the pup is abandoned to live off of fat stores until it learns to feed on its own, while the mother swims offshore to feed (Gerrodette and Gilmartin 1990; Johnson and Johnson 1984; Kenyon and Rice 1959; Wirtz 1968). At weaning, pups normally weigh between 43-73 kg (Kenyon and Rice 1959). Rice (1964) suggested that adult females weigh approximately 205 kg and are about 2.3 m long, and the average adult male is smaller, at about 170 kg and 2.1 m.

Although nursing monk seal mothers generally avoid other adult seals, occasional pup switches do occur (Johnson and Johnson 1978, Boness 1990), and mothers sometimes foster a pup if her own is lost (Alcorn and Henderson 1984, Gerrodette *et al.* 1992). If switched pups are of similar size, survival for the first year is minimally affected; however if a larger pup switches with a small one, the larger pup will have a longer nursing period and the smaller pup's probability of survival will be reduced (NMFS 2007b).

Threats to the Species

Natural threats. Hawaiian monk seals appear to be threatened by the spread of infectious diseases, including leptospirosis, toxoplasmosis, and West Nile virus, although domestic animals and humans may be vectors for these diseases (which would make them anthropogenic rather than natural threats). The absence of antibodies to these diseases in monk seals would make them extremely vulnerable to potential infection.

Biotoxins such as ciguatera can cause mortality in phocids, but its role in mortality of monk seals was implicated and not confirmed, remaining unclear due to the lack of assays for testing tissues and the lack of epidemiological data on the distribution of toxin in monk seal prey.

The primary cause of adult female mortality affecting the recovery potential in the monk seal population during the 1980s and early 1990s was injury and death of female monk seals caused by "mobbing" attacks initiated by male monk seals. Although NMFS has developed and implemented measures to mitigate the effects of mobbing attacks, they are still considered a serious threat to Hawaiian monk seals. In recent years, low juvenile survival, in part due to food limitation, has been evident at all subpopulations of Hawaiian monk seals in the Northwest Hawaiian Islands.

Monk seals, particularly pups, are also subjected to extensive predation by sharks predation, which appears to be a particular problem for the monk seals occupying French Frigate Shoals in the Northwest Hawaiian Islands. Sharks are known to injure and kill Hawaiian monk seals, and monk seal remains have been found in the stomachs of tiger sharks and Galapagos sharks.

Anthropogenic threats. Several human activities are known to threaten Hawaiian monk seals: commercial and subsistence hunting, intentional harassment, competition with commercial fisheries, entanglement in fishing gear, habitat destruction on breeding beaches, pollution, and unintentional human disturbance (Kenyon 1981, Riedman 1990, Reeves *et al.* 1992).

Marine debris and derelict fishing gear have been well documented to entangle monk seals, and monk seals have one of the highest documented entanglement rates of any pinniped species. Marine debris and derelict fishing gear continue to affect the Northwest Hawaiian Islands. The number of monk seals found entangled has not changed nor has the rate at which marine debris accumulates in the Northwest Hawaiian Islands declined.

Establishment of a 20-person U.S. Coast Guard long-range navigation station at Kure Atoll in 1960 resulted in a significant disturbance of the seal population on Green Island beaches caused by the residents and their dogs and vehicles (Johnson et al. 1982, Kenyon, 1972). After the station was established and occupied, counts of monk seals declined rapidly on Green Island (Gerrodette and Gilmartin 1990, Kenyon 1972). Kenyon (1972) attributed this decline to human disturbance, which caused adult females to abandon prime pupping habitat. Pup survival declined first (Wirtz, 1968), followed by a decline in recruitment of breeding females; these two phenomena combined to skew the age structure skewed of monk seals toward older animals (Johnson *et al*. 1982) and bias the sex ratio of adults toward males (Reddy and Griffith 1988). The number of monk seals born on this atoll declined steadily from the late 1970s to the mid 1980s; in 1986, only one pup was born on the atoll (Reddy 1989, Gerrodette and Gilmartin 1990).

Recovery actions. In June 2006, the Papahanaumokuakea Marine National Monument (71 FR 51134, August 29, 2006) was established in the Northwest Hawaiian Islands. The boundary of the Monument includes about 140,000 square miles of emergent and submerged lands and waters of the northwest Hawaiian Islands and regulating activities such as fishing that pose potential risks to the marine habitat of Hawaiian monk seals.

Status and Trends

The Hawaiian monk seal was listed as endangered under the ESA on November 23, 1976 (41 FR 51611). A recent five-year status review conducted by NMFS recommended that Hawaiian monk seals' should retain their classification as an endangered species (72 FR 46966, August 2007). Hawaiian monk seals are considered one of the most endangered groups of pinnipeds on the planet because all of their populations are either extinct (Caribbean monk seal) or close to extinction (Mediterranean and Hawaiian monk seals).

Two periods of anthropogenic decline have been reported; the first decline occurred in the 1800s when sealers, crews of wrecked vessels, and guano and feather hunters nearly hunted monk seals to extinction (Dill and Bryan 1912, Kenyon and Rice 1959).

Following the initial collapse, expeditions to the Northwest Hawaiian Islands reported increasing seal numbers and partial recovery to slightly more than 1,000 individuals (Bailey 1952, Rice 1960). However, a second decline occurred from the late 1950s to the mid-1970s; the population declined by roughly 50% by the 1980s (NMFS 1991). The total population in the French Frigate Shoals, Laysan Island, Lisianski Island, Pearl and Hermes Reef, Kure Atoll, and Midway, Necker, and Nihoa was estimated to be 1,501 in 1984, 1,976 seals in 1986, and 1,580 in 1992 (Ragen 1993). For the years 1985 to 1993 the mean beach counts declined by approximately 5% per year. This downward trend is expected to continue, mainly because of poor pup and juvenile survival in recent years.

The population dynamics at the different monk seal subpopulations have varied considerably, and current demographic variability among the island populations probably reflects a combination of different histories of human disturbance and management (Gerrodette and Gilmartin 1990, Ragen 1999), and varying environmental conditions (Baker *et al.* 2007; Baker and Thompson 2007; Craig and Ragen 1999; Polovina *et al.* 1994). The current status of the Hawaiian monk seal is dire, due to low juvenile survival and the number of aging breeding females in the population. Consequently, NMFS is currently exploring development of a captive care program for juvenile Hawaiian monk seals to enhance their potential for survival and recovery (NMFS 2007b).

The total of mean, non-pup, beach counts at the main reproductive subpopulations in 2005 was approximately 67% lower than in 1958 (Carretta et al. 2007). A log-linear regression of estimated abundance from 1998 (the first year for which a reliable total abundance estimate was obtained) to 2006 estimates that abundance declined by 3.9% annually (Fig. 2)(NMFS 2007b).

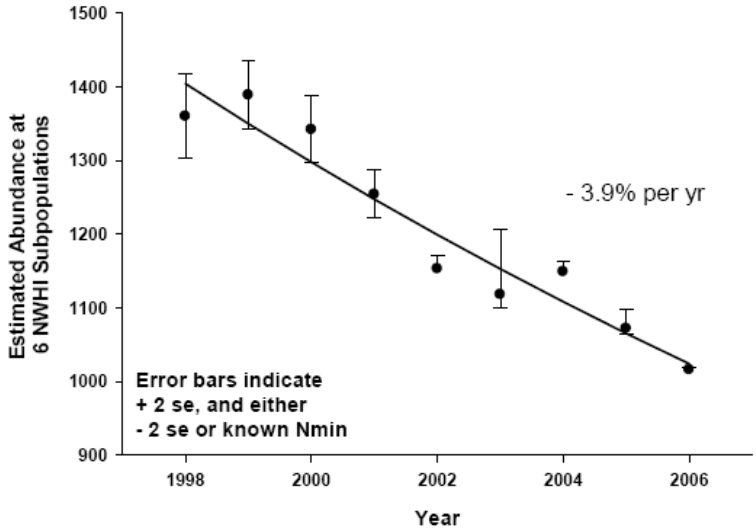

Figure 2. Trends in abundance of Hawaiian monk seals at the six main Northwest Hawaiian Islands subpopulations combined, 1998-2006. This graph does not include abundance estimates for Necker, Nihoa, or the Main Hawaiian Islands. Error bars indicate ±2 standard errors or known minimum abundance. The fitted trend line reveals an estimated decline of 3.9% (NMFS 2007b).

Trends vary among the six main subpopulations. Non-pup beach counts at French Frigate Shoals have decreased by 73% from 1989 to 2005 (Carretta et al. 2007). At one time, French Frigate Shoals accounted for over 50% of the total non-pup beach counts among

the Northwest Hawaiian Islands subpopulations; however, that proportion has dropped to 25%, although French Frigate Shoals still maintains the single largest subpopulation (NMFS 2007b). The annual number of births has dropped from a high of 127 in 1988 to 39 in 2006, and survival from weaning to age two has declined from a high near 90% in the mid-1980s to a low of 8% in 1997 (NMFS 2007b). Shark predation and prey availability are two potentially responsible factors.

Populations at Laysan and Lisianski Islands declined sharply after the late 1950s. In 1994, 21 adult male Hawaiian monk seals were relocated from Laysan Island to the Main Hawaiian Islands in an attempt to equalize the sex ratio at Laysan Island, and beach counts increased from 1995 to 2000, but have declined in the following years, while the Lisianski subpopulation has remained relatively stable, yet low, since the 1970s. Marine debris and low fecundity are factors that might contribute to the lack of subpopulation growth at Lisianski Island. And while the decline in abundance in Laysan may be related to female mortality caused by male aggression, juvenile survival is relatively good for most cohorts, and the lack of recovery on Laysan is not understood (NMFS 2007b).

Until recently, the three westernmost subpopulations, Kure, Midway and Pearl and Hermes Reef exhibited substantial growth. Beach counts on Kure increased 5% per year from 1983 to 2000, declined in 2000-2001, and are now slowly increasing. At Midway, beach counts increased from 1995 to 2000, and have since declined. The subpopulation at Pearl and Hermes Reef increased after the mid-1970s. Prior to 1999, beach count increases of up to 7% per year were observed. This is the highest estimate of the maximum net productivity rate observed for this species. Since 2000, low juvenile survival, thought to be due largely to food limitation, has been widespread with rare exceptions in the Northwest Hawaiian Islands, resulting in the population decline (Carretta et al. 2007), and several recent cohorts at the three westernmost sites indicate a drop in juvenile survival (NMFS 2007b).

The decrease in survival rates of immature animals, including a decline in survival from birth to weaning, and survival from weaning to age 2 years has contributed to a dramatically imbalanced age structure for all six of the main Northwest Hawaiian Islands subpopulations (Fig. 3) (NMFS 2007b, 2009c). Although studies show that the relationship between size of pups and first year survival vary between subpopulations and over time, site-specific analyses do support girth and year as predictors of first-year survival at each location. When conditions for survival are worse, the relationship between size and survival strengthens. The simplest explanation for this is food limitation (Baker 2008).

Sightings and births are increasing in the Main Hawaiian Islands, although systematic surveys were not conducted before 2000, and counts do not represent total abundance, as they do not account for seals in the water, and not every seal on land is detected. In 2000, the count in the Main Hawaiian Islands was 45 seals, and in 2001, 52 were counted. In 2005, the total number of unique seals identified was 77, based on non-systematic sightings. Annual births have increased since the mid-1990s. Although this could be a positive indication for the survival of the species, the increased chance of contraction of diseases such as leptospirosis and toxoplasmosis from wild and domestic animals, and increased interactions with humans, including fishermen, boaters, and divers raise

conservation concerns which do not apply to the Northwest Hawaiian Islands (NMFS 2007b).

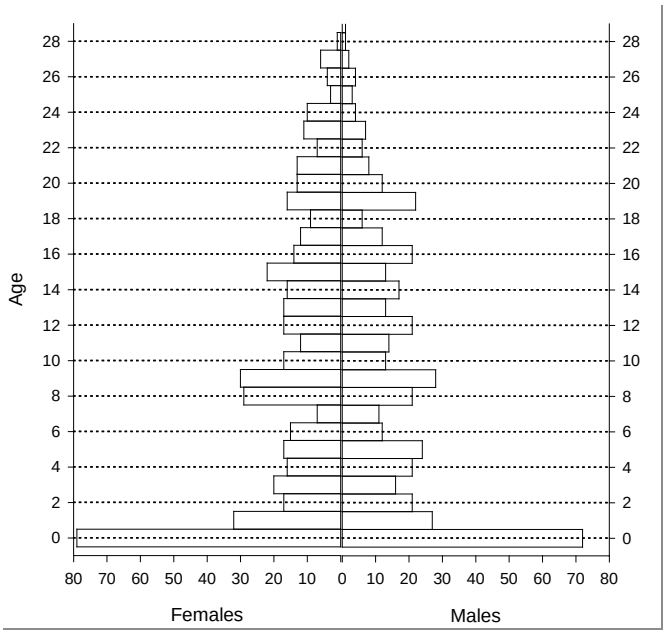

Figure 3. Age distribution for the Hawaiian monk seal population in the Northwest Hawaiian Islands (MMRP unpublished data in NMFS 2009c).

Hawaiian monk seal pups weaned in the Main Hawaiian Islands exhibit higher girths and lengths compared to pups from the Northwest Hawaiian Islands, as a result of pre- and post-partum maternal investment – a partial reflection of prey availability – contradicting the studies that indicate better foraging conditions in the Northwest Hawaiian Islands. Suggested explanations for this include a higher per capita availability of prey in the Main Hawaiian Islands, similar absolute preferred prey densities when apex predators are not included in the biomass, and increased prey availability due to reduced competition from apex predators (Baker and Johanos 2004).

The best estimate of the total population of Hawaiian monk seals is 1,202 seals and the minimum population size estimate for the Hawaiian monk seal is 1,176 seals (NMFS 2007b). Data collected in 2008 suggest that the species population is now 1,146 (NMFS 2009c). A log-linear regression of estimated abundance from 1998 to 2006 suggests the population has declined on average -3.9% per year, and models predict that the total population of the species will fall below 1,000 monk seals within 5 years (NMFS 2007b). Trends in abundance vary considerably among the six main subpopulations.

