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THE BIOLOGICAL RESOURCES OF THE HAWAIIAN ISLANDS HUMPBACK WHALE NATIONAL MARINE SANCTUARY'S ENVIRONMENTAL IMPACT STATEMENT

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ABSTRACT

As an isolated archipelago, the main Hawaiian Islands constitute a unique ecological setting and a prime habitat for endemic species. The Hawaiian Islands Humpback Whale National Marine Sanctuary (sanctuary) encompasses five marine protected areas within the main Hawaiian Islands. Within these waters and the waters beyond these boundaries reside species and habitat of great ecological, cultural, and economic value. While the current purpose of the sanctuary is to protect humpback whales and their habitat, the sanctuary may also play a significant role in the protection of additional threatened and endangered species, important habitat, and even entire ecosystems. As the sanctuary undergoes a management plan review, a process required by law that will result in an updated management plan for the sanctuary, the protection of additional species will likely be considered.

This report describes the biological resources within and beyond the boundaries of the sanctuary, examines threats to each biological resource, and provides possible management approaches for each biological resource. Specifically, the report will examine humpback whales, Hawaiian spinner dolphins, false killer whales, Hawaiian monk seals, and sea turtles. In its scope and supporting research, the report also provides the groundwork for the development of an Environmental Impact Statement (EIS) to be written during the sanctuary's management plan review process. In particular, the research on the biological resources may be useful in preparing the Affected Environment section of the EIS while the research on management approaches may be useful in preparing the Range of Alternatives of the EIS.

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I. INTRODUCTION

The Hawaiian Islands Humpback Whale National Marine Sanctuary is a federally-designated area that encompasses 1,400 square miles of waters within the four-island area of Maui, Molokaʻi, Lānaʻi, and Kahoʻolawe, including Penguin Bank; the waters off the shore of Kīlauea Point National Wildlife Refuge, Kauaʻi; the waters off the north and southeast shores of Oʻahu; and the waters off the northwest shore of Hawaiʻi (National Marine Sanctuary Program 2007). These waters are particularly important to the endangered North Pacific population of humpback whales (*Megaptera novaengliae*). Currently, the sanctuary's main objective is to protect humpback whales and their habitat within the waters surrounding the main Hawaiian Islands.

Congressionally designated by the Hawaiian Islands National Marine Sanctuary Act in 1992, the sanctuary was required by the Act to create a management plan that outlined the sanctuary's objectives, policies, and activities. As required by the Act, the sanctuary must periodically update its management plan in order to ensure that it is completing its objectives of protecting biologically significant resources, such as humpback whales. Currently, the sanctuary is undergoing a management plan review, the process through which the sanctuary updates its management plan.

As part of a management plan review, the sanctuary must follow a specific process. This process includes 1) an internal evaluation during which sanctuary staff evaluate the existing sanctuary management plan, 2) scoping meetings (when interested members of the public comment on the existing management plan), 3) the development of action plans in which sanctuary staff review comments and prioritize issues for the management plan review, and 4)

the development of draft and final management plans during which sanctuary staff develop new action plans as well as an Environmental Impact Statement (EIS) to support and explain proposed changes to the existing management plan.

Throughout this process, a main concern that has been voiced by both general members of the public and biologists interested in the status of biological resources within the main Hawaiian Islands is that the sanctuary should propose the protection of additional species as an action plan in its updated management plan. The sanctuary's protection of additional species would significantly widen the scope of the sanctuary, likely changing the sanctuary's major objective from solely protecting humpback whales and their habitat to an ecosystem-based approach focused on protecting a number of key species within the sanctuary waters. In order for the sanctuary to justify protecting additional species, the sanctuary will need to develop an Environmental Impact Statement that demonstrates the threatened or endangered status of the species under consideration and supports the improved status of those species through protection within the sanctuary.

This report, then, simulates an Environmental Impact Statement in that it describes the key biological resources within the sanctuary waters, threats to those species, and possible management approaches that would help the protection of those species. The species included within this report are humpback whales, Hawaiian spinner dolphins, false killer whales, Hawaiian monk seals, and sea turtles. These species were chosen primarily based on public support and a previous assessment of additional marine resources for possible inclusion in the Hawaiian Islands Humpback Whale National Marine Sanctuary, prepared for Governor Linda Lingle of Hawai‘i in 2007. This updated report, which is based on information gathered from an array of scientific research papers published on each key species inhabiting the waters of the

main Hawaiian Islands, will provide the sanctuary with summarized research which can be presented to the public during scoping meetings and which can also be used in the official Environmental Impact Statement. Further, this report will be helpful to the sanctuary as it includes specific management and policy recommendations regarding each species based on prior scientific research.

II. HUMPBACK WHALES

Figure 1: Endangered humpback whale.
Credit: Barbara LaCorte, Channel Islands Naturalist Corps.

DESCRIPTION OF SPECIES AND HABITAT

The humpback whale (*Megaptera novaeangliae*), often recognized by its large pectoral fins and entertaining aerial displays, is an endangered marine mammal. Humpback whales inhabit all the major ocean basins and are divided into separate populations based on migratory patterns between their wintering and summering grounds (Reilly et al. 2010). Because humpback whales show a strong site fidelity to wintering and summering grounds, it is possible to designate subpopulations of humpback whales. The North Pacific humpback whale populations include the western North Pacific subpopulation, the central North Pacific subpopulation, and the eastern North Pacific subpopulation (Reilly et al. 2010).

The central North Pacific population of humpback whales characteristically winters in the waters surrounding the main Hawaiian Islands. For this population, its primary occurrence in the winter is from the coast to 50 nautical miles offshore, with the greatest densities of humpback whales in the four-island region and Kaua‘i (Mobley et al. 2001). This population breeds in the main Hawaiian Islands in the winter and feeds in Prince William Sound, Alaska and British Columbia during the summer (Reilly et al. 2010).

As the primary focus of the Hawaiian Islands Humpback Whale National Marine Sanctuary, humpback whales have benefitted greatly from the protection provided by the sanctuary. Listed as an endangered species under the Endangered Species Act in 1973, humpback whales have since recovered to a notable extent (Perry et al. 1999). The North Pacific populations of humpback whales, more than half of whom winter in Hawaiian waters, have rebounded to approximately 20,000 individuals from 1,500 (Barlow 2009). Protection provided by the sanctuary as well as the Endangered Species Act, the Marine Mammal Protection Act, and the international ban on whaling has allowed for the estimated 5.5-6.0% annual increase, suggesting a moderate rate of recovery (Symposium 2009).

THREATS TO SPECIES

Due to the significant increase of the North Pacific populations of humpback whales since the Endangered Species Act and the ban on commercial whaling, the possibility of de-listing humpback whales from the Endangered Species Act has received attention. However, while several populations of humpback whales show signs of recovery, many threats, including persistent organic pollutants, entanglement, ship strikes, whaling, habitat degradation, climate change, and anthropogenic noise, still pose a risk to the full recovery of humpback whales.

Persistent Organic Pollutants

The bioaccumulation of persistent organic pollutants, or POPs, constitutes a serious concern for long-lived, top-level predators, such as humpback whales (Elfes et al. 2009). Bioaccumulation of POPs in humpback whales leads to impaired immunity, increased susceptibility to disease, neurotoxicity, and reproductive impairment (Elfes et al. 2009). Furthermore, additional or heightened health impairments may result from transgenerational accumulation of pollutants, resulting from the transfer of POPs from mothers to calves through birth (Clapham 1999). While studies have found that contaminant levels in Atlantic humpback whales are the highest among humpback whales, the North Pacific populations of humpback whales are particularly threatened by high levels of hexachlorocyclohexane, or HCH, a pollutant which most likely originated from industries in Asia (Elfes et al. 2009).

Entanglement and Ship Strikes

Other threats to humpback whales include entanglement in fishing gear and ship strikes. A study that covered the period from 1972 through 1996 recorded a total of 26 deaths and entanglements of humpback whales between 1972 and October 1996 within the waters surrounding the main Hawaiian Islands (Mazzuca et al. 1998). The study found that the majority of deaths and entanglements occurred in February and that more than half of the deaths and entanglements were calves (Mazzuca et al. 1998). While the cause of death was unknown in several cases, it was found that shark predation was often a secondary cause of death subsequent to entanglement, vessel collision, perinatal death, calf abandonment, illness, or unknown causes (Mazzuca et al. 1998). In this study, vessel strikes accounted for one death and one unknown fate. Additional research suggests that vessel strikes to humpback whales are relatively common

(Laist et al. 2001). In instances of vessel strikes to large-whales, important factors contributing to the seriousness of the vessel strike are the size of the vessel and the speed at which the vessel is traveling at the time of the strike. Larger vessels are more likely to inflict lethal and serious injuries while vessels traveling at 14 knots or faster cause the most severe and lethal injuries (Laist et al. 2001). Thus, because entanglement and ship strikes are serious threats to humpback whales, regulations of the fishing industry as well as vessels traveling within humpback whale habitat may prove beneficial in reducing humpback whale mortality.

