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HAWAIIAN MONK SEAL (*Monachus schauinslandi*)

STOCK DEFINITION AND GEOGRAPHIC RANGE

Hawaiian monk seals are distributed throughout the Northwestern Hawaiian Islands (NWHI) in six main reproductive subpopulations at French Frigate Shoals, Laysan and Lisianski Islands, Pearl and Hermes Reef, and Midway and Kure Atoll. Small numbers also occur at Necker, Nihoa, and the main Hawaiian Islands, primarily at Niihau. Genetic variation in Hawaiian monk seals is extremely low and may reflect both a long-term history at low population levels and more recent human influences (Kretzmann et al., 2001). The tendency for genetic drift may have been relatively large, due to the small size of different island/atoll subpopulations. However, 10-15% of these seals migrate among the subpopulations (Johnson and Kridler 1983; National Marine Fisheries Service [NMFS] unpubl. data) and, to some degree, this movement should counter the development of separate genetic stocks. Genetic variation among the different island populations is low (Kretzmann et al., 1997; 2001).

Demographically, the different island subpopulations have exhibited considerable independence. For example, abundance at French Frigate Shoals grew rapidly from the 1950s-1980s, while other subpopulations declined rapidly. Variability in past population trends may be partially explained by changes in levels of human disturbance (Gerrodette and Gilmartin 1990; Ragen 1999). Current demographic variability among the subpopulations probably reflects a combination of age structure effects resulting from different recent histories and variable environmental conditions. While research and recovery activities may focus on the problems of single island/atoll subpopulations, the species is managed as a single stock.

POPULATION SIZE

The best estimate of the total population size is 1,409. This estimate is the sum of counts at the six main Northwest Hawaiian Islands subpopulations, an extrapolation of counts at Necker and Nihoa Islands, and counts at the main Hawaiian Islands. Abundance of the main reproductive subpopulations is best estimated using the number of seals identified at each site. Individual seals are identified by flipper-tags and applied bleach-marks, and distinctive natural features such as scars and pelage patterns. Flipper-tagging of weaned pups began in the early 1980s and the majority of the seals in the main reproductive subpopulations can be identified on the basis of those tags. In 2001, identification efforts were conducted during two- to six -month studies at all main reproductive sites. A total of 1,257 seals (including 178 pups) were observed at the main reproductive subpopulations in 2001 (Johanos and Baker, in press). The estimated probability that known-aged seals are identified during a given field season average over 90% at French Frigate Shoals, Laysan Island, Midway Atoll and Kure atoll; approximately 85% at Lisianski Island, and approximately 80% at Pearl and Hermes Reef (Harting 2002). These probabilities likely represent the potential extent of negative bias in enumerating the subpopulations.

Monk seals also occur at Necker and Nihoa Islands, where counts are conducted from zero to a few times in a single year. Abundance is estimated by correcting the mean of all beach counts accrued over the past five years. The mean (±SD) of all counts (excluding pups) conducted between 1997-2001 were 15.4 (± 6.8) at Necker Island and 18.0 (± 9.2) at Nihoa Island (Johanos and Ragen 1999; Johanos and Baker 2000, 2001, 2002, in press). The relationship between mean counts and total abundance at the reproductive sites indicates that the total abundance can be estimated by multiplying the mean count by a correction factor (±SE) of 2.89 (±0.06, NMFS unpubl. data). Resulting estimates (plus the average number of pups known to have been born during 1997-2001) are 45.7 (± 19.8) at Necker Island and 54.3 (± 26.5) at Nihoa Island.

A 2001 aerial survey determined a minimum abundance of 52 seals in the main Hawaiian Islands (Baker and Johanos, submitted). Seals in the main Hawaiian Islands include those naturally occurring and any animals remaining from 21 seals released around the islands in 1994.

Minimum Population Estimate

The total number of seals identified at the main reproductive sites is the best estimate of minimum population size at those sites (i.e., 1,257 seals). Minimum population sizes for Necker and Nihoa Islands (based on the formula provided by Wade and Angliss (1997)) are 32 and 37 , respectively. The minimum abundance estimate for the main Hawaiian Islands based upon the 2001 aerial survey is 52 seals. The minimum population size for the entire stock (species) is the sum of these estimates, or 1,378 seals.