Critical Habitat

Critical habitat was originally designated on April 30, 1986 (51 FR 16047), and was extended on May 26, 1988 (53 FR 18988; CFR 226.201). The critical habitat includes all beach areas, sand spits and islets, including all beach crest vegetation to its deepest extent inland, lagoon waters, inner reef waters, and ocean waters out to a depth of 20 fathoms (37 m) around the following: Kure Atoll (28°24′ N, 178°20′ W), Midway Islands, except Sand Island and its harbor (28°14′ N, 177°22′ W), Pearl and Hermes Reef (27°55′ N, 175° W), Lisianski Island (26°46′ N, 173°58′ W), Laysan Island (25°46′ N, 171°44′ W),

Maro Reef (25°25′ N, 170°35′ W), Gardner Pinnacles (25°00′ N, 168°00′ W), French Frigate Shoals (23°45′ N, 166°00′ W), Necker Island (23°34′ N, 164°42′ W), Nihoa Island (23°03.5′ N, 161°55.5′ W). The marine component of this habitat was designated primarily as feeding areas for Hawaiian monk seals, while terrestrial habitat serves as pupping and nursing habitat for mothers and pups. Both components are currently under significant degradation pressure. Because the marine critical habitat is in the Papahānaumokuākea Marine National Monument, fishing is forbidden in the critical habitat. A result of this is the establishment of large predatory fishes (sharks and jacks) that compete with Hawaiian monk seals for prey resources. This may be a cause of seal malnourishment seen throughout many islands in the region.

Environmental Baseline

By regulation, environmental baselines for Opinions include the past and present impacts of all state, federal, or private actions and other human activities in the action area, the anticipated impacts of all proposed federal projects in the action area that have already undergone formal or early Section 7 consultation, and the impact of state or private actions that are contemporaneous with the consultation in process (50 CFR §402.02). The *Environmental baseline* for this Opinion includes the effects of several activities affecting the survival and recovery of ESA-listed whale, pinniped, and sea turtle species in the action area.

Malnutrition

In recent years, low juvenile survival (due partly to food limitation) has been evident in all Hawaiian monk seal subpopulations in the Northwest Hawaiian Islands. Recent declines have been associated with poor body condition, particularly amongst juvenile individuals (Parrish *et al.* 2008). Reduced body condition is evident in a time series of axillary girth and standard length measurements taken from juveniles and pups at most sites, where sizes were significantly smaller at French Frigate Shoals (where the subpopulation is in decline) compared to Laysan (Craig and Ragen 1999).

Overall, mean age-specific birth rates of Hawaiian monk seals are low compared to rates in some other phocid species (Bowen *et al.* 1981, Hammill and Gosselin 1995) under likely food-abundant conditions. During the late 1980s and through the 1990s, female harp seals appeared to undergo a reduction in pregnancy rate in response to food limited conditions (Bowen *et al.* 1981; Chabot *et al.* 1996; DFO (Department of Fisheries and Oceans) 2000; Sjare *et al.* 1996). Similarly, by analogy, the low birth rate in monk seals may be indicative of food limitation in adult females.

Interspecific competition may be a key to monk seal food limitation in the Northwest Hawaiian Islands. Here, 54% of the total fish biomass in the Northwest Hawaiian Islands is estimated to be apex predators (Friedlander and DeMartini 2002). Apex predators of the Northwest Hawaiian Islands are significantly larger and more abundant than in the Main Hawaiian Islands; some growing to sizes comparable to monk seals themselves (Friedlander and DeMartini 2002). It is likely that large sharks, jacks, and monk seals occupy a similar niche as monk seals, leading to direct competition for prey. Crittercam has documented sharks and jacks routinely competing for the same prey items on which monk seals attempt to feed. It has been hypothesized that increased competition for food

with jacks, gray snapper, and sharks may be involved, but studies of adult foraging show that when these predators associate with adult monk seals during foraging dives, monk seal foraging success actually increases (Parrish *et al.* 2008). It is unknown if this is also true of juveniles, who may not be as adept at out-competing predatory fish. Interspecific competition could be the most severe on young monk seals, whom are less capable of defending their catch against competitors and may be less proficient at locating profitable foraging habitat and capturing prey.

Although food limitation is likely a severe threat to Hawaiian monk seals in the Northwest Hawaiian Islands, individuals in the Main Hawaiian Islands appear to be doing well and appear not to be food limited (Baker and Johanos 2004). Main Hawaiian Islands pups wean at very large sizes (average girth and length exceeds the 95th percentile observed in the Northwest Hawaiian Islands), with good physical condition. This is despite the greater commercial and recreational fishing effort here. (Baker and Johanos 2004) postulated that the excellent condition of seals in the Main Hawaiian Islands may, in part, reflect the relative paucity of competing predators due to human take of sharks and jacks.

To compound reduced nutrition, monk seals host several gastrointestinal parasites, including tapeworms, nematodes, and an acanthocephalan (Dailey *et al.* 2004; Dailey *et al.* 1988; Rausch 1969). Although broader effects are unknown, stomach ulceration associated with nematode infection has been commonly reported (Whittow et al. 1980, NMFS-PIFSC 2008, NMFS 2009c). Treatment for parasites is hypothesized to increase survival probability, similar to Soay sheep during a period of high overall mortality (Gulland *et al.* 1993).

Predation

Shark predation is a natural phenomenon and is recognized as an important part of the ecosystem (Fig. 4). Nonetheless, shark predation is considered a threat because of the small number of remaining Hawaiian monk seals and previous declines in monk seal numbers. Sharks prey upon pups and subadults primarily, but may injure or kill individuals of any age (Alcorn and Kam 1986; Bertilsson-Friedman 2006). Injuries and scars from old shark bites can be seen on many monk seals and predation has been occasionally observed (Alcorn and Kam 1986; Balazs and Whittow 1979; Bertilsson-Friedman 2002; Hiruki *et al.* 1993; Johanos and Kam 1986; Taylor and Naftel 1978; Wirtz 1968). Historically, attacks were believed to be from tiger sharks, but recent observation support Galapagos sharks to also be significant predators, particularly at French Frigate Shoals (Bertilsson-Friedman 2006). Female pups appear to be preyed upon more frequently than male pups (Bertilsson-Friedman 2006). Male juveniles are more frequently attacked than females of this age class (Bertilsson-Friedman 2006). Pups tend to sustain more severe injuries than other age classes (Bertilsson-Friedman 2006).

Predation is most apparent at the location of highest monk seal abundance, French Frigate Shoals (Bertilsson-Friedman 2006). Bertilsson-Friedman (2002), found predation-related injuries to be more common at French Frigate Shoals than at either Laysan or Lisianski. In recent years, there has been a marked increase in shark predation upon pups born here (Hawn 2000; Hayes 2002; NMFS 2003; NMFS 2004; NMFS 2005). Within French Frigate Shoals, the number of known or suspected predation mortalities peaked in 1997-

1999, with 18-28 probable mortalities each year at Trig and Whaleskate Islands. Predation declined thereafter, with <10 possible mortalities in each of the last 5 years. Atoll-wide, the number of known or suspected mortalities has been generally stable during the last 5 years, with 8-12 losses annually (15-21% of French Frigate Shoals recruitment). Predation on 2008 pups reflects continued high mortality from predation at French Frigate Shoals, with eight known mortality events to pups out of 41 pups born (three additional pup losses could not determined; (NOAA 2009a). Monk seal density appears to be tied to predation at French Frigate Shoals, as predation rates rose whenever the number of pup-mother pairs exceeded 14 at Trig Island (NOAA 2009a). Currently, predation on nursing pups appears to be limited to French Frigate Shoals (NMFS, unpublished data). However, predation is not limited to French Frigate Shoals. In 2002, nine shark attacks were recorded from Midway, two from Kure, and zero from Pearl and Hermes Reef (Baker and Johanos 2004).

In attempts to reduce predation, 12 sharks were killed at Trig Island from 2000-2006. As a likely result, pup mortality from sharks dropped in all these years (from 28 in 1997 of all age classes to three in 2003). Mitigation of shark predation also included "hazing" sharks away and lethal removal in 2000-2001, when six Galapagos sharks attempting to prey on pups were removed by hook and line. However, efforts were only temporarily successful. In 2002-2003, hazing was discontinued because sharks became wary and difficult to catch although four Galapagos sharks were removed by hook and line and harpoon. In 2003, predation on pre-weaned pups increased at other sites within French Frigate Shoals atoll. This was because of concern that concentrating the hazing and removal activities at one location in the atoll had displaced sharks to other locations. Trig Island now accounts for a smaller proportion of annual atoll-wide shark predation.

Figure 4. Hawaiian monk seals and sharks in the Northwest Hawaiian Islands.

Starting in 2008, a program of shark deterrents was established at French Frigate Shoals. This program has expanded in 2009 and includes visual, acoustic, magnetic, and electromagnetic stimuli to keep sharks away from pupping areas (NOAA 2009a). Expanded research also includes tagging of sharks exhibiting predatory behavior towards pups to track which individual sharks are engaged in predation and what areas they frequent. Lethal removal of up to 15 Galapagos sharks will also occur (NOAA 2009b).

Disease

Hawaiian monk seals, like other marine mammals, can become ill or die from several diseases (Aguirre et al. 2007). Epidemiological studies have not shown significant differences in presence of diseases and infectious disease is not currently a significant cause of overall mortality (Aguirre 2000; Aguirre *et al.* 2007; Banish and Gilmartin 1992; Reif *et al.* 2004). However, toxoplasmosis has been identified as the cause of death in two adult seals (Dubey *et al.* 2004; Honnold *et al.* 2005; (NMFS 2007b). A novel herpesvirus isolate has been identified from captive and wild monk seals as a possible cause of eye disease in rehabilitated seals (Goldstein *et al.* 2006).

To date no epidemics of infectious diseases have been identified. However, there have been three events during which mortality or reproductive failure raised concern over the potential role of disease. These include a die-off of at least 50 seals on Laysan Island in 1978, a cluster of four aborted fetuses on Laysan Island in 2000, and a die-off of at least 11 seals throughout the Northwest Hawaiian Islands in 2001 (Gilmartin *et al.* 1980, Antonelis *et al.* 2001). In 2001, the discovery of four dead seals on Laysan Island within one week led to the declaration of an unusual mortality event.

Furthermore, several diseases of terrestrial vertebrates may be contracted through runoff, potentially increasing disease incidence above the rate for normally-occurring pathogens in the marine environment (Littnan et al. 2006). Infectious diseases known to cause morbidity in other Pacific pinnipeds include leptospirosis (California sea lions), tuberculosis (fur seals), phocine herpesvirus-1 (harbor seals) and *Otostrongylus circumlitis* (northern elephant seals; (Dunn *et al.* 2001, Kennedy-Stoskopf 2001).

Male aggression

The primary cause of adult female mortality affecting recovery potential in the monk seal population during the 1980s and early 1990s was frequent injury and death by multiple male aggression, or “mobbing” attacks (Banish and Gilmartin 1992; Carretta *et al.* 2006). Multiple-male aggression is thought to be related to an imbalance in adult sex ratios, with males outnumbering females. If not killed outright, a wounded female’s reproductive success in the year of injury drops.

In response to this threat to recovery, a group of ten adult males that had been observed attacking females, or whose behavior profile was similar to those that attacked females, were captured on Laysan in 1984 and transported to Johnston Atoll. One of the ten died prior to release, and of the remaining nine, most were not seen after a few months. Another group of five problem males was removed from Laysan and placed into permanent captivity in 1987.

To avoid removing individuals from the population, two other remediation methods were attempted in the 1990s. First, suppression of male aggression was attempted by suppressing testosterone initially in captive monk seals and then as a pilot field study (Atkinson and Gilmartin 1992; Atkinson *et al.* 1998). However, severe limitations, including expensive drugs and repeated disturbance through capture and injection led to cessation of this approach. In 1994, 22 problem males were collected at Laysan and relocated to the Main Hawaiian Islands to balance the Laysan Island adult population sex ratio. One died shortly after capture. However, a significant reduction in deaths due to

male aggression followed. In recent years, the sex ratio has become more balanced and was estimated at 1.2 males per female in 2003 (NMFS, unpublished data). Subsequently, problem males have not been identified as a significant, widespread source of injury or mortality for several years.

Males have not only been an important source of injury and mortality for females, but also for pups. At French Frigate Shoals in 1997, at least eight pups died as a result of adult male aggression (Carretta *et al.* 2006). Many more pups were likely killed in the same way, but the cause of their deaths could not be confirmed. Death typically occurred either from immediate drowning when pups are mounted in the water or from infections resulting from bite wounds. In 1991, two adult male seals were identified as being particularly aggressive towards weaned pups, exhibiting unique behaviors such as "lurking" in deep water areas near Trig Island. Upon appearance of a weaned pup, the males would violently and aggressively launch themselves out of the water, landing atop the pup. This was the only time that this behavior has been observed in wild monk seals, and these animals were removed.

Since the removal of 22 males in 1994 from Laysan Island, only five seals were thought to have died from multiple male aggression attacks (Carretta *et al.* 2006)). A few adult males at French Frigate Shoals were observed killing pups, of whom one was euthanized and two were translocated to Johnston Atoll (Carretta *et al.* 2006). In total, 40 adult male seals were either translocated (32 seals), placed in permanent captivity (five seals), died during translocation (two seals), or were euthanized (one seal). This removes individuals from the gene pool. However, as Hawaiian monk seals are polygynous with low genetic diversity, the loss of these males has little effect on the species as a whole. Male removal does reduce pup and female mortality, providing a sizeable benefit to the species.