Whaling

Whaling, though banned by the International Whaling Commission, also poses a threat to the survival and recovery of the North Pacific humpback whale populations. Even though the North Pacific humpback whale populations are generally increasing, the western North Pacific stock shows signs of a less successful recovery rate (Barlow 2009). With Japan's ongoing scientific whaling program, the western North Pacific stock is at risk for planned catches of 50 individuals per year (Gales et al. 2005). Furthermore, since photographic capture-recapture estimates of North Pacific humpback whales show that small numbers of individuals from the western North Pacific stock winter in Hawaiian waters, whaling poses a threat to several humpback whales that winter within the Hawaiian Islands Humpback Whale National Marine Sanctuary (Barlow 2009).

Habitat Degradation

Habitat degradation of humpback whales may also pose a threat to their long-term recovery. Ongoing and planned offshore oil and gas development may interrupt significant parts of humpback whale habitat (Reilly et al. 2010). Development of coastal lands near humpback

whale habitat may affect humpback whale behavior as humpback whales tend to avoid densely populated areas.

Climate Change

The effects of climate change on humpback whales and their habitat will likely become a cause for concern in the near future. Since humpback whales require coastal bays and lagoons for breeding, such as those located within the main Hawaiian Islands, rises in sea levels due to climate change will affect humpback whale breeding grounds (Learmonth et al. 2006). Furthermore, since triggers for migration, such as seasonality, may be influenced by climate change, it is possible that climate change will disrupt the usual migratory patterns of humpback whales (Learmonth et al. 2006). Additional threats to humpback whales that may result from climate change include a change in prey availability and a loss of feeding grounds.

Anthropogenic Noise

Anthropogenic noise is yet another threat to humpback whales and other cetaceans. Research suggests that cetaceans exhibit behavioral, acoustic, and physiological responses to anthropogenic noise (Nowacek et al. 2007). Specifically, vessel noise from whale-watching boats in Hawai‘i elicited behavioral responses in humpback whales, including abrupt course changes and abnormally long dives (Nowacek et al. 2007). In an observational study conducted by McCauley et al., humpback whales consistently changed course and speed to avoid close encounters with operating seismic arrays (Nowacek et al. 2007). Another study conducted near Kaua‘i indicated that Acoustic Thermometry of Ocean Climate (ATOC) signals lead to consistent effects on humpback whale distribution (Frankel and Clark 2002). Further, coincidental occurrences of marine mammal strandings and military tests of naval sonar suggest

that military sonar may cause some whale species to strand (Nowacek et al. 2007). While additional research is necessary to determine the entirety of effects of anthropogenic noise on humpback whales, it is evident that humpback whales may be negatively affected.

POSSIBLE MANAGEMENT APPROACHES

No-Action Alternative

Because humpback whales still face many threats that are likely to endure and even become worse in the future, it is advisable that the Hawaiian Islands Humpback Whale National Marine Sanctuary maintain its protection of humpback whales and their habitat. Even though the IUCN recently changed the status of humpback whales from Vulnerable to Least Concern, the western subpopulation of North Pacific humpback whales has not recovered as well as other populations. Thus, to ensure the full recovery of this endangered species, protection provided by the sanctuary is necessary.

Additional Regulations

To increase the effectiveness of the sanctuary's protection of humpback whales, several regulations may be implemented. Since research suggests that both the speed and size of vessels affects the frequency and magnitude of vessel strikes to humpback whales, regulations limiting the size and speed of vessels within the sanctuary could play a major role in humpback whale protection (Laist et al. 2001). Specifically, to reduce vessel collisions with humpback whales, the sanctuary could implement management actions to reduce vessel speed below 14 kn in sanctuary waters. The sanctuary may also consider management actions to reduce the number of

vessels larger than 100 m long since larger vessels typically cause a greater percentage of serious injuries to humpback whales than smaller vessels (Laist et al. 2001).

Sanctuary Boundary Expansion

Further, since surface sightings of humpback whales demonstrate the presence of humpback whales in areas outside of the sanctuary boundaries, the expansion of current boundaries would enhance the protection of humpback whales and their habitat. Currently, the sanctuary encompasses the waters within the four-island area of Maui, Molokaʻi, Lānaʻi, and Kahoʻolawe, including Penguin Bank; the waters off the shore of Kīlauea Point National Wildlife Refuge, Kauaʻi; the waters near the north and southeast shores of Oʻahu; and the waters off the northwest shore of Hawaiʻi (National Marine Sanctuary Program 2007). However, high densities of humpback whales also occur in non-sanctuary waters off of Kauaʻi, Oʻahu, and Niʻihau (HIHWNMS). Thus, expansion of sanctuary boundaries to include the waters off the northwest and west shores of Kauaʻi; the waters off the northwest shore of Oʻahu; and the waters surrounding Niʻihau would provide additional protection of humpback whales and their habitat. Boundary expansion beyond these areas would also provide protection for areas in which medium to low densities of humpback whales have been observed.

III. HAWAIIAN SPINNER DOLPHINS

Figure 2: Hawaiian spinner dolphins.
Credit: NMFS Southwest Fisheries Science Center.

DESCRIPTION OF SPECIES AND HABITAT

The spinner dolphin (*Stenella longirostris*) is a small cetacean species found in tropical waters worldwide. Named for their impressive aerial acrobatics, adult spinner dolphins generally grow to six to seven feet in length and weigh approximately 120 to 170 pounds (NOAA Fisheries Office of Protected Resources 2010). Throughout tropical waters, spinner dolphins are associated with inshore waters, islands, or banks (Hammond et al. 2008). For this reason, different populations of spinner dolphins exist across the globe and the species is divided into subspecies and races (Hammond et al. 2008). The Hawaiian spinner dolphin is recognized within the subspecies *Stenella longirostris longirostris* and is considered a separate race of spinner dolphins (Perrin 1998).

Hawaiian spinner dolphins are common throughout the Hawaiian archipelago and within the Hawaiian Islands Humpback Whale National Marine Sanctuary waters. High density areas of Hawaiian spinner dolphins include the waters along the Kona coast of the island of Hawai‘i and the southern and western shores of O‘ahu (Lammers 2004). During the day, Hawaiian spinner dolphins are typically found close to shore in shallow wind-sheltered coves and bays. Shallow coves and bays near the shore provide safe habitat for spinner dolphins to rest during the day. Hawaiian spinner dolphins feed primarily at night by foraging on small mesopelagic fish, shrimp, and squid (Lammers 2004).

There are an estimated 1,488 Hawaiian spinner dolphins in the main Hawaiian Islands and an estimated 3,351 in Hawaiian waters (Barlow 2006). Research suggests that Hawaiian spinner dolphins may consist of smaller subpopulations associated with different islands. In particular, a population genetics study suggests that limited exchange occurs between the spinner dolphin populations that inhabit the waters of each of the main Hawaiian Islands (Andrews et al. 2006). The study demonstrates that there is little gene flow between spinner dolphin populations associated with each island, which allows for the possibility to divide the Hawaiian spinner dolphin population into distinct population segments. Further support for this distinction of populations comes from a study that demonstrates great site fidelity for at least some Hawaiian spinner dolphins in nearshore habitats (Marten et al. 2006) and a study that demonstrates different social behaviors in different regions in the Hawaiian Archipelago (Andrews et al. 2010).

THREATS TO SPECIES

Spinner dolphins, as a species, are not considered endangered or threatened under the Endangered Species Act and are not considered depleted under the Marine Mammal Protection Act. One exception, however, is the subspecies of eastern spinner dolphins (*Stenella longirostris orientalis*), which is considered a depleted stock under the MMPA due to frequent takes by the eastern tropical Pacific purse-seine tuna fishing industry (Southwest Fisheries Science Center 2002). While Hawaiian spinner dolphins, like most spinner dolphins, are not considered endangered, threatened, or depleted, it may be the case that one or more of the island-associated subpopulations of Hawaiian spinner dolphins suffer greater threats than the entire population of Hawaiian spinner dolphins.