Current Population Trend

The total of mean non-pup beach counts at the main reproductive NWHI subpopulations in 2001 is approximately 60% lower than in 1958. In previous Hawaiian monk seal stock assessments, current population trend was estimated using log-linear regression of total non-pup beach counts (excluding Midway) since 1985. This method however, had two shortcomings. First, Midway Atoll counts were excluded because there was very little field effort at Midway prior to 1992, due to the small number of seals present at that time. By excluding Midway, comparability throughout the time series was achieved at the expense of completeness. By now, the Midway subpopulation has grown considerably and is an integral part of the stock that should be represented in the trend analysis. Thus, this report analyzes current population trend using all six main subpopulations.

Counts declined from 1985 to 1993, then became rather stable. As a result, a log-linear trend through the entire time series has resulted in lack of fit. To remedy this, a broken-line regression is fitted (two regression lines joined at a break point), with the break point chosen to minimize the sum of squares error (B. Venables, s-news website, http://www.biostat.wustl.edu/mailinglists/s-news/200004/msg00212.html). This method estimates that the total counts declined 4.3% yr^{-1} until 1993, then declined at 0.7% yr^{-1} thereafter (Fig. 1). The broken line regression fit significantly better than a single regression line (p = 0.02). Thus, current population trend is best estimated as -0.7% yr^{-1} (95% CI = -2.1% to 0.8% yr^{-1}. For comparison, if Midway Atoll counts are excluded from this analysis, results are similar (pre-1993 decline of 4.5% yr-1, subsequent decline of 1.4% yr^{-1}), except that the post-1993 decline is steeper because the increasing trend at Midway is omitted. The low mean beach count in 2001 reflects, in part, both continued declines in counts at French Frigate Shoals and widespread low juvenile survival associated with an Unusual Mortality Event in 2001 (see below).

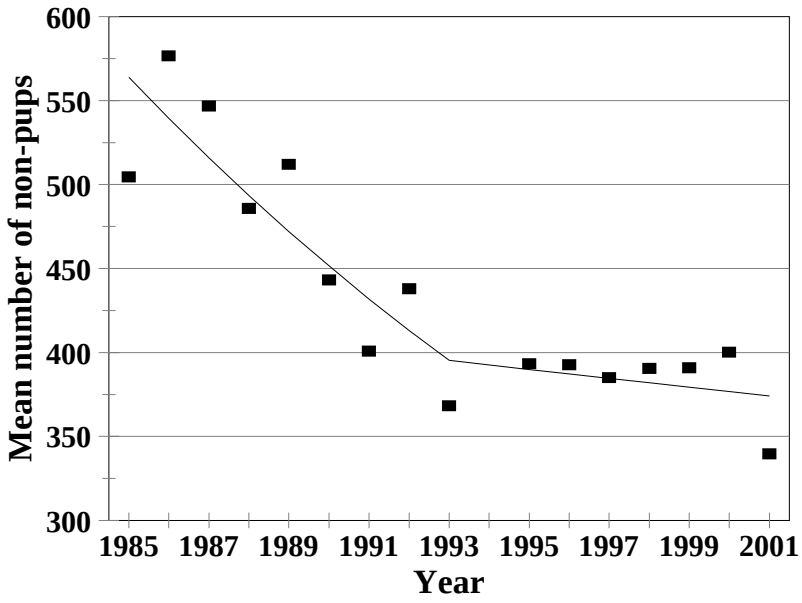

Figure 17. Mean beach counts of Hawaiian monk seals (non-pups) at the six main NWHI subpopulations, 1985-2001.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

Assuming mean beach counts are a reliable index of total abundance, the current net productivity rate for this species is -0.007 yr^{-1} (see above). Trends in abundance vary considerably among the six main subpopulations. For example, the decline since the mid-1980's (Fig. 1) was largely due to a severe decline at French Frigate Shoals, where non-pup beach counts decreased by 70% from 1989 -2001. Populations at Laysan and Lisianski Islands have remained relatively stable since approximately 1990, though the former has tended to increase slightly while the latter has decreased slowly.