Commercial and subsistence harvest

Seal hunters, crews of wrecked vessels, and guano and feather hunters hunted Hawaiian monk seals to near extinction in the late 1880s (Dill and Bryan 1912; Kenyon and Rice 1959; Ragen and Lavigne 1999). There is virtually no empirical information on the effect of this unregulated hunting pressure on Hawaiian monk seals, so the declines in their population have been inferred primarily from reports on where monk seals were not observed for several years (Ragen and Lavigne 1999). See *Status of Listed Resources* for available island-specific data.

Hawaiian monk seals appear to have increased in population size after hunting pressure reduced their densities to levels below thresholds where human disturbance and commercial exploitation were significant factors (Ragen and Lavigne 1999).

Genetic diversity

Commercial and subsistence hunting of Hawaiian monk seals is a significant cause of concern not only for numerical depletion of the species, but also as a major cause for loss of genetic diversity, and the small population size threatens the long-term maintenance of genetic diversity (Kretzmann *et al.* 1997; Schultz *et al.* 2009). As a species, Hawaiian monk seals have the lowest genetic diversity of any species thus far studied (Schultz *et al.* 2009). As individuals tend to return to specific nursing beaches, genetic diversity is further reduced and genetic abnormalities and inbreeding can become problematic to the

health of the species. Genotypic variation and differentiation amongst subpopulations are low some local inbreeding may be occurring (Kretzmann *et al.* 2001; Kretzmann *et al.* 1997). The isolated evolutionary history and recent human impacts to Hawaiian monk seals are likely sources for the extremely low genetic variation observed (Schultz *et al.* 2009).

Further, the small population size may be below a critical minimum population size, where a low birth rate limits the species ability to recover from disturbance. Hawaiian monk seals also have a highly variable reproductive and survival rates from year to year, which is a risk factor for extinction (demographic stochasticity). The age structure is also a concern, where adults outnumber juvenile and subadults. This likely means that, as adults die and no longer reproduce, a declining population trend ensues. Ragen and Lavigne (1999) found that Hawaiian monk seals compared similarly to a hypothetical "most endangered animal."

Ship strikes

At present, ship strikes of Hawaiian monk seals is believed to be extremely low or non-existent, primarily because most monk seal subpopulations are located in restricted waters far from heavily traveled waters. Although there is no published evidence that monk seals were struck by vessels, one seal was found in 1986 with a broken jaw and presumed propeller cuts on its belly. Another seal was found off Kona with an injured back and broken vertebrae. With the growth of the Main Hawaiian Islands subpopulation, the probability of ship strike is likely to increase.

The Main Hawaiian Islands serve as a major port for international shipping and naval operations. In 1987, approximately 20.3 billion kg of freight were handled through Hawaiian ports involving 21,325 vessel arrivals and departures from Hawaiian ports (Office of Naval Research 2001). Nine commercial harbors are regulated, including:

- Honolulu Harbor, Barbers Point Harbor, and Kewalo Basin (Oahu)
- Port Allen and Nawiliwili Harbors (Kauai)
- Kahului Harbor (Maui)
- Hilo and Kawaihae Harbors (Hawaii)
- Kaunakakai Harbor (Molokai)

Honolulu Harbor is the state's primary hub, with nearly all overseas waterborne traffic entering or leaving this harbor. It is also the focal point for inter-island cargo transportation (HDOT 2004).

Navigable waterways encircle each of the Main Hawaiian Islands and lead into and out of a number of the state's ports and commercial harbors. Transoceanic shipping lanes extend offshore from the region (primarily from Oahu and Kauai) north towards Alaska, northeast towards Washington, Oregon, and California, east towards the Panama Canal, southwest towards Guam and Wake Island; and northwest towards Japan and Okinawa.

Habitat degradation

Several factors currently threaten to curtail the quality or quantity of Hawaiian monk seal habitat, including human disturbance, toxins, contaminants, reef deterioration, and overfishing.

Hawaiian monk seals exhibit a “critical intolerance of humans” (Kenyon 1972). Human interactions with monk seals have ranged from unintentional disturbances at haul-out sites, to inflicting deliberate injuries on seals and killing them. Human disturbance can affect haul-out behavior, including causing seals to return to the water or decreasing attendance and nursing in mother and pup seals (Schneider and Payne 1983). Following an initial period of decline from expeditions to the Northwest Hawaiian Islands, a second period occurred from the late 1950s to the mid-1970s when beach counts declined 50% where military and U.S. Coast Guard operations occurred. Here, pregnant females abandoned preferred pupping sites and nursing females abandoned their pups (Kenyon 1972, Gerrodette and Gilmartin 1990). Even today, Hawaiian monk seals in the Northwest Hawaiian Islands avoid beaches where people have often disturbed them.

In the Main Hawaiian Islands, Hawaiian monk seals tend to distribute themselves in more remote areas where human disturbance is less likely (Baker and Johanos 2004). However, individual seals have become habituated to human presence and frequent beaches and other areas heavily used by humans. Recent successful monk seal pupping events have occurred on popular Main Hawaiian Islands beaches, in spite of documented instances of residents throwing coconuts at a resting seal and dogs biting beached monk seals.

As with many other marine mammals, organochlorines have been isolated from Hawaiian monk seals (Willcox 1999; Willcox *et al.* 2004; Ylitalo *et al.* 2008). Chemical species include DDT, DDE, and PCBs, with higher levels in males than in females. This is due to lactation and pregnancy transferring toxins to offspring in sexually mature females (Ylitalo *et al.* 2008). Once menopause is reached, toxins accumulate at equivalent rates in males and females. Toxins have been found in highest concentrations in animals breeding at Midway Atoll, and levels across all atolls are significant enough to potentially affect health (Ylitalo *et al.* 2008). In all contaminant studies of the wild monk seals to date, the OC levels were comparable to or lower than those reported in blubber of various pinnipeds from the Northeastern Pacific (Calambokidis *et al.* 2001; Krahn *et al.* 1997; Lee *et al.* 1996). However, these levels still exceed “safe” levels for marine mammals recommended by Kannan *et al.* (2000).

Ciguatoxin is a concern for Hawaiian monk seal health. It is produced by a benthic dinoflagellate common in coral reefs and eaten by herbivorous fish, which consume and concentrate the ciguatoxin and are then consumed by monk seals (Gollop and Pon 1992). In 1978, at least 50 monk seals died on Laysan Island, and high levels of ciguatoxin and maitotoxin, a similar neurotoxin, were detected by bioassay in their livers (Gilmartin *et al.* 1980). Natural levels of ciguatoxin fed to two captive northern elephant seals resulted in their deaths (2.5-9% of body weight per day; (DeLong 1979). The role of ciguatoxin in Hawaiian monk seal mortality is unclear due to the lack of assays testing.

Although vessel groundings do not present a direct threat to monk seals, groundings that damage coral reefs may adversely affect monk seal habitat. In addition, reef trauma associated with vessel groundings have been implicated in ciguatera outbreaks (Gilmartin *et al.* 1980, Gulko *et al.* 2002).

In August 1998, a tanker offloading spilled approximately 5,000 gallons of bunker fuel off of Barber’s Point, Oahu. The waters and shoreline of Kauai were affected, and up to five monk seals were subsequently reported in the area and may have been oiled. As there

were no physical exams conducted on the animals observed, no conclusion about the effects of the oil on the monk seals could be made (Natural Resources Trustees 2000).

On Tern Island (French Frigate Shoals), an aging and deteriorating sheet metal bulkhead sea wall is a serious entrapment hazard to Hawaiian monk seals. Between 1988-2006, 43 Hawaiian monk seals have become entrapped behind the eroding sea wall. Although most were rescued, two subadult males died (USFWS 2001). As both the sea wall and island erode, buried debris and contaminants have become exposed, creating additional hazards to wildlife.

Coral reefs are a major component of the ecosystem upon which Hawaiian monk seals depend, both for terrestrial habitat and foraging. Reefs have undergone significant deterioration since the late 1700s in the Main Hawaiian Islands (Maragos 2000). Contributing factors have historically included accelerated soil erosion and sediment discharge from land clearing, road construction, sugar cane and pineapple plantations, logging, livestock ranching, and overgrazing (Maragos 2000). More recently, coastal development, urbanization, coastal pollution, increased sedimentation, excessive nearshore fishing, resort development, overuse of nearshore reefs, ship groundings, anchor damage, and invasive species have been significant detriments to reefs on Hawaii (Friedlander *et al.* 2004; Jokiel *et al.* 2004; Jokiel *et al.* 2001; Maragos 2000). Marine debris is also a threat, as it snags on and kills coral in the Northwest Hawaiian Islands, then freeing itself only to snag and kill again (Donohue *et al.* 2001). In 2004, Main Hawaiian Islands coral reefs were considered to be in fair to good condition, but degraded from prior conditions (Friedlander et al. 2004, Jokiel et al. 2004, Pandolfi et al. 2005). Reef sedimentation ceased to be a problem on Kahoolawe when grazing animals were removed and the island was revegetated (Maragos 2000, Friedlander et al. 2004). Overfishing on Hawaiian reefs is also of concern because removal of herbivores allows algae to outcompete corals; a situation that is not present or likely to happen in the Northwest Hawaiian Islands (Pandolfi et al. 2003, Friedlander et al. 2004, Pandolfi et al. 2005).

Coral bleaching as a result of climate change is a significant concern in the Northwest Hawaiian Islands (Friedlander et al. 2004). Climate change can adversely affect coral reefs in several ways: (1) increased atmospheric carbon dioxide acidifies the ocean, weakening coral skeletons and diminishing skeletal accretion at high-latitude reefs (Kleypas 1999); (2) higher ocean temperatures increases the frequency and/or severity of hurricanes and tropical storms; and (3) more extensive of bleaching episodes and disease epidemics (Hughes *et al.* 2003). The coral reefs of the Hawaiian Islands are potentially susceptible to all three consequences. However, the Main Hawaiian Islands are likely more susceptible to degradation due to added human disturbances (Friedlander et al. 2004, Pandolfi et al. 2005).

Naval activities

Since 1971, the U.S. Navy has conducted the biennial Rim of the Pacific exercises. These exercises, which historically have lasted for about a month, have involved forces from various nations on the Pacific Rim including Australia, Canada, Chile, Japan, and the Republic of Korea. We have limited information on the particular components of those exercises between 1971 and 2005, but we assume that most of those exercises involved

many of the components that are part of contemporary Rim of the Pacific Exercises, although sonar systems and ordnance have evolved and changed over time.

We also have limited information on the timing and nature of Rim of the Pacific Exercises prior to 2002 and we have no information on their potential effects on endangered and threatened marine animals in the Hawai'i Range Complex prior to 2006, when we started to consult with the U.S. Navy on the exercises in 2006. Since 2006, we have completed four section 7 consultations on training activities that employ mid-frequency active sonar, underwater detonations, and assorted other training and research, development, test, and evaluation activities and we have completed three section 7 consultations on missions the U.S. Navy has conducted with its Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA) Sonar system in the Northwest Hawaiian Islands. NMFS' biological opinions on U.S. Navy training activities in the Hawai'i Range Complex concluded that training activities would result in 110 instances in which Hawaiian monk seals would experience changes in their behavior that would be classified as "harassment"; biological opinions on the SURTASS LFA sonar system concluded that those training missions would result in 27 instances in which Hawaiian monk seals would experience changes in their behavior that would be classified as "harassment" (both Opinions expressed "take" in terms of the number of instances in which monk seals and other species might be "harassed" rather than refer to the number of animals that might be "harassed" because some individual animals might be "harassed" more than once during a training event).

Between June and July 2006, the U.S. Navy conducted Rim of the Pacific exercises in the Hawai'i Range Complex. Based on the U.S. Navy's 7 December 2006 After-Action Report, over the 15 calendar days of the 2006 RIMPAC (U.S. Navy 2006c), hull-mounted mid-frequency sonars were employed for a total of 472 hours (with 8 hours of transmission lost to comply with shut-down protocols required by a Marine Mammal Protection Act permit). Over the 15 calendar day of the 2006 RIMPAC, active and passive sonobuoys were deployed for 115 hours (which does not translate to 115 hours of sonar transmissions because some of the sonobuoys were deployed but were not transmitting).

U.S. Navy watchstanders reported marine mammals on 29 occasions (with the exception of two reports of pilot whales, marine mammals were not identified to species). On 12 of those 29 occasions, for a total of 8 hours, mid-frequency sonar associated with the exercise was shut down to avoid exposing marine mammals that had been observed. On 2 other occasions, marine mammals were observed more than 1,000 yards from a vessel while mid-frequency sonar was active.

The After Action Report for the 2006 RIMPAC concluded that (a) there was no evidence of any behavioral effects on marine mammals throughout the exercise; and (b) there were no reported standing events or observations of behavioral disturbance of marine mammals linked to sonar use during the exercise. The observations contained in the report (1) do not identify or estimate the number of endangered or threatened species that might have been exposed to mid-frequency active sonar during the exercise, (2) did not allow the U.S. Navy to evaluate the efficacy of the mitigation measures the U.S. Navy had implemented during the exercises (that is, those measures the Navy had proposed to implement on their own as well as the additional measures they implemented to comply

with the MMPA permit), and (3) did not allow the U.S. Navy to evaluate the efficacy of the monitoring program associated with the exercises.

Between June and July 2008, the U.S. Navy conducted another Rim of the Pacific exercise in the Hawai'i Range Complex, with the at-sea portions that involved mid-frequency active sonar occurring between 7 and 31 July 2008. Based on the U.S. Navy's 30 November 2008 After-Action Report, over the 25 calendar days of the 2008 RIMPAC (U.S. Navy 2008d), mid-frequency active sonars from hull-mounted (surface vessels), dipping, and DICASS sonobuoys were employed for a total of 547 hours. Of this total, active sonar was employed between the shoreline and the 200-meter bathymetric contour for about 6 hours.