Human Disturbance

Since Hawaiian spinner dolphins typically inhabit nearshore areas where vessels and swimmers are common, human disturbance can be a frequent annoyance for populations of Hawaiian spinner dolphins. Recent studies on the effects of human disturbance on dolphins suggest that anthropogenic disturbances elicit behavioral responses in spinner dolphins, including changes in swimming speed, diving and aerial behavior, vocalization patterns, and movement patterns (Courbis 2008). In the long-term, such behavioral responses may lead to decreased fitness, an avoidance of certain habitat, and changes in population status (Courbis 2008). The most common forms of human disturbance to Hawaiian spinner dolphins are disturbances from vessels and "swim-with-wild-dolphins" tours.

Because of their impressive aerial spins, Hawaiian spinner dolphins attract a significant amount of recreational viewing from both residents and tourists in Hawai‘i. However, when

people attempt to approach Hawaiian spinner dolphins in vessels (motor powered or kayak), it disrupts the habitat and rest of Hawaiian spinner dolphins (National Marine Fisheries Service 2007). Similarly, "swim-with-wild-dolphins" tours, during which people approach and swim with wild dolphins, disrupt Hawaiian spinner dolphins while they rest during the day. Since Hawaiian spinner dolphins are protected by the Marine Mammal Protection Act, this type of human disturbance, or harassment, to Hawaiian spinner dolphins can be considered a "take" under the MMPA, thereby making such activities illegal (National Marine Fisheries Service 2007). Specifically, the MMPA defines "take" as "to harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill any marine mammal" and defines "harassment" as "any act of pursuit, torment, or annoyance which (i) has the potential to injure a marine mammal or marine mammal stock in the wild [Level A harassment]; or (ii) has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering [Level B harassment]" (National Marine Fisheries Service 2007). Thus, under the MMPA, human disturbance to Hawaiian spinner dolphins through vessel interaction and "swim-with-wild-dolphins" tours should be prohibited by law.

Entanglement and Bycatch

As with many cetacean species inhabiting the waters of the main Hawaiian Islands, the Hawai‘i-based longline fishery has caused injury to individuals of the Hawaiian spinner dolphin population. From 1994-2005, two spinner dolphins were observed as hooked or entangled by the Hawai‘i-based longline fishery (Forney 2007). One of the injuries was caused by the swordfish-targeting effort in the Hawai‘i-based longline fishery, and the other was caused by the swordfish-style effort (targeting species other than swordfish) (Forney 2007). While both injuries were

non-serious and relatively infrequent compared to other cetaceans, the occurrences demonstrate that the Hawai‘i-based longline fishery poses a threat to Hawaiian spinner dolphins.

In addition to the Hawai‘i-based longline fishery, the nearshore gillnet fisheries in Hawai‘i also pose a threat to Hawaiian spinner dolphins. While there are no estimates on the occurrence of spinner dolphin entanglement in the Hawaiian gillnet fishery, nearshore entanglements of spinner dolphins have been observed (National Marine Fisheries Service 2006). Similarly, occurrences of spinner dolphins becoming entangled in or ingesting marine debris have been observed. Spinner dolphins that become entangled in ghost gillnets or derelict fishing gear could suffer serious injury or mortality as a result of entanglement. Ingestion of plastics by dolphins can result in diminished food consumption, loss of nutrition, internal injury, intestinal blockage, starvation, and death (National Marine Fisheries Service 2006). While these threats to spinner dolphins are known to occur, more specific studies are necessary to determine the extent to which these threats harm Hawaiian spinner dolphins.

Another significant threat to spinner dolphins, especially the eastern tropical Pacific (ETP) population of spinner dolphins, is serious injury or mortality due to bycatch. Bycatch, or the incidental take of species other than those targeted by fishing industries, is prevalent in the eastern tropical Pacific purse-seine tuna fishery, in which spinner dolphins are caught frequently in an attempt to catch large yellowfin tuna (Southwest Fisheries Science Center 2002). While actions have been taken to reduce dolphin bycatch in the ETP purse-seine tuna fishery, the bycatch of spinner dolphins continues to be one of the largest in the world (Southwest Fisheries Science Center 2002).

Anthropogenic Noise

A threat to Hawaiian spinner dolphins that is also known to affect other cetaceans is anthropogenic noise produced from boats, offshore drilling, seismic surveys, explosions, dredging, construction, and sonar (National Marine Fisheries Service 2006). Research on the relationship between anthropogenic noise and cetaceans largely suggests that human-induced underwater noise influences both cetacean behavior and physiology. Specifically, studies examining the relationship between military sonar and marine mammal behavior suggest connections between marine mammal strandings and mid-frequency military sonars (Nowacek 2007). In general, research demonstrates that anthropogenic noises can illicit cetacean behavioral responses, including displacement, changes in distribution, and strandings.

Additional effects of anthropogenic noise on marine mammals include temporary loss of hearing, permanent loss of hearing, disruption of foraging or resting, disruption of communication, change in habitat use, and chronic or acute stress (National Marine Fisheries Service 2006). All of these effects have the potential to directly or indirectly harm Hawaiian spinner dolphins by causing a reduction in fitness and reproduction, disease, and death (National Marine Fisheries Service 2006).

Habitat Degradation

The degradation of important habitat for Hawaiian spinner dolphins constitutes another threat to the health and survival of the Hawaiian spinner dolphin population. Because Hawaiian spinner dolphins inhabit nearshore areas including shallow coves and bays, their habitat is especially threatened by coastal pollution, runoff, and sediment discharge (National Marine

Fisheries Service 2006). Since the effects of habitat degradation on Hawaiian spinner dolphins is not entirely known, further research should be conducted to assess the threat to the population.

POSSIBLE MANAGEMENT APPROACHES

No-Action Alternative

Since the Hawaiian spinner dolphin population is not considered endangered, threatened, or depleted, there is no federal law that mandates the protection of Hawaiian spinner dolphins. For this reason, the sanctuary may decide that no action needs to be taken to protect the population of Hawaiian spinner dolphins.

Promote Existing NOAA Programs and Guidelines

Even without the explicit protection of Hawaiian spinner dolphins by the sanctuary, the sanctuary may enhance protection by promoting existing NOAA programs and guidelines, including Dolphin SMART and NOAA dolphin viewing guidelines. Dolphin SMART is a partnership program between NOAA's Office of National Marine Sanctuaries and National Marine Fisheries Service, the Whale and Dolphin Conservation Society, and the Dolphin Ecology Project (National Marine Sanctuaries 2009). Dolphin SMART encourages responsible stewardship of wild dolphins in coastal waterways by educating commercial businesses about how to minimize wild dolphin harassment (National Marine Sanctuaries 2009). Because a Dolphin SMART program does not currently exist in Hawai‘i, the sanctuary may play an important role in implementing a Hawai‘i Dolphin SMART program similar to the ones developed in other areas.

In addition to Dolphin SMART, the sanctuary could promote current NOAA dolphin viewing guidelines, which recommend that people remain at least 50 yards from spinner dolphins, limit observing time to 30 minutes, and refrain from trying to chase, closely approach, surround, swim with, or touch the animals (Protection of Marine Mammals 2006). The promotion of these guidelines would limit human disturbance to Hawaiian spinner dolphins, especially "swim-with-wild-dolphins" tours, which have been shown to adversely affect Hawaiian spinner dolphins.

Protect Hawaiian Spinner Dolphins

Because of threats to the species and the likelihood of discrete, genetically- and behaviorally-distinct subpopulations of Hawaiian spinner dolphins, the sanctuary may consider protecting Hawaiian spinner dolphins as an additional biological resource within the Hawaiian Islands Humpback Whale National Marine Sanctuary. The variety of threats to the population illustrates the likely need for protection of Hawaiian spinner dolphins in order to maintain the current status of the population. Protection of Hawaiian spinner dolphins provided by the sanctuary could have a variety of results including education and outreach programs promoting the protection of Hawaiian spinner dolphins, the reduction of Hawaiian spinner dolphin incidental takes, the regulation of anthropogenic noise, the regulation of "swim-with-wild-dolphin" tours, and the protection of important habitat. Any of these results, if implemented by the sanctuary, would have a significant role in protecting Hawaiian spinner dolphins.

Expand Boundaries

If the sanctuary concludes that protection of Hawaiian spinner dolphins is appropriate and necessary, as research seems to suggest, the expansion of sanctuary boundaries would further

enhance protection of Hawaiian spinner dolphins. As demonstrated by recorded sightings, spinner dolphins regularly occur at all of the main Hawaiian Islands (Andrews et al. 2010). Given their wide distribution but distinct subpopulations, Hawaiian spinner dolphins may be best protected if the sanctuary expanded its boundaries to include more of the population's habitat, especially the waters off the west side of Hawai‘i, along the Waianae coast of O‘ahu, and along the west side of Kaua‘i (Andrews et al. 2010).

IV. FALSE KILLER WHALES

Figure 3: False killer whale and calf.
Credit: Doug Perrine/seapics.com.