Contrary to trends at the above sites, the subpopulation at Kure Atoll has grown at an average rate of 5% yr^{-1} since 1983 (loglinear regression of beach counts, 1983-2001; R^2 = 0.85, P<0.001), due largely to decreased human disturbance and introduced females. The subpopulation at Pearl and Hermes Reef has grown at approximately 6% yr^{-1} since 1983 (loglinear regression of beach counts, 1983-2001; R^2 = 0.84, P<0.001). Growth of the Pearl and Hermes population may be slowing slightly, as previous to 1999 the growth rate averaged 7%yr^{-1}. This latter annual growth rate is the best indicator of the maximum net productivity rate (R_{max}) for this species. Finally, the small subpopulation at

Midway Atoll continues to show signs of recovery.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for this stock is calculated as the minimum population size (1,378) times one half the maximum net growth rate for this stock (½ of 7%) times a recovery factor of 0.1 (for an endangered species, Wade and Angliss 1997), which yields a PBR of 4.8 monk seals per year.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Human-related mortality has caused two major declines of the Hawaiian monk seal (Ragen 1999). In the 1800s, this species was decimated by sealers, crews of wrecked vessels, and guano and feather hunters (Dill and Bryan 1912; Wetmore 1925; Clapp and Woodward 1972). Several subpopulations may have been driven extinct; for example, no seals were seen at Midway Atoll during a 14-month period in 1888-89, and only a single seal was seen during three months of observations at Laysan Island in 1912-13 (Bailey 1952). A survey in 1958 indicated at least partial recovery of the species in the first half of this century (Rice 1960). However, subsequent surveys revealed that all subpopulations except French Frigate Shoals declined severely after the late 1950s (or earlier). This second decline has not been explained at Pearl and Hermes Reef, or Lisianski and Laysan Islands. At Kure Atoll, Midway Atoll, and French Frigate Shoals, trends appear to have been determined by the pattern of human disturbance from military or U.S. Coast Guard activities. Such disturbance is believed to have caused pregnant females to abandon prime pupping habitat and nursing females to abandon their pups (Kenyon 1972; Gerrodette and Gilmartin 1990), resulting in decreased pup survival, which led to poor reproductive recruitment, low productivity, and population decline.

Fishery Information

Detrimental fishery interactions with monk seals include: operations/gear conflict, seal consumption of discarded fish, and competition for prey. Entanglement of monk seals in fishing gear, which is believed to originate outside the Hawaiian archipelago, is described in a separate section below. Since 1982, fishery-related monk seal deaths have included the following: one seal died from entanglement in the bridle rope of lobster trap (1986; NMFS, unpubl. data), another entanglement death in an illegally set gill net off the western shore of Oahu (1994; NMFS, unpubl. data), and one died from ingestion of a recreational fish hook and probable drowning off the island of Kauai (1995; NMFS, unpubl. data). A total of 24 seals have been observed with embedded fish hooks during 1982-2001. The hooks were not always recovered and it was not possible to attribute each hooking event to a specific fishery. Among hooks that could be identified, sources included recreational fisheries (esp. for *Caranx* sp. in the main Hawaiian Islands), federal and state bottomfish and federal longline fisheries (NMFS unpubl. data). For the purposes of a recent Biological Opinion, hookings conservatively judged to be of commercial origin were summarized (NMFS 2002). Importantly, the majority of these deaths and injuries have been observed incidentally during land-based research or other activities; monk seal/fisheries interactions need to be monitored to assess the rate of fisheries-related injury or mortality for this species.

Four fisheries may interact with Hawaiian monk seals. The NWHI lobster fishery began in the late 1970s, and developed rapidly in the early 1980s (Polovina, 1993). Annual landings peaked in 1985 (1.92 million lobsters) and 1986 (1.69 million lobsters; Haight and DiNardo 1995). Thereafter, the fishery declined and was closed temporarily in 1993 due to low spawning stock biomass of spiny lobster. After 1994, landings remained lower than in the mid- to late 1980s, while catch of slipper lobster increased in some areas. The number of vessels in the fishery increased from four in 1983 to 17 in 1985, then ranged from 0-12 during 1991-2000 (Dollar 1995; DiNardo et al. 1998; Kawamoto and Pooley, 2000). Historically, both effort and landings were concentrated at Gardner Pinnacles, Maro Reef, Necker Island, and St. Rogatien Bank (Clarke and Todoki 1988; Polovina and Moffitt 1989). However, spatial management of the NWHI lobster fishery began in 1998 in an effort to prevent local depletion of lobster stocks and to disperse fishing effort, which in recent years had been limited to Necker Island and Maro Reef. As a result of the new management approach, lobsters were taken from Area 4 (all banks between Nihoa Island and Kure Atoll, excepting Necker Island, Maro Reef and Gardner Pinnacles), which, until 1998, had not been fished since the early 1990's (DiNardo et al.1998; Kawamoto and Pooley 2000). Summaries of catch by area, trends and available data on bycatch are published in annual reports, the most recent being Kawamoto and Pooley (2000). Neither incidental mortality nor serious injury have been observed by NMFS observers of the lobster fishery through 2001. As was noted, one mortality was documented in 1986; a monk seal drowned after becoming entangled in the bridle rope of an actively fishing lobster trap near Necker Island. The potential for indirect interaction due to competition for prey is being investigated (see Habitat Issues below).