Participants in the 2008 RIMPAC exercises reported 29 sightings of marine mammal groups totaling about 200 animals; dolphins represented 21 or 72 percent of these sightings (125 of the individuals). Six whale groups were sighted during the exercise, all in waters more than 100 nm west of the Island of Hawai'i. An aerial survey over a portion of the area in which the 2008 RIMPAC exercises occurred reported 24 sightings of marine mammal groups involving eight species of small odonotocetes, Hawaiian monk seals, or unidentified dolphins (or sea turtles). A shipboard survey that also occurred in a portion of the area in which the 2008 RIMPAC exercises occurred reported 9 sightings of marine mammal groups consisting of either bottlenose dolphins, rough-toothed dolphins, or Hawaiian spinner dolphins. None of the observers reported unusual behavior or adverse behavioral responses to active sonar exposures or vessel traffic associated with the exercises.

The U.S. Navy has also conducted Undersea Warfare Exercises in the Hawai'i Range Complex for several years, but the components (number of vessels involved, amount of active sonar produced, etc.) of these exercises can vary widely. For example, an Undersea Warfare Exercise conducted in the Hawai'i Range Complex from 13 to 15 November 2007, involved two ships equipped with AN/SQS-53C, one ship equipped with AN/SQS-56, and entailed a total of 77 hours of mid-frequency active sonar from all sources (hull-mounted sonars, dipping sonars, and DICASS sonobuoys; U.S. Navy 2008a). An Undersea Warfare Exercise conducted in the Hawai'i Range Complex from 25 to 27 March 2008, involved four ships equipped with AN/SQS-53C, one ship equipped with AN/SQS-56, and entailed a total of 169 hours of mid-frequency active sonar from all sources (hull-mounted sonars, dipping sonars, and DICASS sonobuoys; U.S. Navy 2008b). An Undersea Warfare Exercise conducted in the Hawai'i Range Complex from 27 to 31 May 2008, involved four ships equipped with AN/SQS-53C, one ship equipped with AN/SQS-56, and entailed a total of 204 hours of mid-frequency active sonar from all sources (hull-mounted sonars, dipping sonars, and DICASS sonobuoys; U.S. Navy 2008c).

Monitoring surveys associated with the November 2007 Undersea Warfare Exercises reported 26 sightings of five species during exercise, including green sea turtles and Hawai'ian monk seals. None of the marine animals observed from survey vessels or aircraft were reported to have exhibited unusual behavior or changes in behavior during the surveys. Monitoring surveys associated with the March 2008 Undersea Warfare Exercises reported 47 sightings of five species during exercise, including humpback whales (40 sightings of 68 individuals) and an unidentified sea turtle. None of the marine

animals observed from survey vessels or aircraft were reported to have exhibited unusual behavior or changes in behavior during the surveys.

Fishery interactions

Fisheries interactions are a significant problem for several marine mammals species, and can cause entrapment and entanglement. Additionally, many marine mammals in commercial fishing gear sink rather than strand ashore, thus making it difficult to accurately determine the frequency of such mortalities. Further, many areas where Hawaiian monk seals frequently occur are locations with little human presence, so entangled individuals likely are never observed. Large amounts of marine debris accumulate on remote nursing beaches, entangling and killing animals (Boland and Donohue 2003). Young and subadults are the primary groups to become entangled in netting and die (Henderson 2001).

Hawaii has an extensive commercial fishery, which caught 22 million pounds of fish in 2003 worth $52.4 million and averaged $60.1 million from 1994-2003 (NMFS 2004a). The pelagic fishing industry dominates the commercial realm, with 91% of commercial landings in 2002, and uses mostly longline gear (Simonds 2003). Other commercial fisheries in Hawaiian EEZ waters include:

- Troll gear
- Hook-and-line gear
- Purse/beach seines
- Barrier nets
- Trap gear

Drift gill nets and fishing by foreign nations are no longer allowed within the U.S. EEZ (Simonds 2003).

There is also a considerable, yet unknown recreational and subsistence fishery around the Hawaiian Islands that may account for as much harvest as the commercial fisheries (Meadows *et al.* 2005). Anglers contribute about $138 million annually to the Hawaiian economy and caught ~12.5 million pounds of fish in 2003 (Wilson 2001, NMFS 2004b).

From 1982-2006, there were 12 recorded instances of seals interacting with active fishery equipment in the Northwest Hawaiian Islands and 43 seals have been documented in fishery interactions in the Main Hawaiian Islands from 1982-2006 (Carretta *et al.* 2006, NMFS 2007b). Five of the Main Hawaiian Islands interactions involved gillnets, and four of these occurred in the past 7 years. The remaining 38 interactions have involved embedded hooks, with one mortality (Carretta et al. 2006; NMFS unpub. data). Two monk seals drowned in recreational gillnets on Oahu within the past 3 years (NMFS 2007a). It is expected that a seal is hooked at least every 2.9 years, resulting in serious injury or mortality at least every 6.7 years (NMFS 2003). Data from 1991-1992 support a Hawaiian monk seal stealing bait or caught fish once every 34.4 hours of fishing effort (Nitta and Henderson 1993). Data accumulated since 1990 indicate a total of 3 seals hooked by longlines, with another 13 possibly attributable to the fishery. At least three seals are known to have been hooked as a result of recreational fishing on Kure while the USCG operated a station there (Forney *et al.* 2000). While monk seals have been

observed near fishing boats, there have been no reported interactions between monk seals and the bottomfishing fishery in the Main Hawaiian Islands. Although the Northwest Hawaiian Islands are closed to most fisheries and all remaining fisheries will cease operations within one year, fisheries interactions are expected to become more numerous in the Main Hawaiian Islands as more seals inhabit the islands. Although de-hooking has been more successful in recent years, this does not alleviate the problem or the potential for future interaction.

Entanglement in marine debris and derelict fishing gear

Entanglement in fishing gear is a major threat to marine mammals in general and Hawaiian monk seals specifically. It has been estimated that nearly 100,000 marine mammals die each year due to marine debris ingestion or entanglement (Wallace 1985). The increased use of plastics, polypropylene, nylon nets and line has resulted in a corresponding increase of derelict debris on beaches in the Northwest Hawaiian Islands (Donohue *et al.* 2001; Henderson 2001). Derelict fishing gear is a chronic pollutant affecting the Northwest Hawaiian Islands (Donohue *et al.* 2001). Most fishing debris appears to be trawl webbing, comprising 84-88% of debris encountered (Boland and Donohue 2003; Donohue *et al.* 2001). Although the Marine Mammal Research Program staff have routinely removed debris from study sites, the Pacific Islands Fisheries Science Center began a concerted marine debris removal program that, in its first year (1996-1997), recovered 4,368 kg of derelict fishing gear from the Northwest Hawaiian Islands. Over the next decade, at least 511 metric tonnes of derelict net gear was removed from the coral reef ecosystems of the Northwest Hawaiian Islands (NMFS 2007b). Derelict fishing gear continues to accumulate at a rate of roughly 52 metric tonnes per year (Dameron *et al.* 2007). The NMFS continues to remove accumulating marine debris from the Northwest Hawaiian Islands on an annual basis. Pearl and Hermes Reef accumulates over half of the annual marine debris deposition in the Northwest Hawaiian Islands, although Lisianski Island also accumulates debris at very high rates (Dameron *et al.* 2007; Donohue *et al.* 2001). Accumulation is highest in lagoon areas, where Hawaiian monk seals frequently occur (Dameron *et al.* 2007). Debris accumulation is related to oceanography, with more debris accumulating when the subtropical convergence zone shifts southward and marine debris accumulated within the North Pacific Central Gyre is deposited or snags on reefs in the Northwest Hawaiian Islands (Dameron *et al.* 2007; Pichel *et al.* 2007). For this reason, accumulation in the Northwest Hawaiian Islands is heavier during El Niño events than during normal periods or La Niña events, resulting in higher Hawaiian monk seal entanglement rates (Dameron *et al.* 2007; Morishige *et al.* 2007).

Marine debris and derelict fishing gear have been well documented to entangle monk seals, who have one of the highest entanglement rates of any pinniped (Henderson 1984; Henderson 1985; Henderson 1990; Henderson 2001). Monk seals have become entangled in net, line, net/line combinations, straps, rings, and other random items such as discarded lifejackets, buckets, bicycle tires, and rubber hoses (Henderson 1990). Once entangled, unless a seal can free itself or is freed by researchers, the animal may suffer from:

- increased hydrodynamic drag while swimming and pursuing prey

- severe wounds that may become infected and lead to secondary complications and death
- severance of vital tissues, particularly in the neck and head region
- death by strangulation, drowning, starvation, or shark attack.

A total of 268 monk seals entanglements are known from 1982-2006 (11.2 entanglement annually), including 118 in fishing gear. Of these, 183 were released, 69 escaped unaided, 8 died, and 8 were not released, with their fate unknown. There were 57 serious injuries (32 from fishing gear) and 8 mortalities (7 from fishery items). From 1982 – 2000, an average of 2.3 seals were seriously injured or died as a result of fishery related marine debris (NMFS 2007b).

Entanglements are unequal across locations and age classes. Proportionally, pups (including newly weaned pups) are most frequently entangled (Henderson 1985; Henderson 1990; Henderson 2001). Between 1982-1988, pups comprised 11% of the population, but accounted for 42% of observed entanglements. Immature seals account for nearly 80% of all observed entanglements, but only 46% of the total population (Henderson 2001). Pups and juveniles are most frequently entangled in nets, while subadults and adults more often entangle in lines (Henderson 2001). The Lisianski subpopulation has had the most entanglements, even though it does not consistently accumulate the highest amounts of debris nor does it have the largest seal subpopulation (Henderson 1990; Henderson 2001). Henderson (1990) suggested that the high entanglement rate (0.7% of the entire species; Henderson 2001) results from the windward location of pupping areas, where young seals are more exposed to than their counterparts at other islands. However, 25 Hawaiian monk seals were entangled in 1999, representing 1.7% of individuals in the species (Donohue *et al.* 2001).

Scientific research and permits

Although most human disturbance has been removed from the Northwest Hawaiian Islands, disturbance continues to be a threat with the presence of extensive research activities in the Northwest Hawaiian Islands as a result of the area's recent Papahānaumokuākea Marine National Monument designation. Table 2 summarizes the number of animals that might be "taken" as a result of activities permitted from 2003-2007 by action and island. Table 3 identifies the total number of Hawaiian monk seals that are currently authorized to be "taken" by research activities from July 2009 through June 2014 by Permit 10137-03.

We have summarized the probable effects of the actions authorized by Permit 10137 (and amendments) below, as presented in NMFS (2009a) and NMFS (2009b). The objectives of the activities are:

- assess survivorship, reproductive rates, pup production, condition, abundance, movements among subpopulations, and incidence and causes of injury or mortality of Hawaiian monk seals (*Monachus schauinslandi*)
- diagnose disease, monitor exposure to disease, and develop normal baseline hematology and biochemistry parameters
- conduct activities to increase survival

- investigate foraging ecology to determine foraging locations, diving parameters, characteristics of foraging substrate, and prey identification and foraging behaviors
- enhance survival of weaned pups and juveniles through de-worming.

Every Hawaiian monk seal could be exposed to the permitted activity in some form. The number of exposures to various activities will vary significantly, with all or nearly all individuals exposed to flipper tagging, and multiple exposures to bleach marking, and approaches for observation per year. In addition to these exposures, a few individuals are expected to also be exposed to health and disease screening, intra-island translocation, instrumentation, de-worming, and disentanglement in any given year. Rarely, individuals may be removed (adult males) or die as a result of permitted activities.

An approach will be part of any action authorized by Permit 10137. Over a decade (1997-2007) and over the Hawaiian monk seals' entire range, the overall rate of behavioral response to approaches is 2.95%, ranging from 0.52-11.6% by location, including head raises, and moving less than two body lengths away, with less than 1% entering the water (NMFS 2008). In addition, monk seals may vocalize in response to disturbance by approach (NMFS-PIFSC 2008). The likely behavioral responses to approach are not likely to have a fitness consequence to individuals.

Capture, restraint, and handling will occur with all actions except passive monitoring. We expect that these will cause moderate and sometimes frequent stress to the exposed Hawaiian monk seals, comparable to the level of stress from an encounter with a predator. This stress could confer a negative fitness consequence, including death, depending on the age and body condition of the targeted animal, and the duration and intensity of actions that could occur during handling. Baker and Johanos (2002) studied the effects of research activities from 1983 to 1998 (including tagging, instrumentation, and blood sampling) on the survival, migration, and condition of Hawaiian monk seals. Their study suggests that if Hawaiian monk seals are released alive, there are no apparent differences in their health condition or behavior when compared with monk seals that have not been handled. Even re-sighting rates after one year did not differ between the experimental (monk seals that had been handled) and control groups.

Any mortality that occurs in association with healthy individuals who have a significant chance of surviving for years and contributing significantly to species recovery will carry significant negative fitness consequences. Permit 10137 authorizes no more than two mortalities per year, and up to four mortalities over the 5-year permit. Based upon the Marine Mammal Research Program's previous experiences, we believe that that a monk seal may die as a response to actions involving capture, handling, and restraint over the life of the permit.

Hawaiian monk seals will be tagged after weaning for monitoring survival and detecting movements between subpopulations. In some cases, tags could be lost or broken, and so some individuals would be re-tagged. We considered the risk of infection and hydrodynamic drag, and do not expect a fitness consequence to be experienced by any individuals.

A number of stressors will elicit responses indistinguishable from the response to handling, as described above, or will have a lower response, due to the seals being under

sedation. These include bleaching, milk collection (which will rarely occur, due to the limited circumstances under which it would be possible), weighing, girth and length measurements, and swabbing. For each of these, we determined that any additional stress experienced, and the additional amount of time of handling, will not constitute a negative fitness consequence.

As a part of the health and disease investigation and foraging and instrumentation study, seals will be sedated with diazepam, under the supervision of a veterinarian. We expect the sedation to have beneficial effects, in that it will alleviate the stress response experienced due to capture and handling. While there is some risk of a drug reaction to the sedative, mortality is not expected as a result of sedation, and the presence of a veterinarian will allow other reactions to the sedative to be treated with emergency drugs.