DESCRIPTION OF SPECIES AND HABITAT

The false killer whale (*Pseudorca crassidens*) is a large cetacean that, as its name suggests, shares characteristics with the more well-known species commonly referred to as the killer whale (*Orcinus orca*). Similar to killer whales, false killer whales have 7-12 pairs of large conical teeth and are characteristically black with a rounded, conical head (Pacific Islands Regional Office 2010). False killer whales range in length from 16 feet to 20 feet and can weigh up to approximately 3,000 pounds (Pacific Islands Regional Office 2010). Because false killer

whales are highly social animals and exhibit food sharing behaviors, they typically form pods ranging in size from 10 to 100 individuals (Baird 2002).

False killer whales enjoy a large distribution throughout the world, as they are found in all tropical and temperate oceans (Pacific Islands Regional Office 2010). Both pelagic and insular populations of false killer whales exist, though the large majority are mainly pelagic, which has restricted the amount of research that has been conducted on false killer whales (Baird 2002). In the waters surrounding the Hawaiian Islands, there exist two genetically distinct populations of false killer whales – the insular and pelagic Hawaiian populations. The insular population is considered a discrete population segment since its members are behaviorally unique, genetically distinct, and constitute a separate stock (NRDC 2009). Further, according the Natural Resource Defense Council, the insular population is significant because it occupies a unique ecological setting and differs markedly from other populations of the species in its genetic characteristics (NRDC 2009).

Both the pelagic and insular Hawaiian populations of false killer whales feed mainly on squid and fish, such as mahi-mahi and tuna. The estimated population of the insular population is between 120 and 160 individuals while the number of potentially breeding individuals is less than 50. The insular population has habitat throughout both shallow and deeper waters surrounding the main Hawaiian Islands, including the waters of the Hawaiian Islands Humpback Whale National Marine Sanctuary, whereas the pelagic population inhabits only deeper waters near the Hawaiian Islands. (NRDC 2009)

THREATS TO SPECIES

The Hawaiian insular population of false killer whales inhabits the waters of the Hawaiian Islands Humpback Whale National Marine Sanctuary, where it is affected by the fishing and tourism industries of the main Hawaiian Islands and is subjected to a wide array of threats. Research suggests that the many threats affecting the insular population of false killer whales have contributed to a notable decline in the species over the past 20 years. In particular, the fishing industry, small population size, prey reduction, persistent organic pollutants, ocean acidification, and acoustic impacts pose significant threats to false killer whales.

Hawai‘i-based Longline and Shortline Fisheries

Due to the tendency of the insular population of Hawaiian false killer whales to inhabit both shallower and deeper waters surroundings the main Hawaiian Islands, the population has likely suffered injuries from both the Hawai’i-based longline and shortline fisheries. Fin disfigurations within the insular population of Hawaiian false killer whales suggest that the near-shore individuals experience fisheries interactions and injuries (Baird and Gorgone 2005). Fin disfigurations and other injuries from the fishing industry likely result from fishing gear employed by the industry. According to NRDC, between 2003 and 2007, false killer whales suffered an average mortality/serious injury rate of 7.4 animals per year in the Hawaiian Exclusive Economic Zone, although it is possible that this rate included some individuals from the pelagic population of false killer whales (2009). Hook ingestion is another related threat to false killer whales, as false killer whales can suffer serious injury as a result of depredation and ingestion of fishing hooks meant for tuna or other large fish (Baird 2005). Further, there is a

possibility that several false killer whales have been deliberately shot by small-scale fishers who seek the same fish that false killer whales hunt (Baird 2009).

Small Population Size

The small population size of less than 170 individuals suggests that the population may soon start to experience adverse genetic effects caused by the emergence and persistence of deleterious genes. As research suggests, the insular population of false killer whales has decreased significantly over the past 20 years from at least 500 individuals to approximately 150 (Reeves et al. 2009). The prevalence of other threats suggests that this trend of a declining population will continue and that the small number of potential breeding individuals (50) will contribute to this decline in population size, as 50 individuals is likely to be smaller than the effective population size, or the ideal number of breeding individuals that would not experience the effects of inbreeding and the emergence of deleterious alleles.

Prey Reduction

Another threat that arises as a consequence of the Hawai'i-based fishing industry is the reduction in size and number of the typical prey that false killer whales hunt. Research shows that decreased average body weights and lower catch-per-unit of various fish in the waters surrounding the main Hawaiian Islands has been caused by overfishing by the Hawaiian fishing industry. In turn, the reduction in body weight and abundance of fish can have adverse effects on false killer whales that typically eat mahi-mahi and different types of commercially-fished tuna.

Specifically, research demonstrates that populations of bigeye tuna have been overfished, the average biomass of yellowfin tuna has declined, the catch-per-unit effort of yellowfin tuna has had a declining trend, and the average body weight of mahi-mahi has declined (NRDC 2009). The threat of prey reduction can be especially dangerous to false killer whales that eat significant quantities of large fish and participate in ritualistic prey sharing.

Persistent Organic Pollutants

In larger animals that feed at higher trophic levels, such as dolphins and whales, the potential for dangerous levels of toxic chemicals such as persistent organic pollutants (POPs) and their bioaccumulation becomes a more serious problem. POPs are associated with both biological and physiological effects, including reproductive impairment and immunosuppression (Ylitalo et al. 2009). Further, exposure to PCBs are known to depress false killer whales' immune system and females transfer high concentrations of pollutants to offspring through lipids, so the danger of POPs to the insular population of false killer whales remains high.

Ocean Acidification

Ocean acidification, which can result in large-scale dead zones, can pose a threat to false killer whales since dead zones decrease the availability of prey. Increasing carbon dioxide and declining midwater oxygen concentrations lead to the presence of large dead zones in otherwise healthy oceanic ecosystems. As a result of the reduced oxygen concentrations, productivity declines in mesopelagic microneckton will eventually negatively impact primary predators such as false killer whales (Oleson et al. 2010).

Acoustic Impacts

The effect of acoustics on false killer whale behavior is not well-known. However, mid-frequency acoustic sources are associated with injury and mortality in other cetaceans. The U.S. Navy's Hawai'i Range Complex, or the area that supports Navy training activities in Hawai'i, effects the entire known range of the insular population of Hawaiian false killer whales, so it is likely that acoustics constitute a threat to false killer whales in Hawai'i. (NRDC 2009)

POSSIBLE MANAGEMENT APPROACHES

Because the insular population of Hawaiian false killer whales inhabits and frequents the waters protected by the Hawaiian Islands Humpback Whale National Marine Sanctuary, it would be advisable that the sanctuary consider taking action to protect this species. As suggested by the NRDC in its petition to list the insular population of false killer whales as endangered as well as NOAA's recent recommendation to protect this species, the protection of false killer whales seems to have governmental and public support (NOAA News 2010).

Education and Outreach

In order for the sanctuary to gain the necessary public support to the protect the insular population of false killer whales, it is likely the sanctuary would need to raise awareness about the species and the numerous threats affecting its survival. Because the insular population has decreased in numbers so significantly and because the species is not known to attract public attention to the extent that humpback whales or spinner dolphins do, the public of Hawai'i has not had much interaction with the species. Thus, in order to raise awareness and support for the protection of false killer whales, the sanctuary may consider implementing education and

outreach programs to inform the public about false killer whales and the numerous threats to their survival.

Regulate the Fishing Industry

Because many of the threats to the insular population of Hawaiian false killer whales are connected to the Hawai'i-based longline and shortline fishing industries, additional regulations on the industry would likely result in increased protection of false killer whales. Specifically, as the insular population is considered for protection under the Endangered Species Act, it is likely that the take of false killer whales by the fishing industry will be prohibited. As such, it is advisable that the sanctuary promote regulations that would support the protection of false killer whales. One example is the false killer whale take reduction team's suggestion to the fishing industry to use circle hooks that reduce hooking and entanglements of false killer whales in the Hawai'i-based shortline and longline fisheries (False Killer Whale Take Reduction Team 2010).

Expand Boundaries

Since the insular population of false killer whales inhabits almost the entirety of waters surrounding the main Hawaiian Islands, it would be beneficial if the sanctuary boundaries were expanded to include more waters around the main Hawaiian Islands. The additional protected waters would allow for greater protection of the species as well as increased opportunities for research of the population. While the sanctuary may not have to take the lead role in protecting false killer whales, given that the population will likely become protected under the Endangered Species Act, it is clear that the sanctuary should play a role in false killer whale protection in order to ensure the species survival in the main Hawaiian Islands.

V. HAWAIIAN MONK SEALS

Figure 4: Hawaiian monk seal and pup.
Credit: Flip Nicklin/Minden Picture.