NMFS closed the Northwestern Hawaiian Islands lobster fishery in 2000 due to uncertainty in the estimates of biomass, and the fishery remains closed to date. President Clinton's Executive Order (1/18/2001) creating the Northwest Hawaiian Islands coral reef ecosystem reserve may preclude some lobster fishing in the NWHI, but this issue has yet to be resolved.

The NWHI bottomfish fishery has been reported to interact with monk seals. This fishery occurred at low levels (< 50 t per year) until 1977, steadily increased to 460 metric tons in 1987, then dropped to 284 metric tons in 1988, and varied from 119 - 201 metric tons per year from 1989-2001 (Kawamoto 1995; Moffitt, pers. comm.). The number of vessels rose from 19 in 1984 to 28 in 1987, and then varied from 10 to 17 in 1988 through 2001 (Kawamoto 1995; Moffitt, pers. comm.). Currently, the bottomfish fishery remains open, although its area of operation has been substantially restricted by President Clinton's Executive Order (1/18/2001). The Agency prepared a Section 7 Biological Opinion on the Fishery Management Plan for the bottomfish fishery, and concluded that the operation of this fishery is not likely to jeopardize the continued existence of the Hawaiian monk seal nor would it likely destroy or adversely modify the monk seal's critical habitat (NMFS 2002). The fishery was monitored by observers from October 1990 to December 1993 (ca. 13% coverage), but is currently monitored by the State of Hawaii using logbooks. However, the State logbook does not include information on protected species and, therefore, the nature and extent of interactions with monk seals cannot be assessed from logbooks. Fishers, however, are required to report all incidental mortality and injury within 48 hours of their return to port (pursuant to MMPA section 118(e)); no such mortality or injury has been reported since 1994 when the MMPA was amended to include section 118. Nitta and Henderson (1993) evaluated observer data from 1991-92 and reported an interaction rate of one event per 34.4 hours of fishing, but they do not provide a confidence interval for their estimate. The authors documented observer reports of seals taking bottomfish and bait off fishing lines, and observer reports of seals attracted to discarded bottomfish bycatch. The ecological effects of this fishery on monk seals (e.g., competition for prey or alteration of prey assemblages by removal of key predator fishes) are unknown. However, published studies on monk seal prey selection based upon scat/spew analysis and seal-mounted video, rarely revealed evidence that monk seals fed on families of bottomfish which contain commercial species (many prey items recovered from scats and spews were identified only to the level of family; Goodman-Lowe 1998, Parrish et al. 2000). Fatty acid signature analysis is incomplete regarding the importance of commercial bottomfish in the monk seal diet, but this methodology continues to be pursued.

In the past, interactions between the pelagic longline fishery and monk seals were documented. This fishery targets swordfish and tunas, primarily, and does not compete with Hawaiian monk seals for prey. The fishery began in the 1940s, and operated at a relatively low level (< 5000 t per year) until the mid-1980s. In 1987, 37 vessels participated, but by 1991, the number had grown to 141 (Ito, 1995). The number of active vessels ranged from 101-141 during 1991-2001. Entry is currently limited to a maximum of 164 vessels (Ito and Machado, 1999). Total landings ranged from 7,076-13,000 metric tons during 1991-2001 (Ito, pers. comm.). While most of the fishery has operated outside of the NWHI Exclusive Economic Zone, evidence of interactions began to accumulate in 1990, including at least two hooked seals (included in hookings reported above) and 13 unusual seal wounds thought to have resulted from interactions. In response, NMFS established a permanent Protected Species Zone extending 50 nautical miles around the NWHI and the corridors between the islands in October 1991. Subsequent shore-based observations of seals have found no further evidence of interactions with the longline fishery after establishment of the Protected Species Zone. At present, interactions with protected species are assessed using Federal logbooks and observers (4-5% coverage), which may lack sufficient statistical power to estimate monk seal mortality/serious injury rates from longline interactions. However, since 1991, there have been no observed or reported interactions of this fishery with monk seals.