We assessed the effects of euthanasia and mortality of unhealthy seals during the health and disease investigation. In both cases, these actions will result in death to the focal animal. The euthanasia or mortality of moribund seals, which have no chance of survival to reproduce, will allow for a necropsy of the dead animal, increasing researchers understanding of disease and illness in monk seals.

Blood collection and blubber biopsy are both components of the health and disease investigation. We considered that drawing blood from seals could increase the need for additional blood production. However, for the unhealthy seals, for whom this could be of greater significance, less blood would be drawn. Blubber biopsy, while it could cause some scarring at the biopsy site, is unlikely to result in infection. We do not expect blood collection or blubber biopsies to have a significant effect on the fitness of individuals.

Lancing of abscesses could be conducted under the health and disease investigation, and we anticipate that individuals will receive a significant fitness benefit, by reducing the likelihood of systemic infection and death that could result if the abscesses were not treated.

In emergency situations, drugs could be administered based on the judgment of the on-site veterinarian. Although there is some risk inherent to the use of any drug, we expect that the fitness benefit to using these drugs in emergency situations (and in the case of atropine as a pre-medication before sedation) will outweigh any potentially negative responses.

Under the foraging study, Hawaiian monk seals will be equipped with instruments, including TDR and Crittercam. We considered the hydrodynamic drag and the potential for the instruments to disrupt foraging and/or decrease an animal's energy budget. Data suggest that Hawaiian monk seals will not experience a fitness consequence due to instrumentation.

For both mother and pup reunifications and intra-atoll or island relocation for the purposes of risk alleviations (e.g. removing seals from areas of high risk predation to areas of lower predation within the same subpopulation), we anticipate significant fitness benefits, which will out-weigh any of the potential negative effects of this intervention.

The removal of mobbing males (either by euthanasia or relocating them to an area away from conspecifics, essentially removing them from the gene pool), will prevent serious injury or death to the subjects of the attacks, and while this will eliminate the male's

chances for future reproduction, it will allow for the reproductive success of others, and would therefore provide a benefit to the species.

Disentanglement, while potentially causing the seal to undergo stress and injury, will ultimately benefit the seal. It is expected that seals have a greater chance of dying as a result of entanglement, and therefore the mitigation of this will provide a beneficial fitness consequence.

Necropsy and opportunistic sample collection will not be conducted on living seals, and therefore will have no effect on an individual's fitness, and could serve to benefit the species.

The de-worming treatment could result in significant energy savings for most or all of the 58 seals, or over 100 if the de-worming treatment is fully implemented, who will be treated with praziquantel and fendbendazole (the administration of which, if issued, this amendment would replace with a subcutaneous injection of ivermectin). This energy savings is expected to exceed the metabolic loss resulting from stress in each treated individual. Weight retention or reduced weight loss for prolonged periods is expected to be so significant as to significantly improve survivorship in treated seals, many of whom would likely die due to starvation or be predated upon due to their poor body condition. At the subpopulation level, we expect that the actions could improve survivorship of Hawaiian monk seals at each study location and for the population and species as a whole.

The August 2009 translocation of six juvenile seals from French Frigate Shoals to Nihoa, which was assessed in NMFS (2009b), is complete, but the long term effects to the individuals, as well as the monk seal sub-populations at French Frigate Shoals and Nihoa, are still unknown. Monitoring of these individuals and sub-populations will continue to determine what, if any, effects occurred. No future translocations are currently approved.

In summary, actions including lancing, disentanglement, de-worming treatment, mother-pup reunifications, intra-atoll or island relocations for risk alleviation, and emergency use of drugs will all be beneficial to the species. Other actions, such as removal of aggressive or mobbing males and euthanasia of moribund seals, will reduce the population but would provide a benefit to the remaining seals. Sedation, while involving some risk, will help reduce stress to the seal. Approach, capture, restraint, handling for various procedures, tagging, and instrumentation do have the potential to adversely affect Hawaiian monk seals.

Many Hawaiian monk seals will be exposed to multiple actions during the year, the lifetime of the permit, and the lifetime of the individual. While the individual actions will generally not have a negative fitness consequence on a seal, or in some cases the actions could have a fitness benefit, multiple exposures to stressors could lead to fitness reductions for the individual.

From the evidence available, NMFS (2009a) and NMFS (2009b) concluded that the research authorized by Permit 10137 is likely to adversely affect endangered Hawaiian monk seals and, in some instances, reduce their numbers in some populations (through removal of aggressive males, euthanasia or mortality of unhealthy seals, and mortality of healthy seals). However, those populations that might experience reductions in their

number can also be expected to experience increased survival rates over short- and long-time intervals. Therefore, we do not expect the adverse effects of the research to reduce the reproduction, numbers, or distribution of endangered Hawaiian monk seals in a manner or to a degree that would appreciably reduce their likelihood of surviving and recovering in the wild. To the contrary, the efforts covered by the research constitute some of the primary tasks associated with the monk seal's recovery and, if conducted with the same research protocols that have been applied over the past few years, should increase the Hawaiian monk seal's likelihood of surviving and recovering in the wild.

Table 2. Summary of monk seals that were "taken" by location and kind of activity during research conducted from 2003-2007 (MMRP unpub. data).

	Main Hawaiian Islands	Nihoa	FFS	Laysan	Lisianski	PHR	Midway	Kure
Disturbance	0	0	584	818	423	1,113	240	568
(Re)tagging	74	8	184	177	128	157	64	101
Bleaching	24	0	354	1,029	794	518	61	254
Health assessment	39	0	0	0	0	0	11	0
Nursing pup relocation	0	0	17	10	2	0	3	2
Weaned pup relocation	4	0	102	0	0	0	0	0
Rehab/release	0	0	0	0	0	0	9	0
Disentanglement/ dehooking	17	0	1	6	10	7	6	13
Miscellaneous harassment	0	0	5	9	2	0	0	9
Mortalities	1	0	0	0	0	0	1	0
Total	**159**	**8**	**1,247**	**2,049**	**1,359**	**1,795**	**395**	**947**

Table 3. Currently authorized "takes" of Hawaiian monk seals, under Permit 10137-03. Locations: Hawaiian Archipelago=Main Hawaiian Islands (Hawaii, Maui, Molokai, Kahoolawe, Lanai, Oahu, Kauai, and Niihau) and adjacent islets, Kaula Rock, Necker Island (Is.), Nihoa Is., and the Northwest Hawaiian Islands (French Frigate Shoals, Laysan Is., Lisianski Is., Pearl and Hermes Reef, Midway Atoll, and Kure Atoll); Johnston Atoll.

Task	Size (Age)	Sex	No. Seals Taken /Year	No. Takes/ Seal /Year	Type of Takes	Locations	Dates/Time Period And Details
1. Monitoring	Any	Both	150	3	Disturbance from visual observation and photo-identification during ground monitoring and aerial and vessel surveys	Main Hawaiian Islands	Annually at any time of year.
			50	1		Nihoa Is.	
			50	1		Necker Is.	
			250	5		French Frigate Shoals	
			10	1		Gardner Pinnacles	
			250	3		Laysan Is.	
			225	3		Lisianski Is.	
			200	3		Pearl and Hermes Reef	
			100	2		Midway Atoll	
			150	2		Kure Atoll	
			5	1		Johnston Atoll	
2a. Tagging	Any except nursing pups, lactating females, or obviously pregnant females.	Both	30	3	Restraint, tagging (flipper and PIT), collect flipper plugs, morphometrics (length and girth)	Main Hawaiian Islands	Annually at any time of year (predominantly during summer field camps). All of the animals may also be taken by Tasks 1 and 3. Seals are typically tagged on the first handling event; however, in some cases up to 3 captures may be necessary to successfully tag (flipper/PIT) and measure seals at specified locations. Therefore, not every seal will be handled multiple times for flipper tagging. [1]At French Frigate Shoals, 35 weaned pups of either sex may have a sonic tag deployed on a third flipper tag concurrent with flipper tagging at weaning (annually over three years).
			25	1		Nihoa Is.	
			15	1		Necker Is.	
			150	3		French Frigate Shoals[1]	
			75	3		Laysan Is.	
			50	3		Lisianski Is.	
			50	3		Pearl and Hermes Reef	
			25	2		Midway Atoll	
			35	2		Kure Atoll	
			1	1		Johnston Atoll	

Table 3. Currently authorized "takes" of Hawaiian monk seals, under Permit 10137-03. Locations: Hawaiian Archipelago=Main Hawaiian Islands (Hawaii, Maui, Molokai, Kahoolawe, Lanai, Oahu, Kauai, and Niihau) and adjacent islets, Kaula Rock, Necker Island (Is.), Nihoa Is., and the Northwest Hawaiian Islands (French Frigate Shoals, Laysan Is., Lisianski Is., Pearl and Hermes Reef, Midway Atoll, and Kure Atoll); Johnston Atoll.

Task	Size (Age)	Sex	No. Seals Taken /Year	No. Takes/ Seal /Year	Type of Takes	Locations	Dates/Time Period And Details
2b. Retagging	Any except nursing pups, lactating females, or obviously pregnant females.	Both	100	1	Restraint, retagging (flipper), flipper plugs, morphometrics	Hawaiian Archipelago	Annually at any time of year. Seals may have been taken by Task 1 and may have been tagged in previous years.
3. Marking	Any	Both	75	2	Temporary bleach marking	Main Hawaiian Islands	Annually at any time of year. All of the animals may also be taken by disturbance (Task 1) and tagging (Task 2).
			30	2		Nihoa Is.	
			30	2		Necker Is.	
			250	2		French Frigate Shoals	
			250	2		Laysan Is.	
			225	2		Lisianski Is.	
			200	2		Pearl and Hermes Reef	
			100	2		Midway Atoll	
			150	2		Kure Atoll	
			5	1		Johnston Atoll	
4. Health Screening and Foraging Studies (Note: for these capture activities, up to 10 animals may be captured, not fully processed/ released, and recaptured for full processing annually (to account for failed capture/ processing attempts.)	Any <u>healthy</u> seal excluding lactating females with pups and nursing pups	Both	70	2	Restraint, sedation, tagging, blood sampling, swabs, blubber biopsy, weight, morphometrics (girth and length), instrumentation	Hawaiian Archipelago	Annually any time of year. Up to 60 healthy seals may be instrumented. Animals recaptured for instrument removal and health sampling. All animals may have been taken by Tasks 1-3.
	Any unhealthy seal excluding lactating females with pups and nursing pups	Both	30	2	Restraint, sedation, tagging, blood sampling, swabs, blubber biopsy, morphometrics, treatment (lance abscesses), humane euthanasia or mortality of 10 moribund animals	Hawaiian Archipelago	Annually at any time of year. Includes humane euthanasia or mortality of up to 10 moribund or severely injured seals at discretion of veterinarian authorized over a 5-year period. All animals may have been taken by Tasks 1-3.

Table 3. Currently authorized "takes" of Hawaiian monk seals, under Permit 10137-03. Locations: Hawaiian Archipelago=Main Hawaiian Islands (Hawaii, Maui, Molokai, Kahoolawe, Lanai, Oahu, Kauai, and Niihau) and adjacent islets, Kaula Rock, Necker Island (Is.), Nihoa Is., and the Northwest Hawaiian Islands (French Frigate Shoals, Laysan Is., Lisianski Is., Pearl and Hermes Reef, Midway Atoll, and Kure Atoll); Johnston Atoll.

Task	Size (Age)	Sex	No. Seals Taken /Year	No. Takes/ Seal /Year	Type of Takes	Locations	Dates/Time Period And Details
5. Intestinal Parasite Treatment	Pups ≥ 120 days post-weaning and juveniles up to age 3	Both	200	8	Restraint, weigh and measure (morphometrics), fecal collection (voided feces or fecal sample collected via fecal loop or digital extraction), treatment (intramuscular injection praziquantel and oral fenbendazole), ultrasound; post-treatment monitoring at approximately 4 week intervals (visual assessments and recapture for weight, morphometrics, and fecal sampling)	Hawaiian Archipelago	Annually, year-round. Initial study trials to include pups ≥ 120 days post weaning to juveniles ≤ 2 years. Maximum number of seals that may be included in initial study are: French Frigate Shoals: 47 seals; Laysan Island: 41 seals; and Lisianski Island: 29 seals. Treatments may be combined with other activities requiring restraint and sedation
6. Relocation/ Translocation	Nursing pup	Both	20	6	Capture, restraint, and relocation by hand to natural mother or prospective foster mother.	Hawaiian Archipelago, Johnston Atoll	Annually at any time of year but predominantly during summer field camps. Most takes will occur in the Northwest Hawaiian Islands.
	Weaned pup	Both	35	3	Capture, restraint, sampling, and relocation from high risk areas via boat, ship, vehicle, or air craft	Hawaiian Archipelago, Johnston Atoll	Annually at any time of year. Most takes will occur at French Frigate Shoals.
	Weaned pup	Both	6	3	Capture, restraint, sedation, sampling, instrumentation, temporary holding, translocation from areas of low survival via boat and ship	French Frigate Shoals and Nihoa Island	Seals may be translocated from French Frigate Shoals to Nihoa Island in 2009.
7. Adult Male Removal	Adult	Male	10	2	Capture, restraint, sedation, sampling, instrumentation/trans-location, permanent captivity, or euthanasia	Hawaiian Archipelago; Johnston Atoll	Up to 5 males may be removed over a five year period.
8. Disentanglement	Any	Both	As warranted (likely not to exceed 25/year)	>1	Disentanglement and dehooking (with or without capture and release)	Hawaiian Archipelago; Johnston Atoll	Annually at any time of year. All animals may have been taken by Tasks 1-3
9. Conduct Necropsies	Any	Both	As warranted	1	Necropsy any seal found dead, that died during restraint, or that was euthanized.	Hawaiian Archipelago; Johnston Atoll	Annually at any time of year.