DESCRIPTION OF SPECIES AND HABITAT

The Hawaiian monk seal (*Monachus schauinslandi*) is a critically endangered species that is endemic to the Hawaiian Islands. Due to its uniqueness and cultural significance, Hawaiian monk seals have been recognized as an especially important species. Known as ‘Ilio-holo-i-ka-uau, or “dog that runs in rough water,” the Hawaiian monk seal has a particular cultural significance to native Hawaiians. Only one other species of monk seal still exists today, the Mediterranean monk seal, as the Caribbean monk seal was last sighted in 1952 and is believed to be extinct.

Hawaiian monk seals are pinnepeds that typically grow to seven feet in length and to a weight of 400-600 lbs. Individuals generally live between 20 and 25 years and consume a diet consisting of bottom-dwelling and reef fish, eels, octopus, squid and crustaceans (HIHWNMS 2010). According to studies on the diet of Hawaiian monk seals in the Northwestern Hawaiian Islands, Hawaiian monk seals are opportunistic predators that feed on a variety of prey, including coastal, benthic, and offshore-mesopelagic species (Goodman-Lowe 1998). Hawaiian monk seals inhabit the waters and beaches of the main Hawaiian Islands and the Northwestern Hawaiian Islands. In total, the population is estimated to be only 1100-1200 individuals with a little over 10% of individuals inhabiting the main Hawaiian Islands. However, due to increasing threats in the Northwestern Hawaiian Islands, more Hawaiian monk seals have begun inhabiting the main Hawaiian Islands and the waters of the Hawaiian Islands Humpback Whale National Marine Sanctuary, especially the islands of Kauaʻi and Oʻahu. Decreased predation from sharks and a higher survival rate of pups make the shores of the main Hawaiian Islands ideal habitat for monk seals, with certain areas likely to be designated as critical habitat in the near future (Endangered and Threatened Species 2009). However, research also suggests that habitat in the main Hawaiian Islands may also pose several threats to Hawaiian monk seals, particularly disease transmission from humans, pets, livestock, and feral animals (Littnan et al. 2006).

THREATS TO SPECIES

As a critically-endangered species, the Hawaiian monk seal suffers from a variety of threats that have collectively undermined population recovery efforts. The major threats to Hawaiian monk seals include entanglement in marine debris, effects from human interaction, death or injury from vessel strikes, death from infectious disease, genetic effects of small

population size, fitness loss due to food limitation, death by predators, and effects of climate change.

Entanglement in Marine Debris and Interactions with the Fishing Industry

Entanglement in marine debris, especially derelict fishing gear, constitutes a major threat to the recovery of the Hawaiian monk seal. Because Hawaiian monk seals inhabit the waters and beaches of the Northwestern Hawaiian Islands and, increasingly, the main Hawaiian Islands, derelict fishing gear mainly from the Hawai‘i-based longline and shortline fisheries had become an issue for both adults and pups. A study that investigated the marine debris accumulation in the nearshore marine habitat of the Hawaiian monk seal found that most recovered derelict fishing gear consisted of primarily netting and line. Trawl net was the most common type of net found in the monk seal's habitat. The habitat from which the most debris (7875 kg in 2000) was recovered was the Pearl and Hermes Atoll high entanglement risk zone in the Northwestern Hawaiian Islands. The habitat with the greatest debris density, 165 debris items/km^2 was Kure Atoll high entanglement risk zone. The large amounts of debris found within the critical habitat of the Hawaiian monk seal is known to result in mortality of monk seals from drowning or injury from lacerations and infection. In addition, indirect effects such as lower reproductive success, increased stress, and food limitation have been found to result from entanglement in marine debris. (Boland and Donohue 2003)

While the designation of the Papahānaumokuākea Marine National Monument eliminated most of the interactions between fisheries and Hawaiian monk seals in the Northwestern Hawaiian Islands, fisheries in the main Hawaiian Islands still pose a threat. As Hawaiian monk seals more frequently inhabit the main Hawaiian Islands, concerns about monk seals'

interactions with the fishing industry become more evident. An increasing number of monk seal hookings have occurred in the last decade. State-regulated, shore-based recreational fisheries have been the major cause of these monk seal hookings, which often result in injury or death (Antonelis et al. 2006). Commercial fisheries, particularly those which use nearshore lay gillnets which can cause monk seals to drown, also pose a risk of interactions with Hawaiian monk seals.

Habitat Loss

Habitat loss from coastal development and erosion is a significant threat to the recovery of the Hawaiian monk seal. In the Northwestern Hawaiian Islands, erosion has resulted in loss of critical habitat. In the future, rising sea levels due to climate change will likely lead to a loss of critical habitat for Hawaiian monk seals. Further, for the 10% of the population that inhabit the main Hawaiian Islands and use the beaches for haul-outs and pupping, human development of habitat continues to decrease the habitat available for Hawaiian monk seals.

Currently, critical habitat for the Hawaiian monk seal is only officially designated in the Northwestern Hawaiian Islands. However, with increasing numbers of Hawaiian monk seals inhabiting the main Hawaiian Islands, efforts to designate critical habitat in the main Hawaiian Islands have gained support. In 2008, a petition developed by the Center for Biological Diversity, KAHEA: The Hawaiian-Environmental Alliance, and the Ocean Conservancy requested that critical habitat for the Hawaiian monk seal be expanded to include key beach areas, sand spits and islets, lagoon waters, inner reef waters, and ocean waters out to a depth of 200 meters around the main Hawaiian Islands. This petition outlines the importance of the main Hawaiian Islands to the survival of the Hawaiian monk seal, as this habitat includes physical or biological features essential to the conservation of the species, and qualifies the main Hawaiian

Islands as critical habitat under the Endangered Species Act. (Center for Biological Diversity 2008)

Further, Hawaiian monk seals are known to avoid beaches where they are disturbed. Human presence on beaches where Hawaiian monk seals haul-out can cause the monk seals to avoid those beaches, consequently reducing available habitat and population size. As Hawaiian monk seals avoid particular habitat, this behavior may lead to increased vulnerability to shark predation, particularly for pups that may avoid beaches that are safer but have a greater human presence. (Antonelis et al. 2006)

Infectious Disease

As more Hawaiian monk seals begin to inhabit the waters and beaches of the main Hawaiian Islands, the risk for disease transmission from terrestrial animals to monk seals has become a likely threat to the recovery of the species. A study that examined the potential exposure of Hawaiian monk seals to infectious diseases in near-shore marine habitats found that six of 18 monk seals in the main Hawaiian Islands tested positive for *Chlamydophila abortus*, four tested positive for *Sarcosystis neurona*, two for *Neospora caninum*, two for *Toxoplasma gondii*, and six for *E. coli* 0157. Thus, research shows that Hawaiian monk seals in the main Hawaiian Islands are at risk of exposure to infectious diseases associated with terrestrial animals. Seals are likely infected from inhabiting marine habitats that become contaminated from runoff and from foraging on beaches also inhabited by terrestrial animals. (Littnan et al. 2006)

Small Population Size and Low Genetic Diversity

The small population size of Hawaiian monk seals, approximately 1100-1200 individuals, constitutes a threat to the recovery of the species, as the population may suffer detrimental effects from low genetic diversity. A study on the genetic diversity of Hawaiian monk seals confirmed that the Hawaiian monk seal exhibited low variation at all molecular markers tested. Screening of microsatellite loci revealed unprecedentedly low levels of allelic diversity and heterozygosity. The low genetic diversity of Hawaiian monk seals is most likely the result of a population bottleneck in the Hawaiian monk seal population. A population bottleneck, or an event in which a significant percentage of a population are killed, can lead to inbreeding and subsequent genetic problems. The Hawaiian monk seal population likely suffered from the bottleneck effect when the population was drastically reduced as a result of hunting in the 19th century. (Schultz et al. 2008)

Food Limitation

A significant concern for the recovery of Hawaiian monk seals is food limitation. Overfishing by the Hawai‘i-based shortline and longline fisheries and changing oceanographic processes due to climate change have both contributed to a limited food supply for Hawaiian monk seals in the Northwestern Hawaiian Islands. The limited food supply in the Northwestern Hawaiian Islands has contributed to the movement of Hawaiian monk seals from the Northwestern Hawaiian Islands to the main Hawaiian Islands. Pups in the main Hawaiian Islands tend to have higher birth weights and fitness levels than pups born in the Northwestern Hawaiian Islands, likely because of the greater food supply in the main Hawaiian Islands. (NMFS 2007)

Predation

Shark predation is a major threat to Hawaiian monk seals, especially to the majority of the population that inhabit the Northwestern Hawaiian Islands. The incidence of shark attacks and mortalities of pups has increased in recent years, with a range of 18 to 30% of pups in French Frigate Shoals being attacked each year. However, efforts to reduce shark predation on pups, including removing sharks via hook and line and harpoon, have decreased the total estimated shark predation at French Frigate Shoals. (Antonelis et al. 2006)

POSSIBLE MANAGEMENT APPROACHES

Given the critically endangered status of the Hawaiian monk seal and the numerous threats that persist and could worsen in the future, it is advisable that the sanctuary take measures to enhance the protection of the Hawaiian monk seal through a number of possible approaches.