There have also been interactions between recreational fisheries and monk seals in both the NWHI and the main Hawaiian Islands. At least three seals were hooked at Kure Atoll before the U.S. Coast Guard vacated the atoll in 1993. In the main Hawaiian Islands, one seal was found dead in an offshore (non-recreational) gillnet in 1994 and a second seal was found dead with a recreational hook lodged in its esophagus. A total of 14 seals have been observed with embedded hooks in the main Hawaiian Islands during 1989-2001 (NMFS unpubl. data). Several incidents involved hooks used to catch ulua (Caranx spp.). A sport fishing charter company recently ceased operations at Midway Atoll.

Interest in the harvest of precious coral in the NWHI represents a potential for future interactions with monk seals. The impact that removal of precious corals might have on monk seal prey resources and foraging habitat is unknown. However, recent studies of seals with satellite transmitters and surveys using manned submersibles indicate that some seals forage at patches of precious gold corals occurring over 500m in depth (Parrish et al., 2002). The recruitment rate of gold coral is unknown, but thought to be slow, raising concern that coral harvesting could have negative long-term impacts on monk seal foraging habitat. As a result, the Western Pacific Regional Fisheries

Management Council has recommended regulations to suspend or set to zero annual quotas for gold coral harvest at specific locations until data on impacts of such harvests become available.

Table 1. Summary of incidental mortality of Hawaiian monk seals due to commercial and recreational fisheries since 1990 and calculation of annual mortality rate. n/a indicates that sufficient data are not available.

Fishery Name	Years	Range of # of vessels per year	Data type	Range of observer coverage	Total observed mort.	Estimated mort. (in given years)	Mean annual mort.
NWHI lobster	91-01	0-12	Observer Log book	0-100%	0	n/a	n/a
NWHI Bottomfish	91-01	11-17	n/a	n/a	n/a	n/a	n/a
Pelagic longline	91-01	101-141	Observer Log book	4-5%	0	n/a	n/a
Recreational	91-95	n/a	n/a	n/a	2†	n/a	n/a

† Data collected incidentally.

Fishery Mortality Rate

Data are unavailable to fully assess interaction with specific fisheries in Hawaii, thus one cannot conclude that the total fishery mortality and serious injury for this stock is less than 10% of the calculated PBR. Therefore, total fishery mortality and serious injury cannot be considered to be insignificant and approaching a rate of zero. Monk seals also continue to die from entanglement in North Pacific fishing gear and other debris (likely originating from various countries), and NMFS along with partner agencies, is pursuing a program to mitigate this source of mortality (see below).

Direct fishery interactions with monk seals remains to be thoroughly evaluated and the information above represents only observed interactions. Without further study, an accurate estimate cannot be determined. In addition, interactions may be indirect (i.e., involving competition for prey or consumption of discards from the bottomfish fishery) and, to date, the extent or consequences of such indirect interactions remain the topic of ongoing investigation.

Entanglement in Marine Debris

Hawaiian monk seals become entangled in fisheries and other marine debris at rates higher than reported for other pinnipeds (Henderson 2001). A total of 212 cases of seals entangled in fishing gear or other debris have been observed through 2001 (Henderson 2001; NMFS, unpubl. data), including six documented mortalities resulting from entanglement in fisheries debris (Henderson 1990, 2001; NMFS, unpubl. data). The types of fishing gear fouling the reefs and beaches of the NWHI and entangling monk seals are not among types used in fisheries conducted in the NWHI. For example, trawl net and monofilament gillnet accounted for approximately 35% and 34% of the debris removed from reefs in the NWHI by weight, and trawl net alone accounted for 88% of the debris by frequency (Donohue et al. 2001). Yet there are no commercial trawl fisheries in Hawaii.