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Task	Size (Age)	Sex	No. Seals Taken /Year	No. Takes/ Seal /Year	Type of Takes	Locations	Dates/Time Period And Details
10. Opportunistic Retrieval of samples	Any	Both	Unlimited samples	Unlimited samples	Collect parts (placentae, scats, spews, and molted fur/skin) from haul out areas	Hawaiian Archipelago; Johnston Atoll	Annually at any time of year but predominantly during summer field camps.
11. Import and Export Parts	Any	Both	Unlimited import/export	Unlimited samples	Export (and re-import) Hawaiian monk seal samples collected under the authority of this permit. Import (and re-export) Mediterranean monk seal specimens for research related to monk seal conservation.	World-wide (including but not limited to Canada, the Netherlands, Scotland, Greece, Australia)	Annually at any time of year.
12. Incidental harassment of monk seals	Any	Both	200	2	Incidental harassment during any research and enhancement activity	Hawaiian Archipelago; Johnston Atoll	Total incidental harassment over all activities.
13. Mortality	Any	Both	2[2]	1	During any research or enhancement activity, most likely due to capture, restraint, and handling	Hawaiian Archipelago; Johnston Atoll	[2]Four (4) mortalities over a 5-year period, not to exceed two deaths in any 1 year.

Physical and oceanographic features

Collectively, the Main Hawaiian Islands and Northwest Hawaiian Islands comprise the "Hawaiian archipelago." This 21,500 km long island chain includes 132 islands, islets, and reefs which are the most geographically isolated in the world, with Johnston Atoll being the next closest land 800 km southwest (Balazs 1980, Miller 1994, Maragos 2000). About 99% of land mass is in the Main Hawaiian Islands, along with almost all human inhabitants (Balazs 1980). The Northwest Hawaiian Islands are comprised primarily of submerged islands, shoals, and atolls and are the remains of high volcanic islands. All atolls in the Northwest Hawaiian Islands belong to the State of Hawaii except for Midway, which is a U.S. territory. Kure Atoll is a state preserve; the other atolls of the Northwest Hawaiian Islands are national wildlife refuges.

Along with these land masses that rise steeply from the seafloor, 390 additional seamounts are known in the archipelago that do not break the water's surface. These formations alter current patterns locally, regionally, and on oceanic scales and are correlated with increased primary productivity and concentrations of pelagic and demersal fish (Zaika and Kovalev 1984, Fedorov and Chistikov 1985, Greze and Kovalev 1985, Parin et al. 1985, Boehlert and Genin 1987, Rogers 1994, Johnston and Santillo 2006). Seamounts in the Hawaiian archipelago support large and diverse communities of marine species; up to one-third of the 850 species identified on these seamounts are endemic (Johnston and Santillo 2006). Several species are subject to commercial harvest and may easily be overexploited. On islands where Hawaiian monks seals occur, seamounts have been found to be frequently-used foraging grounds (NMFS 2007b).

Many of the islands, reefs, and atolls on the Northwest Hawaiian Islands on which most of the Hawaiian monk seal population resides were formerly islands that developed by volcanic action, but eventually subsided as the islands moved with the Pacific Plate to the northwest, away from the "hotspot" of magma, which formed another island to the southeast. The islands then subsided and were drowned, at which point coral colonization occurred. Many of the current atolls and reefs are present only because the rate of coral growth keeps pace with the rate of subsidence as the former island sinks. An atoll reef represents the perimeter of the drowned island and frequently forms an interior lagoon open to the sea. As ancient islands moved away, the spores of marine plants and larvae of corals, fishes, and other marine animals drifted to colonize the younger islands. Because of this process, the Hawaiian archipelago has the highest endemism among marine ecosystems from any tropical archipelago in the Pacific (Maragos 1998).

The sandy beaches of these land masses provide important critical habitat for Hawaiian monk seal. Beaches are most abundant along Northwest Hawaiian Islands lagoons and the coasts of Main Hawaiian Islands, especially the west and south sides of Kauai, Oahu, Molokai, Maui, Lanai, and Hawaii (Maragos 2000). Wave action and biological and chemical erosion determine the composition and longevity of beaches (Maragos 1998). Coastlines exposed to westerly and northwesterly swells have lower coral cover and lower species richness and diversity (Friedlander et al. 2004).

While coral reefs occur throughout the Hawaiian archipelago, the rate of coral formation gradually decreases from 15 $kg/m^2/yr$ in the Main Hawaiian Islands to 0.3 $kg/m^2/yr$ at Kure. This is due to decreases in incident light and sea surface temperature as one travels

to the northwest along the Hawaiian archipelago (Grigg and Pfund 1981). The Northwest Hawaiian Islands contain approximately 80% of the coral reef habitat in the Hawaiian archipelago, which itself holds 84% of all coral reef area in the U.S. (Maragos 2000, Maragos *et al.* 2004). The rate of coral formation at Kure Atoll is in balance with the loss of calcium carbonate due to bioerosion and subsidence (Grigg and Pfund 1981). Additional seamounts and guyots present northwest of Kure represent former atolls where coral formation could not keep up and a similar fate awaits Kure and the rest of the Hawaiian archipelago, as they move to the northwest at a rate of 10 cm/yr (Grigg 1988, 1997). Until recently, Hawaiian corals have not experienced the disease epidemics that have plagued reefs worldwide (Friedlander et al. 2004). Over 25% of stations surveyed from 2000-2003 incurred a significant decrease in coral cover (Friedlander et al. 2004). Necrotic tissue, band diseases, and tumors have been observed in several Main Hawaiian Islands, possibly as a result of excessive nutrient levels from sedimentation or mechanical rubbing of corals (Hunter 1999). If these issues spread to the Northwest Hawaiian Islands, severe ecosystem changes are likely in the near term and accelerated subsidence in the long term. The health of coral reefs are vital to Hawaiian monk seals to two regards: terrestrial habitat maintenance (see Climate change section below) and foraging habitat, where several endemic HMS prey species exist.

Although the Hawaiian islands have no true continental shelves, the presence of deep-slope terraces are an additional feature that adds to species richness. This nearly horizontal surface provides abundant shelter for numerous fishes and invertebrates and the species they prey upon (Hixon and Beets 1993, Friedlander and Parrish 1998). Planktivorous fish are particularly abundant, although piscivorous fish are also stationed above the terraces (Friedlander and Parrish 1998). Deep-slope terraces are located offshore of almost every island in the Main Hawaiian Islands.

Because of its volcanic origins, the Hawaiian archipelago is subject to significant instability. Hawaii experiences thousands of earthquakes each year and, in recent history, has experienced earthquakes of generally greater magnitude than in the past (Watson 1997, Fletcher et al. 2002, Hansen et al. 2004, Nettles and Ekstrom 2004). The Kapalana earthquake in 1972 (magnitude 7.2) generated a tsunami that inundated some coastlines of Hawaii. Tsunamis generated in the Hawaiian archipelago are not only from earthquakes, but also from landslides. Massive marine debris piles indicate large chunks of islands occasionally break off and are believed to have generated large tsunamis (Clague and Moore 2002, Paduan 2004). “Run-ups”, or the vertical level to which waves can reach on land, are believed to have reached 400 m on Hawaii (Fletcher *et al.* 2002, McMurtry *et al.* 2004). Overall, the Hawaiian islands have experienced roughly one tsunami annually from 1813-1988, including several large tsunamis in the past 50 years generated from earthquakes around the Pacific Rim (Keating et al. 2004, Walker 2005). A damaging tsunami has hit the Hawaiian islands once every 7 years historically, but this rate roughly doubled between 1945-1975 (Oahu Civil Defense Agency 2003). However, the presence of fringing reefs may ameliorate wave severity (Fletcher *et al.* 2002). Tsunamis have the potential to injure or kill Hawaiian monk seals as well as severely affect the nearshore and haul-out habitat that they rely upon.

The ecology of the Hawaiian Archipelago is largely driven by the major currents of the region. The North Pacific Subtropical Gyre (NPSG), the planet's largest circulation

pattern, encompasses 2 x 10 km^2 and is the one of the oldest known ecosystems on the planet (McGowan and Walker 1985). The NPSG is modulated by long and short-term climactic shifts which in turn affects ecosystem communities throughout the Pacific Ocean (Karl 1999). It is normally warm and nutrient-poor with low biological density and low ability to exchange water with adjacent current systems (Karl *et al.* 1995, Karl 1999). However, localized increases in primary productivity occur due to upwelling from tropical storms and hurricanes that pass over the NPSG (Karl 1999). El Niño events also promote additional productivity (Karl *et al.* 1995)). Additional productivity can result from eddy formation along the western side of the Hawaiian archipelago from wind generated upwelling and the westward-flowing North Hawaiian Ridge Current being disrupted by islands and seamounts (Patzert 1969, Wyrtki 1982, Falkowski *et al.* 1991, Miller 1994, Aristegui *et al.* 1997, Lukas and Santiago-Mandujano 2001, Lumpkin and Flament 2001, Seki *et al.* 2002). This is particularly true off the Main Hawaiian Islands and Johnston's Atoll (Doty and Oguri 1956, Barkley 1972, Gilmartin and Revelante 1974, Falkowski et al. 1991, Karl and Lukas 1996, Lukas and Santiago-Mandujano 2001, Seki et al. 2002, Vaillancourt et al. 2003). The lack of primary productivity likely limits food availability for monk seals and the presence of local enhancement features, such as eddies and upwelling, could facilitate important increases in food availability. (Baker *et al.* 2007) found that juvenile Hawaiian monk seal survival (particularly ages 1-2 years) was significantly associated with increased productivity, with a 1-2 year time lag, in northern atolls (Midway and Kure atolls, Pearl and Hermes reef, and Lisianski Island).

Primary production around the Hawaiian archipelago is very low (0.5 grams of carbon per meter), meaning that there is less to eat for larger organisms higher on the food chain (Bienfang and Szyper 1981, Ondrusek *et al.* 2001). Most chlorophyll α occurs below the surface (Bienfang and Szyper 1981, Karl 1999, Ondrusek *et al.* 2001). The phytoplankton are dominated by nanoplankton and picoplankton and additional chlorophyll α occurs in prokaryotes and algae (Andersen *et al.* 1996, Karl 1999, Higgins and Mackey 2000). Phytoplankton tend to accumulate west of islands and atolls due to eddy formation that causes turbulent mixing and subsequent iron enhancement in these waters (Feldman *et al.* 1984, Dandonneau and Charpy 1985, Heywood *et al.* 1990, Signorini *et al.* 1999). Primary productivity can be up to 20% greater in under such conditions (Falkowski *et al.* 1991, Seki *et al.* 2002, Vaillancourt *et al.* 2003). During El Niño events, primary productivity can be further enhanced due to shifts from a nitrogen-limited to a phosphorus-limited habitat (Karl *et al.* 1995). Over the past 30 years, Hawaiian waters have experienced a doubling of chlorophyll α and primary productivity that has been accompanied by a shift from a phytoplankton dominated community to one dominated by prokaryotes (Venrick 1997, Karl et al. 2001). Unfortunately, regions of higher productivity appear to also be regions where marine debris is more likely to accumulate, which offers simultaneous reward and risk for Hawaiian monk seals when cooler, more productive waters shift southward (Pichel *et al.* 2007).

Zooplankton in Hawaiian waters are highly diverse, but surprisingly stable in composition compared to other marine ecosystems (McGowan and Williams 1973, McGowan and Walker 1979, 1985, McGowan and Hayward 1987). The community is dominated by copepods, forming 77-80% of the community (Landry *et al.* 2001)). Since 1994, increases in mesozooplankton biomass have occurred at rate of 45-60 mg/m^2 annually, which mirrors the growth in zooplankton (Landry et al. 2001, Sheridan and

Landry 2004). However, the plankton community is sensitive to bottom-up and top-down influences. They can be vulnerable to both increased foraging pressures from higher-level predators as well as climactic influences that could limit the availability of phytoplankton prey (Landry et al. 2001, Sheridan and Landry 2004).

Climate change

Over the past 1 million years, climate change has had dramatic effects on the Hawaiian archipelago. Sea level has been up to 76 m lower and 91 m higher than at present during different stages of global glaciation and melting (DON 2001). While sea level was at relatively low levels, the current islands of Maui, Lanai, Molokai, and Kahoolawe were a single island (MacDonald *et al.* 1983, Miller 1994). Roughly 80,000 years ago, when sea level was 7.6 m higher than present, leading to carbonate terrace formation around the Hawaiian Islands (Fletcher and Jones 1996, DON 2001). Just 3,500 to 4,000 years ago, mean sea level was 1.6 m above the current sea level.

Climate change is broken down into two forms in this Opinion: a natural, periodic swing lasting a few months to decades and "global warming" that results from human-induced global climate change from greenhouse gas emissions lasting for an unknown period.

El Niño is the result of natural interannual fluctuations in sea level pressures between the eastern and western tropical Pacific (Conlan and Service 2000). These changes can initiate large shifts in the global climate, atmospheric circulation, and oceanographic processes (Jacobs *et al.* 1994). El Niño conditions typically last 6-18 months, but their effects on global climate can last for years (Barber and Chavez 1983, Philander 1983, Lynn *et al.* 1998, Schwing *et al.* 2000, Durazo *et al.* 2001). El Niño events tend to promote hurricane and tropical storm formation by increasing subtropical shear interactions in the equatorial Pacific (Fletcher *et al.* 2002). Storm formation also shifts eastward (Fletcher *et al.* 2002). During typical El Niño events, the Hawaiian Islands experience a decrease in annual rainfall (Fletcher *et al.* 2002). El Niño events do not appear to strongly affect sea surface temperature in the Hawaiian Islands (Karl *et al.* 1995, Department of Defense 2002, Fletcher *et al.* 2002). El Niño events have been associated with increased pinniped mortality through increased inclement weather and decreased prey availability in the eastern Pacific (Trillmich and Ono 1991).