No-Action Alternative

The cultural and ecological significance as well as the critically endangered status of the Hawaiian monk seal counter the possibility of the no-action alternative, in which the sanctuary would make no changes to its management plan regarding Hawaiian monk seals. In addition, this alternative would likely be very difficult to accomplish legally, as critical habitat for the Hawaiian monk seal will soon be designated in the main Hawaiian Islands, thus creating an obligation for the sanctuary to acknowledge the critical habitat. Thus, a no-action alternative is not recommended for the sanctuary's updated management plan.

Education and Outreach

Education and outreach efforts constitute an important policy approach that could assist in the recovery of the Hawaiian monk seal while also keeping regulation to a minimum. The sanctuary could take steps to inform the public to maintain distance from monk seals, especially when hauling out on beaches. As more monk seals frequent the main Hawaiian Islands, educational efforts to inform the public become more important. Informing the public of the importance of Hawaiian monk seals and their habitat could effectively reduce the loss of critical habitat to development and construction. Further, with knowledge of the negative effects of human disturbance on Hawaiian monk seals, the public would be less likely to disturb Hawaiian monk seals in the main Hawaiian Islands.

Habitat Restoration

Habitat restoration could prove to be an effective way to help the recovery of the Hawaiian monk seal. A habitat restoration effort that proved successful for the conservation of monk seals and other species is the enlargement of Tern Island in the French Frigate Shoals when the United States Navy built a Naval Air Station. This enlargement of Tern Island, though not meant as a habitat restoration effort, effectively increased available habitat for breeding monk seals, turtles, and seabirds (Antonelis et al. 2006). Similar efforts to increase available habitat in the Northwestern Hawaiian Islands and to limit development and construction in the main Hawaiian Islands would be advisable policy approaches to protecting the Hawaiian monk seal.

Reduce Marine Debris

Efforts to reduce marine debris, either through regulatory mechanisms or active removal of marine debris in critical habitat, could significantly reduce the instances of Hawaiian monk seal injury and death due to entanglement in marine debris. Regulations on the fishing industry to reduce derelict fishing gear would likely reduce the amount of marine debris that threatens Hawaiian monk seals. However, the predominance of nonlocal sources of debris necessitates a Pacific-wide approach to reducing Hawaiian monk seal entanglement. To effectively combat the issue of derelict fishing gear, other entities beyond the Hawai‘i-based fisheries would need to mitigate the abandonment of fishing gear. (Boland and Donohue 2003)

Actively removing marine debris from the critical habitat of the Hawaiian monk seal would effectively reduce the number of Hawaiian monk seal entanglements. As a study on the marine debris accumulation in the nearshore marine habitat of the endangered Hawaiian monk seal suggests, sites without a well-defined barrier reef would benefit from targeting debris removal from shore whereas sites with classic atoll configurations would benefit from intensive survey and removal of reef-hung derelict fishing gear. Thus, if the sanctuary put resources toward marine debris removal, it could actively contribute to the recovery of the Hawaiian monk seal. (Boland and Donohue 2003)

Expand Boundaries

Since Hawaiian monk seals increasingly inhabit the main Hawaiian Islands, expanding the boundaries of the sanctuary to include the beaches on which Hawaiian monk seals typically haul-out would ensure greater protection of the Hawaiian monk seal and its habitat. To include the most critical habitat of the Hawaiian monk seal, the sanctuary should expand boundaries to

include the shores of Kauaʻi and Niʻihau. This would ensure greater protection of Hawaiian monk seal adults and especially pups from human disturbance and habitat destruction.

VI. SEA TURTLES

Figure 5: An endangered hawksbill sea turtle
Credit: Cheryl King.

DESCRIPTION OF SPECIES AND HABITAT

Sea turtles are commonly found in the waters surrounding the main Hawaiian Islands as well as the Northwestern Hawaiian Islands. The most commonly found species of sea turtles are the green turtle (*Chelonia mydas*), hawksbill turtle (*Eretmochelys imbricate*), leatherback turtle (*Dermochelys coriacea*), loggerhead turtle (*Caretta caretta*), and olive ridley turtle (*Lepidochelys olivacea*). Of these species that inhabit the main Hawaiian Islands, the loggerhead turtle, leatherback turtle, and hawksbill turtle are endangered while the green turtle and olive ridley turtle are threatened under the Endangered Species Act.

Green turtles are the most common of the sea turtles that inhabit the main Hawaiian Islands. The green turtle inhabits the nearshore waters of the main Hawaiian Islands with important foraging areas along the coastlines of Oʻahu, Molokaʻi, Maui, Lanaʻi, and Hawaiʻi Island (HIHWNMS 2007). Green turtles occur in the coastal waters surrounding the Main Hawaiian Islands, primarily from shore to the 55-fathom isobaths. They are found here throughout the year and also migrate seasonally to the Northwestern Hawaiian Islands to reproduce. Specific habitat includes convergence zones in the ocean, oceanic beaches for nesting, and benthic feeding grounds in coastal areas.

The green turtle is the most abundant large marine herbivore and feeds primarily on macroalgae and seagrasses, though specific diet varies depending on an individual turtle's life history stage (Arthur et al. 2008). The coastlines of Oʻahu, Molokaʻi, Maui, Lanaʻi, and Hawaiʻi Island and the Johnston Atoll in the Northwestern Hawaiian Islands are especially important foraging areas for green sea turtles, as these areas are rich in algae pastures (HIHWNMS 2007). Specific foraging grounds in the main Hawaiian Islands include Kāneʻohe Bay, Palaʻau, Kiholo Bay, and Punaluʻu Bay (Dutton et al. 2008).

Research of green sea turtles in the main Hawaiian Islands suggests that Hawaiian green sea turtles are genetically distinct from other populations of green sea turtles in the Pacific Ocean. A specific study on stock mixture analysis shows that green sea turtles that forage in the Hawaiian Archipelago comprise one genetic stock primarily derived from the nesting population at French Frigate Shoals. Only three of the turtles sampled from the French Frigate Shoals contained unique haplotypes, which indicates that the Hawaiian population is rarely visited by turtles from rookeries outside the Hawaiian Archipelago. As a result of genetic research, green sea turtles that inhabit the main Hawaiian Islands and the Northwestern Hawaiian Islands should

be considered a distinct regional population for management purposes and should be assessed separately from other Pacific stocks with respect to risk. (Dutton et al. 2008)

The hawksbill turtle is less commonly sighted in the main Hawaiian Islands, as it is a highly migratory species and nesting areas are widely distributed. Hawksbill turtles are small to medium-sized compared to other sea turtle species, but can weigh up to 200 lbs. The diet of hawksbill turtles consists of a combination of plant and animal material, including primarily sponges and other invertebrates. Hawksbill turtles typically find their food by foraging at or near the sea floor and in coral reefs.

Hawksbill turtles may have important habitat in the main Hawaiian Islands although they are not commonly sighted there. Hawksbill turtles are not known to inhabit the Northwestern Hawaiian Islands. Hawksbill turtles typically inhabit healthy coral reefs, though their main habitat depends on their life history stage. Over the life history of a hawksbill turtle, individuals occupy a range of habitats including coral reefs, hard bottom habitats, sea grass, and algal beds. Kamehame, a small island on the southeastern coast of the island of Hawai‘i, is an important nesting habitat for hawksbill turtles and hosts a major portion of all hawksbill nesting in the Hawaiian Archipelago (Balazs et al. 1996). Other nesting areas on the islands of Hawai‘i, Maui, Moloka‘i, and O‘ahu have been identified (HIHWNMS 2007).