The NMFS and partner agencies continue to pursue an ambitious effort to mitigate impacts of marine debris on monk seals as well as turtles, coral reefs and other wildlife. Marine debris is removed from beaches and entangled seals during annual population assessment activities at the main reproductive sites. Efforts to remove potentially entangling marine debris from reefs surrounding monk seal haulout sites are growing. During 1996-2001 debris survey and removal efforts, 264,726 kg of derelict net and other debris were removed from the coral reef habitat in the NWHI (Donohue et al. 2000, Donohue et al. 2001; Donohue, pers. comm). Using funds dedicated to marine debris mitigation, this effort was greatly expanded in 2001.

Other Mortality

Since 1982, 23 seals died during rehabilitation efforts; additionally, two died in captivity, two died when captured for translocation, one was euthanized (an aggressive male known to cause mortality), three died during captive research and three died during field research (Baker and Johanos, 2002).

In 1986, a weaned pup died at East Island, French Frigate Shoals, after becoming entangled in wire left when the U.S. Coast Guard abandoned the island three decades earlier. In 1991, a seal died after becoming trapped behind an eroding seawall on Tern Island, French Frigate Shoals.

The only documented case of illegal killing of an Hawaiian monk seal occurred when a resident of Kauai killed

an adult female in 1989.

Other sources of mortality which are (or may be) impeding the recovery of this subpopulation include single and multiple male aggression (mobbing), shark predation, and disease/parasitism. When multiple males attempt to mount and mate with an adult female or immature animal of either sex, injury or death of the attacked seal often results. The resulting increase in female mortality appears to have been a major impediment to recovery at Laysan and Lisianski Islands. Since 1982, at least 67 seals have died or disappeared after suffering multiple male aggression at Laysan Island. Multiple male aggression has also been documented at French Frigate Shoals, Kure Atoll, and Necker Island. Multiple male aggression is thought to be related to an imbalance in adult sex ratios, with males outnumbering females. In 1994, 22 adult males were removed from Laysan Island, and only three seals are thought to have died from mobbing at this site since their removal (1995-2001). Such imbalances in the adult sex ratio are more likely to occur when populations are reduced (Starfield et al. 1995).

In addition to mobbing, aggressive attacks by single adult males have resulted in several monk seal mortalities. This was most notable at French Frigate Shoals in 1997, where at least 8 pups died as a result of adult male aggression. Many more pups were likely killed in the same way but the cause of their deaths could not be confirmed. Two males that killed pups in 1997 were observed exhibiting aggressive behavior toward pups at the beginning of the 1998 pupping season. Both males were translocated to Johnston Atoll, 870 km to the southwest. Subsequently, mounting injury to pups has decreased.

Shark-related injury and mortality incidents may have increased in the late 1980s and early 1990s at French Frigate Shoals, but such mortality was probably not the primary cause of the decline at this site (Ragen 1993). However, indications are that shark predation has accounted for a significant portion of pup mortality in the last few years. At French Frigate Shoals in 1999, 17 pups were observed injured by large sharks, and at least three were confirmed to have died from shark predation (Johanos and Baker, 2001). Assigning cause of death to shark predation is problematic, as predation events are rarely observable. However, it is believed that as many as 25 pups of a total 92 born at French Frigate Shoals in 1999 were killed by sharks. After 1999, losses of pups to shark predation have been fewer, but this source of mortality remains a serious concern. Various mitigation efforts have been undertaken by NMFS in cooperation with the USFWS, which manages French Frigate Shoals as part of the Hawaiian Islands National Wildlife Refuge.

Disease effects on monk seal demographic trends is uncertain. In 2001, an Unusual Mortality Event was declared following the deaths of four yearling monk seals in the course of nine days at Laysan Island. At least 11 deaths occurred in the NWHI, but many more are suspected due to unusually low survival of juveniles at most subpopulations. Health screening of both health and unhealthy seals was conducted, and necropsies were performed on six seals. No evidence of infectious disease or toxicosis was found which would link the mortalities. However, all the necropsied animals were emaciated.

STATUS OF STOCK

In 1976, the Hawaiian monk seal was designated depleted under the Marine Mammal Protection Act of 1972 and as endangered under the Endangered Species Act of 1973. The species is assumed to be well below its optimum sustainable population (OSP) and has not recovered from past declines. Therefore, the Hawaiian monk seal is characterized as a strategic stock.

Habitat Issues

Vessel groundings pose a continuing threat to monk seals and their habitat. On 16 October 1998 the *Paradise Queen II*, a lobster fishing vessel, ran aground on the eastern edge of Kure Atoll. In 2001, vessel fragments remained on the reef and shoreline of Green Island. On occasion, monk seals land on wreck debris. During an initial clean up effort, accessible hazardous material and lobster traps were removed. In subsequent years, several hundred traps washed ashore and were removed from Green Island.