El Niño events are frequently followed by La Niña events, which have the opposite climatic effects as El Niño (e.g., higher sea surface temperature in the western equatorial Pacific, high production along Pacific upwelling coasts, and heavy rainfall in Australia and Indonesia) (Schwing et al. 2000, NOAA 2005). Under La Niña conditions, abnormally cold sea surface temperatures are present in the equatorial Pacific. Sea surface temperatures do not change over periods of decades because of the relative brevity El Niño and La Niña events (Department of Defense 2002). Atmospheric and oceanic conditions during early 2009 continued to reflect La Niña conditions, and model forecasts indicate that La Niña will dissipate by May – July 2009 (Climate Prediction Center 2009).

The Pacific Decadal Oscillation (PDO) is a longer-term climatic pattern that changes sea surface temperature, surface winds, and sea level pressures (Mantua 2001, Mantua and Hare 2002). The PDO is similar to a long-lived El Niño, where Pacific climate changes through warm and cool phases (Mantua 2001, Mantua and Hare 2002). However, the

PDO can persist for 20 to 30 years, is more prominent in ecosystems outside the tropics, and controlling forces are poorly known (Mantua and Hare 2002). During warm PDO phases, the western tropical Pacific experiences increased sea level pressures, while the opposite is true during cold periods. Hawaiian precipitation is reduced during cooler PDO phases, but meteorological changes at sea level near Hawaii are relatively small and effects in the area appear to be weak (Mantua 2001, Mantua and Hare 2002, Brix et al. 2004). PDO can have effects on fishery production (Hare 1996). Since 1977, the PDO has been in a warm phase, although it is unknown if a regime shift occurred after 1998, returning to a cold phase (Kurtzman and Scanlong 2007).

In general, climate change (including arthropogenic change) is projected to have substantial direct and indirect effects on individuals, populations, species, and the structure and function of marine, coastal, and terrestrial ecosystems in the foreseeable future(IPCC 2000, 2001b, a, 2002). The direct effects of climate change will result in increases in atmospheric temperatures, changes in sea surface temperatures, patterns of precipitation, and sea level. Oceanographic models project a weakening of the thermohaline circulation resulting in a reduction of heat transport into high latitudes of Europe, an increase in the mass of the Antarctic ice sheet, and a decrease in the Greenland ice sheet, although the magnitude of these changes remain unknown. Long-term climate change has already occurred in the Hawaiian Islands, as rainfall has decreased 20% and average temperatures have increased 2.4º C over the past century (EPA 1998). Climate change is likely to bring significant changes to the North Pacific, particularly in its productivity (Quinn and Neibauer 1995, Mackas *et al.* 1998).

Climate change has significant implications for Hawaiian monk seals, primarily from fluctuations in prey availability and inundation of haul-out sites. Other pinniped species, such as fur seals, sea lions, and harbor seals have been negatively affected by loss of prey during El Niño events (Trillmich and Ono 1991, Anonymous 1998). Climactic fluctuations are likely to have (or are already having) similar effects on Hawaiian monks seals, particularly considering the low-productivity habitats they occupy. Productivity appears to have already declined 30-50% in the central North Pacific at some trophic levels due to climate change, including a possible decline in reef fishes (Polovina *et al.* 1994, DeMartini *et al.* 1996). The Hawaiian monk seal survival rates declined by 40-90% from the 1980s to 1992 (Polovina 1994). Lower foraging success by adult females would mean less support for pups, as evidenced by smaller size at weaning and lower survival seen today (NMFS 2007b). Even weaned juveniles have also been found to have poor foraging success and survival (Craig and Ragen 1999). Polovina et al. (1994) speculated that climate changes in the central North Pacific caused declines in lobster recruitment, which contributed to declines in the survival of monk seal pups. Weaned pup size and survival was greatest following El Niño events at Laysan and French Frigate Shoals, further suggesting a possible link between climate change and female foraging and pupping success, possibly due to cooler, more productive waters moving south into the central North Pacific (Antonelis *et al.* 2003). Oceanographic change may also result in changes in the number or distribution of monk seal predators and subsequent seal survival rates. Furthermore, sea level changes of even a meter or two would inundate atolls and reefs as well as significantly alter reef communities as more light is filtered out before reaching coral communities that rely upon photosynthetic zooxanthellae (Baker et al. 2006). One island at French Frigate Shoals has already been inundated (Whaleskate

Island) and overall terrestrial habitat has been reduced by greater than 50% at most French Frigate Shoals sites since 1963 (Baker et al. 2006).

Conservation measures

A variety of methods have been implemented since 1981 to mitigate declining population trends of the Hawaiian monk seal. These have included removal of aggressive males individuals from the population, moving individuals from one location to another (translocation), rehabilitation, and population monitoring. These have met with a variety of success or failure, but have not altered the species' declining population trajectory.

In 1981, NMFS initiated a temporary "captive maintenance project" designed to restore the then-depleted Kure Atoll monk seal population. From 1981-1991, 32 weaned female pups at Kure were captured and temporarily held in a shoreline enclosure, with the intent to protect them from the presumed threat of sharks and aggressive males through their first summer. After release, 26 (81%) females survived to the end of their first year of life (Lavigne 1999). However, of 33 males that weaned during the same period but not held in the enclosure, 27 (82%) survived to the end of their first year, suggesting that the placement in the enclosure did not affect their survival.

During 1984-1991 and 1993-1995, 49 undersized weaned female pups and juvenile females were taken from French Frigate Shoals to Oahu, where they were held in captivity for 8-10 months to increase their body mass. An additional five healthy pups were transferred directly from French Frigate Shoals, for a total of 54 introduced to Kure. First-year survival for 47 of these females (pooled into a single group) was ~66% (Lavigne 1999). This was the first attempt to rehabilitate and release seals older than pups. In 1993, 14 seals were rehabilitated and released, with eight more in 1994. The rehabilitation/translocation program stopped in 1995, when 10 of 12 captive females contracted an eye condition of unknown origin, leading to blindness, which made them unfit for release in the wild.

From 1991-1992, 24 immature females, selected because they were underweight and/or ill and judged likely to perish without intervention, were collected and rehabilitated on Midway and Oahu. 18 survived captivity and were subsequently released at Midway during 1992-1993. Many of these seals were released prematurely for want of a facility to allow the completion of the rehabilitation effort. For undetermined reasons, 16 of the 18 either died or disappeared, and translocations during 1993-1995 were redirected back to Kure.

Collectively, 104 immature monk seal pups (mostly female) have been collected and either "head-started" or provided captive care. Of these, 68 were successfully released into the wild, 22 died during managed care, and 14 were judged to be unsuitable for release and were placed into public aquaria and oceanaria for research. By 1987, some of the 1981 "head-started" females began giving birth (Gilmartin *et al.* 1993). In 2000, of the 42 identified adult females at Kure Atoll, 25 (60%) had received care or were progeny of monk seals that had received care through past management efforts. Nine of the ten identified parturient females (90%) had received care were progeny of monk seals that had received care through past management efforts (Haase and Harting 2004). However, this process was halted due to the fore-mentioned blindness issues that arose in captivity.

Systematic beach counts of seals have provided the framework for assessing long-term trends since 1982, and represent the most consistent data series during the past 26 years by which a long-term population trend can be assessed (NMFS 2009d). Flipper tags have been successfully applied to Hawaiian monk seals since 1981 and PIT tags have been applied since 1990. Several authors have discounted the negative impacts of these activities on individuals (Henderson and Johanos 1988, Baker and Johanos 2002). the Marine Mammal Research Program biologists have marked an average of 580 Hawaiian monk seals annually since 1995, and no increase in mortality or change in haul-out behavior associated with this activity has been observed.

Effects of the proposed actions

Pursuant to Section 7(a)(2) of the ESA, federal agencies are required to ensure that their activities are not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of critical habitat. The proposed permit by the Permits Division would expose endangered Hawaiian monk seals to actions that constitute "take". In this section, we describe the potential physical, chemical, or biotic stressors associated with the proposed actions, the probability of individuals of listed species being exposed to these stressors based on the best scientific and commercial evidence available, and the probable responses of those individuals (given probable exposures) based on the available evidence. As described in the *Approach to the assessment* section, for any responses that would be expected to reduce an individual's fitness (i.e., growth, survival, annual reproductive success, and lifetime reproductive success), the assessment would consider the risk posed to the viability of the population. The purpose of this assessment is to determine if it is reasonable to expect the proposed studies to have effects on listed whales affected by this permit that could appreciably reduce the species' likelihood of surviving and recovering in the wild.

For this consultation, we are particularly concerned about behavioral disruptions that may result in animals that fail to feed or breed successfully or fail to complete their life history because these responses are likely to have population-level, and therefore species level, consequences. The proposed permit would authorize non-lethal "takes" by harassment of listed species during research activities. The ESA does not define harassment nor has NMFS defined the term pursuant to the ESA through regulation. However, the Marine Mammal Protection Act of 1972, as amended, defines harassment as any act of pursuit, torment, or annoyance which has the potential to injure a marine mammal or marine mammal population in the wild or has the potential to disturb a marine mammal or marine mammal population in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering [16 U.S.C. 1362(18)(A)]. For this Opinion, we define harassment similarly: an intentional or unintentional human act or omission that creates the probability of injury to an individual animal by disrupting one or more behavioral patterns that are essential to the animal's life history or its contribution to the population the animal represents.

Potential stressors

In addition to the larger suite of research, monitoring, and health assessment activities that were authorized in the Marine Mammal Research Program's permit, the Permits Division proposes to authorize the Marine Mammal Research Program to administer a

subcutaneous injection of ivermectin (dose 0.2mg/kg) to replace the use of oral fenbendazole, in the course of the de-worming project. The activities associated with this are likely to result in the following physical and chemical stressors:

- approaches of seals by humans;
- capture, restraint, and handling;
- weight, length and girth measurement;
- ultrasound measurement;
- fecal sampling;
- administration of de-worming medication by injection; and
- de-worming medication, ivermectin.

During this consultation, we also considered several other stressors: boat, ship, and aircraft noise; ship strike; pollution from fuel/trash; harassment of non-focal seals by activities targeted on a focal individual via focal animal vocalization; heightened public awareness, but concluded that these stressors are not likely to occur and, if they occurred, would have negligible effect on monk seals that might be exposed to them. Therefore, we focus the remainder of our effect analyses on the stressors we identified above.

Exposure analysis

The Permits Division proposes to amend the permit it recently issued to the Marine Mammal Research Program to authorize the use of subcutaneously injected ivermectin, to replace the use of oral fenbendazole during the currently authorized de-worming project.

The Marine Mammal Research Program is currently authorized to annually enroll up to 117 weaned pups, at least 120 days post-weaning, and juveniles aged 1 to 2 years (47 seals from French Frigate Shoals, 41 from Laysan Island, and 29 from Lisianski Island) in the pilot de-worming trial. Approximately half of the enrolled Hawaiian monk seals have de-worming medication administered up to 4 times per year; the other half are handled in an identical manner, but do not receive medication. If the trials are deemed effective, up to 200 Hawaiian monk seals in the same age range could receive the de-worming medication.

The proposed amendment would neither change the number of seals receiving the de-worming treatment during the trial, nor would it change the number of seals that could receive the treatment as part of the full-scale deployment of the de-worming project. The seals that would have been exposed to fenbendazole via oral administration would instead be given ivermectin, via subcutaneous injection.

Response analysis

As discussed in the *Approach to the Assessment* section of this Opinion, our response analyses determine how Hawaiian monk seals are likely to respond upon being exposed to the stressors associated with the proposed administration of de-worming medication. For the purposes of consultation, our assessments try to detect potential lethal, sub-lethal (or physiological), or behavioral responses that might reduce the fitness of individuals. Ideally, response analyses would consider and weigh evidence of adverse consequences as well as evidence suggesting the absence of such consequences.

The proposed amendment does not change the approach, capture, restraint, handling, weight, length, and girth measurements, and fecal sampling associated with the de-worming project. These stressors were previously assessed in the June 2009 Opinion, and are summarized below. It also does not change the use of ultrasound or the administration of praziquantel via intramuscular injection, which were included as amendments to the permit, after the Endangered Species Division concurred with the Permits Division that these procedures would not adversely affect the target animals beyond the effects assessed in the June 2009 Opinion. Therefore, our effects analysis will focus on the potential effects of the administration of the de-worming medication, ivermectin, and the effects of the medication itself. However, we take into consideration that these effects would be additive to the effects of the currently authorized actions (approach, capture, restraint, handling, measuring, fecal sampling, ultrasound, and administration of praziquantel), which the individuals enrolled in the de-worming project will be exposed to, and therefore the proposed actions cannot be considered independently.

Capture, restraint, and handling, including the weight, length, and girth measurements, ultrasound measurements, and fecal sampling, would occur during the de-worming project, as currently authorized. We expect that these would cause moderate and sometimes frequent stress to the exposed Hawaiian monk seals, comparable to the level of stress from an encounter with a predator. This stress could confer a negative fitness consequence, including death, depending on the age and body condition of the targeted animal, and the duration and intensity of actions that could occur during handling. Baker and Johanos (2002) studied the effects of research activities from 1983 to 1998 (including tagging, instrumentation, and blood sampling) on the survival, migration, and condition of Hawaiian monk seals. Their study suggests that if Hawaiian monk seals are released alive, there are no apparent differences in their health condition or behavior when compared with monk seals that have not been handled. Even re-sighting rates after one year did not differ between the experimental (monk seals that had been handled) and control groups.

We expect that the currently permitted de-worming treatment, praziquantel, could result in an energy savings that could exceed the metabolic loss resulting from stress in each treated individual, and could improve survivorship in treated seals, many of whom would likely die due to starvation or be predated upon due to their poor body condition.