The leatherback, loggerhead, and olive ridley turtles are less commonly sighted in the main Hawaiian Islands but still inhabit the offshore areas. The leatherback turtle is an offshore species of turtle that is typically found in deep waters off the Hawaiian Islands. As individuals can weigh up to 2,000 lbs., the leatherback turtle is the world’s largest turtle. Leatherback turtles

do not nest in the Hawaiian Archipelago, but individuals inhabit the offshore waters of the main Hawaiian Islands. (HIHWNMS 2007)

Loggerhead turtles characteristically have large heads and powerful jaws. The habitat of loggerhead turtles depends on its life history stage, as loggerhead turtles occupy the terrestrial, oceanic, and neritic zones at different points during their lives. Loggerhead turtles do not nest in the Hawaiian Islands, but frequent the waters surrounding the main Hawaiian Islands. Significant numbers of loggerhead turtles have been caught by the Hawai‘i-based longline fishery. (FWS and NOAA 2010)

Olive ridley turtles are a highly migratory species of sea turtle that are rarely found in Hawaiian coastal waters. However, olive ridley turtles are the most commonly caught turtle species in offshore fishing operations in the Hawaiian Archipelago (NOAA Fisheries 2007). The olive ridley turtle is relatively small and is considered the most abundant sea turtle in the world. Despite its abundance, all populations of the olive ridley turtle are either threatened or endangered under the Endangered Species Act. Olive ridley turtles are omnivores and typically consume algae, lobster, crabs, mollusks, and fish. Research on olive ridley turtles caught in the Hawai‘i-based longline fishery indicates that their most common prey are pyrosomes and salps (Polovina et al. 2004).

THREATS TO SPECIES

Habitat Degradation

A major threat to sea turtles, especially green and hawksbill sea turtles, which inhabit the waters surrounding the main Hawaiian Islands, is habitat degradation and habitat loss. Increased

coastal development in the main Hawaiian Islands has resulted in a loss of nesting habitat for hawksbill and green turtles. Degradation of coral reefs due to coastal development, pollution, overfishing, and overuse is a threat to turtles that depend on corals for foraging purposes, particularly hawksbill turtles. (Hutchinson and Simmonds 1992)

Habitat loss due to climate change is another concern for sea turtles that inhabit both the main Hawaiian Islands and the Northwestern Hawaiian Islands. Many of the islands of the Northwestern Hawaiian Islands are low-lying and are particularly vulnerable to increases in global average sea level rise as predicted by climate models. Scientific models suggest the greatest land loss due to sea level rise will occur on atolls such as French Frigate Shoals and Pearl and Hermes Reef. The predicted loss of land at French Frigate Shoals will be particularly detrimental to the Hawaiian population of green sea turtles, 90% of which nest at French Frigate Shoals. (Baker et al. 2006)

Disease

Green turtles that inhabit the nearshore waters of the main Hawaiian Islands have been subject to fibropapillomatosis, a now-common debilitating tumor-forming disease. Although fibropapillomatosis does not directly cause death of inflicted turtles, it can increase the risk of entanglement for green turtles inflicted with the disease. Fibropapillomatosis can also negatively affect the reproductive success of green turtles (Pepi 2002). Fibropapillomatosis became prevalent in Hawaiian green turtles in the 1980s, but the disease's origins are largely unknown. Since turtles only develop this disease after visiting the nearshore habitat of the main Hawaiian Islands, it is likely that fibropapillomatosis results from some combination of factors related to development. Research shows that elevated disease rates correlated with watersheds with high

nitrogen-footprints, suggesting that natural and anthropogenic factors that affect coastal eutrophication could contribute to the presence of the transmittance of the disease. Research also suggests that turtle size is a consistent disease risk factor, as older turtles are more likely to contract the disease, and that the disease is linked to invasive macroalgae, a major part of the diet of green turtles. (Van Houtan et al. 2010)

Entanglement in Fishing Gear and Marine Debris

Entanglement in fishing gear and marine debris affects all sea turtles that inhabit the waters near the main Hawaiian Islands. Offshore species such as the olive ridley, loggerhead, and leatherback turtles are especially susceptible to entanglement since those species inhabit areas in which the Hawai‘i-based longline fishing industry operates. While recent attempts to reduce the entanglement of sea turtles in fishing gear, such as turtle excluder devices and the use of circle hooks rather than J-shaped hooks, have been successful, the threat of entanglement still remains a serious one.

Harvest by Humans

Overharvesting of green turtles played a significant role in the original decline of the species until harvest ceased due to protection under the Endangered Species Act. Native Hawaiians have traditionally harvested green turtles; however, due to overexploitation of the species, harvest of green turtles was made illegal. The threat of harvest still remains today as Native Hawaiians continue to push for the restoration of indigenous hunting rights in the Archipelago. While the type of harvest that occurred prior to the Endangered Species Act would most certainly lead to a serious decline in the green turtle population, research that utilized a

Bayesian surplus-production model suggests that a limited harvest might now be demographically feasible (Chaloupka and Balazs 2007).

Illegal Trade

Trade of the hawksbill turtle shell or "bekko", illegal under the Convention on International Trade in Endangered Species (CITES), poses a threat to the recovery of the hawksbill turtle. Demand for shell plates and items made from the shell, such as combs, brushes, spectacle frames and luxury goods have fueled the illegal trade of hawksbill turtles. Major suppliers of hawksbill turtle shells have traditionally been Caribbean countries while major markets include Japan, the United States, and European countries. The ban of trade of hawksbill turtles due to CITES, however, reduced this threat. (CITES 2011)

POSSIBLE MANAGEMENT APPROACHES

Protect Sea Turtles

Given the endangered or threatened status of the green, hawksbill, leatherback, loggerhead, and olive ridley turtles, it is advisable that the sanctuary consider protecting these sea turtle species in order to promote the turtles' recoveries. Protection of these turtle species by the sanctuary would likely lessen the threats, especially anthropogenic threats, to sea turtles, thereby helping the recovery of the species. Given the higher incidence of green and hawksbill turtles in the sanctuary waters, it is more advisable to protect those species, as the leatherback, loggerhead, and olive ridley turtles do not frequent sanctuary waters as often.

Regulate Fishing Industry

Given the threat of incidental take by entanglement in fishing gear and marine debris, the sanctuary could effectively promote the recovery of sea turtles by regulating the fishing industry. Specific regulations that have proven successful in reducing the incidental take and bycatch of sea turtles are turtle excluder devices (TEDs) and the use of circle hooks. A turtle excluder device is a grid of bars with an opening at the top or bottom of a trawl net. The bars prevent larger animals, such as turtles and sharks, from entering the trawl net and the opening at the bottom or top of the net allows for the escape of the animal.

The use of circle hooks rather than J-shaped hooks has been proven to significantly reduce the number of turtles caught as bycatch. In 2004, regulations created by the National Marine Fisheries Service for the Hawai‘i-based longline swordfish fishery required vessels to switch from using a J-shaped hook with squid bait to a wider circle-shaped hook with fish bait. These regulations led to significant reductions in sea turtle and shark capture rates without reducing capture rates of target species. Specifically, capture rates of leatherback and loggerhead turtles declined by 83% and 90%, respectively. (Gilman et al. 2007)

The successes of regulations that require the use of turtle excluder devices and circle hooks suggest that additional regulations on the fishing industry could further reduce the number of takes of endangered and threatened sea turtles. If the sanctuary were to protect sea turtles, it would have sufficient leverage to regulate the fishing industry while advancing the recovery of Hawaiian sea turtle populations.

Improve Water Quality

Although poor water quality is not a direct threat to Hawaiian sea turtles, improvement of water quality in nearshore areas would likely contribute to the recovery of green turtles. Green turtles are very susceptible to fibropapillomatosis, a disease that is linked to coastal development and invasive algae. Poor water quality increases the likelihood of green turtles contracting fibropapillomatosis. The sanctuary could effectively improve water quality by creating no-dump zones and limiting coastal development and sedimentation. These efforts could significantly reduce the instances of fibropapillomastosis in green turtles.

No-Action Alternative

Since green turtles, the most commonly sighted turtle in sanctuary waters, have experienced a significant recovery rate, the sanctuary may decide not to provide additional protection to any Hawaiian sea turtle populations. There is a possibility that green turtles could be delisted from the Endangered Species Act, which would make a non-action alternative viable. However, given the variety of threats that remain and the endangered and threatened statuses of the other sea turtles, no additional protection would likely be detrimental to the species.

VII. CONCLUSION

A significant aspect of the Hawaiian Islands Humpback Whale National Marine Sanctuary's ongoing management plan review is the completion of its objective of protecting biologically significant resources, which includes the consideration of other biological resources that inhabit the sanctuary waters. As the sanctuary undergoes its management plan review, it is important that the sanctuary staff has access to broad-reaching, reliable, and summarized information concerning the biological resources within the sanctuary waters. This report seeks to provide that type of information for the biological resources that most frequently visit sanctuary waters and that would most benefit from additional protection provided by the sanctuary. With this type of summarized research available, the sanctuary will be able to determine which species should be included in its updated management plan and what type of steps should be taken to protect the important biological resources inhabiting the sanctuary.