Another grounding occurred on 6 June 2000 when the 77 ft longliner *Swordman I* ran aground on the perimeter reef of Pearl and Hermes Atoll. Of 81,200 gallons of fuel on board; 79,000 gallons were recovered and the remainder spilled. An oil spill response crew evaluated the scene one week later and determined that impacts to wildlife and coral reefs were minimal. No evidence of oiling or other impacts to Hawaiian monk seals was found. Salvage crews subsequently cleaned the *Swordman I*, removed it from the reef and sank it in deep water.

Available data indicate that the substantial decline at French Frigate Shoals was related to lack of available prey and subsequent emaciation and starvation. Two leading hypotheses to explain the lack of prey are 1) the local population reached its carrying capacity in the 1970s and 1980s, diminishing its own food supply, and 2) carrying capacity was

simultaneously reduced by changes in oceanographic conditions and a subsequent decline in productivity (Polovina et al. 1994; Craig and Ragen 2000).

Studies are also being conducted to identify and characterize at-sea habitat use. In 2001, 54 seals of various ages and both sexes were fitted with satellite-linked dive recorders to track movements and dive patterns at Laysan Island and Kure Atoll. With these most recent instrument deployments, information on at-sea movement and diving has been collected from seals at all six main subpopulations in the NWHI. Goodman-Lowe (1998) provides information on prey selection using hard parts in scats and spewings.

Since 1979, human disturbance of seals in their terrestrial habitat has been limited primarily to Kure and Midway Atolls. The U.S. Coast Guard LORAN station at Kure Atoll closed in 1992 and vacated in 1993. Historically, human activities led to the near extinction of the resident monk seal population at Midway both in the late 1800s, and again in the 1960s. The population failed to recover in the 1970s and 1980s, but has recently grown due to immigration from nearby sites. The U.S. Naval Air Facility at Midway closed in 1993 and was transferred in 1997 to the U.S. Fish and Wildlife Service, which manages the atoll as a National Wildlife Refuge. A private company which had provided tourist activities (e.g., scuba diving and sport fishing), as well as harbor services, terminated their operations at Midway Atoll in 2002. As a result, the level of human activity that could impact monk seals at the site has diminished. Any future development which might increase access to the Refuge will need careful management and monitoring to prevent further human disturbance. Disturbance at sea (e.g., direct and indirect fisheries interactions) may also impede recovery. As described above, however, the possible types of disturbance at sea cannot yet be characterized or quantified.

Tern Island is the site of a U.S. Fish and Wildlife refuge station, and is one of two sites in the NWHI accessible by aircraft. The island and the runway have played a key role in efforts to study the local monk seal population and to mitigate its severe and ongoing decline. During World War II, the U.S. Navy enlarged the island to accommodate the runway. A sheet-pile seawall was constructed to maintain the modified shape of the island. Degradation of the seawall is creating entrapment hazards for seals and other wildlife and is threatening to erode the runway. Erosion of the sea wall has raised concerns about the potential release of toxic wastes into the ocean. The Fish and Wildlife Service is scheduled to begin a project to repair and stabilize the seawall and shoreline of Tern Island in 2003.

There are indications that monk seal abundance is increasing in the main Hawaiian Islands (Baker and Johanos, *submitted*). Further, the excellent condition of pups weaned on these islands suggests that there may be ample prey resources available. If the monk seal population does expand in the Main Hawaiian Islands, it may bode well for the species' recovery and long-term persistence. In contrast, there are many challenges that may limit the potential for growth in this region. The human population in the Main Hawaiian Islands is approximately 1.2 million compared to less than 100 in the NWHI, so that the potential impact of disturbance in the Main Hawaiian Islands is great. Potential for disease transfer from domesticated animals to naive monk seals in the main islands, which could, in turn, transmit disease to the core population in the NWHI is also a concern. As noted above, the hooking of monk seals by fishermen in the Main Hawaiian Islands is another source of injury and mortality . Finally, vessel traffic around the populated islands carries the potential for collision with seals and impacts from oil spills. Thus, issues surrounding the presence of monk seals in the main Hawaiian Islands will likely become an increasing focus for management and recovery of this species.

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