Administration of de-worming medication

In 2009, the Marine Mammal Research Program attempted to treat Hawaiian monk seal pups and juveniles that were enrolled in the de-worming study with fenbendazole and praziquantel, both administered orally, the former as a paste, the latter as pulverized tablets, which were then mixed in with the paste. Researchers found it difficult to create a consistency that was fluid enough to push through the syringe (which they used to dispense the medication into the seals' mouths) while keeping it thick enough so that the medication did not drip out. The researchers also found that the seals clenched their jaw and did not respond to the typical methods used to make pinnipeds unclench their jaws, very likely making the restraint and handling process more stressful for the captured Hawaiian monk seal. Additionally, the researchers observed that up to 30-80% of the paste was either spit out by the seals or allowed to passively drip out. Seals that returned

to the water after capture likely spit out paste or allowed seawater to rinse the paste out. This meant that it was impossible to know how much medication was actually received by the seals.

Because of these events, the Marine Mammal Research Program requested an amendment to their permit to allow them to administer the praziquantel via injection, and the Permits Division amended the permit. However, fenbendazole is not available in injectable form, and so could not be immediately substituted. The researchers stopped administering fenbendazole after the first treatment attempt (during which 7 seals received medication), and the following three treatments were conducted with injectable praziquantel only.

The proposed amendment would authorize the administration of ivermectin via subcutaneous injection. Currently, the permit authorizes the administration of praziquantel via intramuscular injection and fenbendazole orally. If the permit is amended as proposed, fenbendazole would no longer be authorized, and both medications would be administered by injection, which would reduce handling time, thereby reducing stress experienced by the seals compared to oral administration of drugs. The proposed method of administering the medication would also ensure that the Hawaiian monk seals would receive the full dosage of both the cestodicide and nematodicide medications, increasing the likelihood of reducing the parasitic load on the animal, which is the main goal of the de-worming project.

There is a risk that injecting the medication will result in an abscess or swelling. In the 2009 annual report, the Marine Mammal Research Program reported that one juvenile Hawaiian monk seal (which had previously been treated for an abscess prior to initiation of the de-worming project) developed an abscess at the injection site after being treated with praziquantel. The abscess was lanced and cleaned in the field, as authorized under the permit, and the animal recovered without complications, although it was removed from the study. In a follow-up report, the Marine Mammal Research Program reported that three seals developed minor swellings near their injection sites within days of treatment; these swellings subsided on their own within 1-3 weeks in each case with no medical intervention.

Compared to the number of injections of praziquantel that were administered in 2009-2010 (62), 1.6% of the injections resulted in an abscess and 4.8% resulted in swelling. Based on these results, if all 58 seals that could potentially receive 2 injections 4 times a year (one for ivermectin, the other for praziquantel), we could expect up to 7 seals per year to develop abscesses that would require lancing, and up to 22 seals per year to develop swelling. As the trials continue, this estimate could change. It is possible that injections of ivermectin would have a higher or lower risk of abscess or swelling, compared to praziquantel.

One female seal displayed distressed respiration, was suspected of having a mass on the ventral side of her neck of unknown origin, and vomited squid after capture. This seal was removed from the study, and was last seen thin and breathing abnormally. Consulting veterinarians stated that these ailments are not consistent with receiving praziquantel. It is not known if the health problems were a result of the capture, and the researchers do not believe this to be the case.

We considered the reduction of stress and increased chance of individuals receiving a full dose of medication compared to the previously authorized mode of administration of the anti-parasitic drug, as well the increased risk of abscesses and swelling forming around the injection site. We believe that the benefits would outweigh the risk of the new method of administration. The permit is conditioned to require the Marine Mammal Research Program to stop de-worming if at any time during treatments there is any indication that handling, treatments, or any other artifact of the de-worming study has compromised the health and welfare of seals. In order to proceed with the full-scale de-worming project, the Marine Mammal Research Program must provide evidence that treatments administered during the de-worming trials were beneficial and had no significant adverse effects to seals and non-target species. These conditions remain in the proposed permit amendment.

Ivermectin

Ivermectin (dose of 0.3 mg/kg) has been used previously on Hawaiian monk seals during captive care enhancement programs in 1987, 1992, and 1993, with no noticeable adverse reactions observed (NMFS unpublished data). Ivermectin has been used broadly on pinniped species around the world. Ivermectin (injectable, dose of 0.2 mg/kg) is routinely administered to pinnipeds at the Marine Mammal Center in Sausalito, CA, and has been deemed effective in killing intestinal worms, as evidenced by worm balls eliminated by treated animals (F. Gulland, NMFS, pers. comm.). Over 300 pinnipeds have been treated at the Marine Mammal Center, with no documented adverse effects (F. Gulland, NMFS, pers. comm.).

Delong et al. (2009) injected wild northern fur seal pups (*Callorhinus ursinus*) subcutaneously with ivermectin at a dose of 0.2 mg/kg. At the time of treatment, control and treated pups had identical prevalence of hookworm eggs in fecal samples (24%). One month after treatment, only 6% of pups from the treatment group had feces positive for hookworm eggs, whereas 67% of the control group was infected (Fisher's exact test, $P < 0.0001$). The study concluded that a single injection of ivermectin in northern fur seal pups can be effective for the treatment of hookworms, and can improve weight gain and survivorship in these animals. A northern elephant seal (*Mirounga angustirostris*) with a parasitic copepod infestation was treated with a subcutaneous injection of ivermectin (0.2mg/kg) (Dailey et al. 2002). The lesion healed and the seal was released.

Based on the available research and information from NMFS veterinarians, we believe that the use of ivermectin to treat nematodes in juvenile Hawaiian monk seals could be effective in reducing parasite load, and we do not expect negative effects for the individuals treated. As mentioned above, the permit is conditioned to require the Marine Mammal Research Program to stop de-worming if at any time during treatments there is any indication that handling, treatments, or any other artifact of the de-worming study has compromised the health and welfare of seals. In order to proceed with the full-scale de-worming project, the Marine Mammal Research Program must provide evidence that treatments administered during the de-worming trials were beneficial and had no significant adverse effects to seals and non-target species. These conditions remain in the proposed permit amendment.

Effects of the action on Critical Habitat

Ivermectin is not fully metabolized by mammals. We considered the potential effects the introduction of ivermectin through feces could have on the environment, specifically on the designated critical habitat. If we assume the dosed seal pups excrete 100% of the ivermectin at the same time, the feces would contain 12-21 mg of ivermectin, based on the dose of 0.2 mg/kg, and the average and maximum pup weights of 59 and 105 kg. This is an unlikely event, but a conservative estimate. Depending on the actual mass of the feces, concentrations of ivermectin in the feces may be high enough to inhibit or kill some invertebrates for a short time. Based on summer soil degradation data, the drug in the feces should degrade within a week to a month in a beach environment in Hawaii. Researchers conduct daily scat collections to recover feces left on the beach, thereby reducing the amount of ivermectin remaining in the environment, although scat excreted in the water column would not be collected. Overall, given the small number of seals dosed, the size of the area where the feces may be deposited, and the fact that ivermectin is likely to degrade between separate dosing events, it is unlikely to affect the aquatic invertebrate community in the area where the seal pups are dosed in any measurable way.

In the Northwest Hawaiian Islands, field camps are temporary structures erected under the authority of the Monument with mitigation to minimize potential impacts to the habitat. Based on this information, we conclude that no significant impact would occur to the physical or biological feature in the environment from the de-worming study.

Cumulative effects

Cumulative effects include the effects of future state, tribal, local or private actions that are reasonably certain to occur in the action area considered by this Opinion. Future federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA. Sources queried include state legislature websites and Nexis. We reviewed bills passed from 2008-2010 and pending bills under consideration were included as further evidence that actions “are reasonably certain to occur.”

Legislative actions have been directed towards maintaining healthy marine ecosystems with regulated development of industry and fisheries management, controlling contaminants in agricultural, stormwater, and municipal effluents, resisting invasive species occurrence, and promotion of policies to decrease greenhouse gas emission and pollution.

Other than this, no future non-federal actions are expected to occur. The NWHI are jointly managed between federal and state agencies. As no other state actions are expected, no other cumulative effects will be assessed.

Integration and synthesis of the effects

As explained in the *Approach to the Assessment* section, risks to listed individuals are measured using changes to an individual's "fitness" – i.e., the individual's growth, survival, annual reproductive success, and lifetime reproductive success. When listed plants or animals exposed to an action's effects are not expected to experience reductions in fitness, we would not expect the action to have adverse consequences on the viability of the population(s) those individuals represent or the species those populations comprise (Brandon 1978, Mills and Beatty 1979, Stearns 1992, Anderson 2000). As a result, if the assessment indicates that listed plants or animals are not likely to experience reductions in their fitness, we conclude our assessment.

The Marine Mammal Research Program is currently authorized to annually enroll up to 117 weaned Hawaiian monk seal pups, at least 120 days post-weaning, and juveniles aged 1 to 2 years (47 seals from French Frigate Shoals, 41 from Laysan Island, and 29 from Lisianski Island) in the pilot de-worming trial. Approximately half of the enrolled Hawaiian monk seals have de-worming medication administered up to 4 times per year; the other half are handled in an identical manner, but do not receive medication. If the trials are deemed effective, up to 200 Hawaiian monk seals in the same age range could receive the de-worming medication.

The NMFS Permits Division proposes to issue a scientific research permit amendment to the Marine Mammal Research Program to authorize administration of with a subcutaneous injection of ivermectin, to replace the use of fenbendazole, due to complications in administration of administering the medication orally. The proposed amendment would neither change the number of seals receiving the de-worming treatment during the trial, nor would it change the number of seals that could receive the treatment as part of the full-scale deployment of the de-worming project.

We considered the effect to the individual of administering the medication via subcutaneous injection, as well as the effects of the medication. There is a risk that injecting the medication will result in an abscess or swelling, and the Marine Mammal Research Program is currently authorized to lance and clean an abscess if this occurs. However, we believe that the administration of de-worming medication via injection instead of orally will reduce the stress experienced by the exposed Hawaiian monk seals during the capture, restraint, and handling event. We considered the potential effects of the ivermectin, and we believe that the use of ivermectin to treat nematodes in juvenile Hawaiian monk seals could be effective in reducing parasite load, and we do not expect negative effects for the individuals treated.

We considered the effect of the proposed action to the designated Critical Habitat for the Hawaiian monk seal. Overall, given the small number of seals dosed, the size of the area where the feces may be deposited, the fact that ivermectin is likely to degrade between separate dosing events, it is unlikely to affect the aquatic invertebrate community in the area where the seal pups are dosed in any measurable way.

Conclusion

After reviewing the current *Status of listed resources*; the *Environmental baseline* for the *Action area*; the anticipated effects of the proposed activities; and the *Cumulative effects*, it is the NMFS' Opinion that the activities authorized by the proposed issuance of scientific research permit amendment No. 10137-04, as proposed, is not likely to jeopardize the continued existence of Hawaiian monk seals. Critical habitat is not expected to be adversely modified or destroyed as a consequence of the proposed actions.

Incidental take statement

Section 9 of the ESA and federal regulation pursuant to Section 4(d) of the ESA prohibit the "take" of endangered and threatened species, respectively, without special exemption. "Take" is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by the NMFS to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of Sections 7(b)(4) and 7(o)(2), taking that is incidental and not intended as part of the agency action is not considered to be prohibited taking under the ESA provided that such taking is in compliance with the terms and conditions of this Incidental Take Statement.

As discussed in the accompanying Opinion, only the species targeted by the proposed research activities would be harassed as part of the intended purpose of the proposed action. Therefore, the NMFS does not expect the proposed action would incidentally take threatened or endangered species.

Conservation recommendations

Section 7(a)(1) of the ESA directs federal agencies to use their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans, or to develop information.

We recommend the following conservation recommendations, which would provide information for future consultations involving the issuance of marine mammal permits that may affect endangered Hawaiian monk seals as well as reduce harassment related to authorized activities:

1. The Permits Division should encourage the Marine Mammal Research Program to establish behavioral, clinical, and observational records for each individual Hawaiian monk seal in the wild. This will allow for analyses of cumulative effects (natural and anthropogenic) at individual and population levels over time. Such analyses can significantly inform biologists as to the pressures which Hawaiian monk seals face and the responses/consequences of those pressures.

2. “Hypervigilent” individuals (those seals who become sensitized to human presence) should be excluded or eliminated from enrollment in any procedure involving capture unless faced with threats to its survival or reproductive potential.
3. The Permits Division should encourage the Marine Mammal Research Program to continue to longitudinally collect and assess data on the potential effects of tagging and instrumentation on all age and sex classes of Hawaiian monk seals.
4. The Permits Division should encourage the Marine Mammal Research Program to consider possible methods to assess what, if any long-term consequences capture, restraint, and handling have for the fitness of the Hawaiian monk seal, both individually and as a species. The Marine Mammal Research Program should develop a protocol to quantifiably evaluate stress during capture and handling events.
5. The Permits Division should encourage the Marine Mammal Research Program to investigate videography of their field procedures. This would greatly aid in informing regulatory agencies in the Marine Mammal Research Program’s procedures, as well as the responses and consequences to listed species and their critical habitat.
6. The Permits Division should encourage the Marine Mammal Research Program to consider possible methods of determining the level of de-worming medication that is not metabolized by treated Hawaiian monk seals and is excreted into the environment, such as assessing scat collected either in the wild or from treated captive Hawaiian monk seals. This information will be useful in future consultations, to confirm our assessment on the potential risk to the environment posed by de-worming medication.

Reinitiation notice

This concludes formal consultation on the proposal to issue scientific research permit No. 10137-04 to the Marine Mammal Research Program for studies of Hawaiian monk seals in the Hawaiian Archipelago and Johnston Atoll. As provided in 50 CFR §402.16, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded; (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this Opinion; (3) the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat not considered in this Opinion; or (4) a new species is listed or critical habitat designated that may be affected by the action. In instances where the amount or extent of authorized take is exceeded, the NMFS Permits Division must immediately request reinitiation of Section 7 consultation.

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