As made clear by an extensive literature review and the summarized descriptions of each species, threats to each species, and possible management approaches, research suggests that all of the species examined would benefit from continued or additional protection provided by the sanctuary. In particular, the status of and current threats to humpback whales, Hawaiian spinner dolphins, false killer whales, Hawaiian monk seals, and five species of sea turtles demonstrate that the recovery of these species would benefit from inclusion in the sanctuary's updated management plan.

Though several populations of humpback whales show signs of recovery and delisting humpback whales from an endangered status to a threatened status is a slight possibility, many threats to the recovery of humpback whales remain. Threats, including persistent organic

pollutants, entanglement, ship strikes, whaling, habitat degradation, climate change, and anthropogenic noise, pose a significant risk to humpback whales. The existence of these threats makes clear that the sanctuary should continue its protection of humpback whales through regulatory mechanisms as well as education and outreach efforts. The sanctuary may even consider the expansion of its boundaries in order to more effectively protect humpback whales.

The island-associated subpopulations of Hawaiian spinner dolphins demonstrate that each genetically-distinct subpopulation suffers from threats that could be reduced by sanctuary consideration and protection of Hawaiian spinner dolphins in its management plan. Human disturbance, entanglement, anthropogenic noise, and habitat degradation are serious threats to Hawaiian spinner dolphins. These threats especially affect subpopulations that associate with different islands in the main Hawaiian Islands. The sanctuary could reduce these threats and promote the protection of the species by outlining action plans in its updated management plan that seek to educate the public, promote existing policies on human and wild dolphin interactions, and protect important habitat.

False killer whales, likely to be listed as endangered due to the significant decline in its population size over the past few decades, should be considered in the sanctuary's updated management plan. The status of false killer whales is largely unknown to the public and the Hawaiian fishing industry, suggesting that the sanctuary could have a significant impact of the recovery of the species by educating the public and regulating the fishing industry. Some major threats to false killer whales include entanglement and take due to the fishing industry, its small population size, prey reduction, persistent organic pollutants, ocean acidification, and acoustic impacts. At least a few of these major threats could be reduced if false killer whales are protected in the sanctuary's updated management plan.

Research on Hawaiian monk seals, a critically endangered species and one of only two species of monk seals remaining, strongly suggests that additional efforts to protect Hawaiian monk seals in the main Hawaiian Islands could significantly help the species' recovery. Threats affecting the Hawaiian monk seal include entanglement in marine debris, effects from human interaction, death or injury from vessel strikes, death from infectious disease, genetic effects of small population size, fitness loss due to food limitation, death by predators, and effects of climate change. To reduce the impact of these threats on Hawaiian monk seals, the sanctuary should take action to protect critical habitat, reduce marine debris and vessel strikes through regulation, and inform the public in order to reduce human and monk seal interaction.

All five species of sea turtles that inhabit the waters of the sanctuary – the green, hawksbill, loggerhead, leatherback, and olive ridley turtles – are either threatened or endangered. Sea turtles in the main Hawaiian Islands suffer from habitat degradation, disease, incidental take, illegal trade and harvest by humans. Given the variety of threats affecting sea turtles in the main Hawaiian Islands, the sanctuary should consider protecting all species of sea turtles by implementing education and outreach programs and developing regulations that would aid the recovery of these species. However, since the green and hawksbill turtles more frequently visit the sanctuary waters, priority should be given to the protection of these two species, as the sanctuary would have to expand its boundaries in order to effectively protect the loggerhead, leatherback, and olive ridley turtles.

As demonstrated by the threats to and status of each species, the sanctuary should aid in the recovery of each species by explicitly outlining action plans in its updated management plan. Priority should be given to the protection of humpback whales, as the sanctuary has already proven effective in protecting humpback whales, as well as false killer whales, Hawaiian monk

seals, and hawksbill turtles due to their critical status. Hawaiian spinner dolphins and the other species of sea turtles are less threatened but are still in need of protection by the sanctuary.

If the sanctuary chooses to protect additional species, as based on public support and research supporting the necessity of protecting the species, this will significantly widen the scope of the sanctuary, likely changing the sanctuary's major objective from solely protecting humpback whales and their habitat to an ecosystem-based approach focused on protecting a number of key species within the sanctuary waters. In order for this to occur, however, the sanctuary must complete its scoping meetings with the public, develop action plans, develop draft and final management plans, and conduct an Environmental Impact Statement. Through the remainder of this process, this report will play a significant role in providing the sanctuary with summarized research on each key species and with management approaches that would aid in the recovery of each species.

VIII. WORKS CITED

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EDUCATION

The Pennsylvania State University, University Park, PA August 2007-May 2011
Schreyer Honors College Scholar, Dean's List
Bachelor of Science in Environmental Resource Management
- Selected Standard Bearer for major, Honors, and Highest Distinction
- Thesis Title: The Biological Resources of the Hawaiian Islands Humpback Whale National Marine Sanctuary's Environmental Impact Statement

Bachelor of Arts in Philosophy

PROFESSIONAL EXPERIENCE

Morgan Center for Student Athletes, University Park, PA September 2010-May 2011
Math, Science, and Business Tutor
- Tutor Penn State students in Math, Biology, and Agribusiness Management 15 hours/week

National Oceanic and Atmospheric Administration, Honolulu, HI June 2010-August 2010
Hollings Scholar for the Hawaiian Islands Humpback Whale National Marine Sanctuary
- Contributed information and edits to documents for the sanctuary's management plan review
- Wrote a report on the possible inclusion of additional biological resources into the sanctuary
- Developed a presentation for the Sanctuary Advisory Council and the NOAA Hollings Symposium

Penn State Biology Department, University Park, PA May 2009-August 2009
Undergraduate research assistant
- Conducted field and laboratory research related to invasive thistles and surrounding ecosystem
- Identified and examined the effects of predicted climate change on the growth and phenology of thistles

Indian Echo Caverns, Hummelstown, PA Seasonal 2004-2007
Educational Tour Guide and Gift Shop Employee
- Gave educational hour-long tours of the cavern to groups of 20-30 tourists, about five times a day

INVOLVEMENT

Penn State Environmental Society (President)	September 2008-January 2011
Penn State Eco-Action	August 2008-May 2011
Penn State Philosophy Club	October 2009-May 2011
Penn State Club Cross Country	September 2008-May 2011

VOLUNTEERISM

The Sierra Club's ReEnergize the Vote Campaign Volunteer	September -December 2010
Pennsylvania Literacy Corps English as a Second Language Tutor	January 2010-May 2010
Penn State's Take Charge! Energy Awareness Campaign Volunteer	November 2009-May 2011
Shaver's Creek Environmental Center Event Volunteer	October 2008-May 2011
Making Strides Against Breast Cancer Event Volunteer	October 2003-May 2011

PUBLICATIONS

Zhang, R., **A. Leshak**, and K. Shea. (Accepted January 25, 2011) Decreased structural defense of an invasive thistle under warming. *Plant Biology*, 459.

FUTURE ACADEMIC PLANS

New York University School of Law, Manhattan, NY August 2011-May 2014
J.D. Candidate, Class of 2014
Intent to specialize in environmental law

HONORS AND SCHOLARSHIPS

The Pennsylvania State University John W. White Graduate Fellowship
- Scholarship awarded by the Senate Committee on Student Life to recognize outstanding undergraduate students graduating with highest distinction and who plan to enroll in graduate study

College of Agricultural Sciences and Gamma Sigma Delta Honor Society Research Exhibition
- Second prize in the Undergraduate Category awarded on March 17, 2011

Honors Thesis in Environmental Resource Management
- Thesis Title: The Biological Resources of the Hawaiian Islands Humpback Whale National Marine Sanctuary Environmental Impact Statement

National Oceanic and Atmospheric Administration 2009 Ernest F. Hollings Scholarship
- A nationally recognized scholarship providing two years of financial assistance and a paid internship

Schreyer Honors College Academic Excellence Scholarship
- An annual scholarship awarded to academically successful students enrolled in the Schreyer Honors College

National Science Foundation Grant Summer 2009
- Funded research for a publication on invasive thistles

Harry and Kathleen Ulrich Agricultural Sciences Scholarship 2010

Soil and Water Conservation Society Keystone Chapter Scholarship 2009

SPECIAL ACHIEVEMENTS

Youth Engagement Roundtable Participant (February 2011)
- Participated in an interactive discussion with Kalpen Modi, Director of the Office of Public Engagement
- Met President Obama prior to his policy speech on alternative energy at Penn State University

Certified Pennsylvania Literacy Corps Tutor
- Certification as an English as a second language tutor after completing 120 hours of tutoring

COMPUTER SKILLS

- Command of Microsoft Office programs including Word, Publisher, and PowerPoint
- Experience interpreting data in Excel, Minitab, and simulation models