Revised 9/30//99

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 populations at French Frigate Shoals, Laysan Island, Lisianski Island, Pearl and Hermes Reef, Midway Atoll, and Kure Atoll. Small populations at Necker Island and Nihoa Island are maintained by immigration, and a few seals are distributed throughout the main Hawaiian Islands. Studies of Hawaiian monk seals have focused on their abundance and behavior on land during the reproductive season (spring and summer). Expanded research is underway, but currently the pelagic distribution and behavior of monk seals cannot be fully characterized.

In the last two centuries, the species has experienced two major declines which, presumably, have severely reduced its genetic variation. The tendency for genetic drift may have been (and continue to be) relatively large, due to the small size of different island/atoll populations. However, 10-15% of these seals migrate among the populations (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).

Demographically, the different island populations have exhibited considerable independence. For example, abundance at French Frigate Shoals grew rapidly during the 1950s to the 1980s, while other populations declined rapidly. However, variation in past population trends may be partially explained by changes in the level of human disturbance (Gerrodette and Gilmartin 1990). Current demographic variability among the island populations probably reflects a combination of different recent histories and varying environmental conditions. While research and recovery activities focus on the problems of single island/atoll populations, the species is managed as a single stock.

POPULATION SIZE

Abundance of the main reproductive populations is best estimated using the number of seals identified at each site. Individual seals are identified by applied flipper-tags and bleach-marks, and natural features such as scars and distinctive pelage patterns. Flipper-tagging of weaned pups began in the early 1980s, and the majority of the seals in the main reproductive populations can be identified on the basis of those tags. In 1997, identification efforts were conducted during two- to six-month studies at all main reproductive sites except Midway Atoll, where the study period was 10 months. A total of 1295 seals (including pups) were observed at the main reproductive populations in 1997 (NMFS, unpubl. data). Removal analyses in previous years and sighting probability calculations suggest that 90% or more of the seals were identified at each site (i.e., any negative bias should be less than 10%).

Monk seals also occur at Necker and Nihoa Islands, where repeated counts in a single year were last conducted in 1993. Single counts in subsequent years do not indicate abundance at those sites has changed appreciably. The 1993 studies were not of sufficient duration to identify all individuals, so local abundance is best estimated by correcting mean beach counts and assuming that abundance at these sites has not changed. In 1993, mean (±SD) counts (excluding pups) were 22 (±5.2) at Necker Island and 18 (±7.3) at Nihoa Island (Ragen and Finn 1996). The observed 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 number of pups born in 1993) are 65 (±15.1) at Necker Island and 56 (±21.1) at Nihoa Island.

Finally, a small number of seals are distributed throughout the main Hawaiian Islands. These include an unknown number of seals, which naturally occur in the main Hawaiian Islands. In addition, twenty-one seals were released around these islands in 1994. All but two were subsequently resighted near their respective release sites, but their survival to 1997 is unknown. Sporadic reports indicate total abundance on the main Hawaiian Islands (including seals released in 1994) may be as high as 40 seals.

Minimum Population Size

The total number of seals identified at the main reproductive sites is the best estimate of minimum population size at those sites (i.e., 1295 seals). Minimum population sizes for Necker and Nihoa Islands (based on the formula provided by Wade and Angliss (1997)) are 54 and 41, respectively. If it is (arbitrarily) assumed that the abundance estimate for seals in the main Hawaiian Islands is, say, 40 ±10 seals (i.e., a coefficient of variation of 0.25), then an estimate of the minimum population size in the main Islands is 33 seals. The minimum population size for the entire stock (species) is the sum of these estimates, or 1423 seals.

Current Population Trend

Between 1958 and 1997, the total of mean beach counts at the main reproductive populations declined by 60%. From 1985 to 1997, the rate of decline was ca. 4% yr^{-1}, although there has been little change since 1993 (Fig. 1). Further decline is likely, due to extremely high juvenile mortality and an imminent drop in reproductive recruitment in the largest population (French Frigate Shoals).

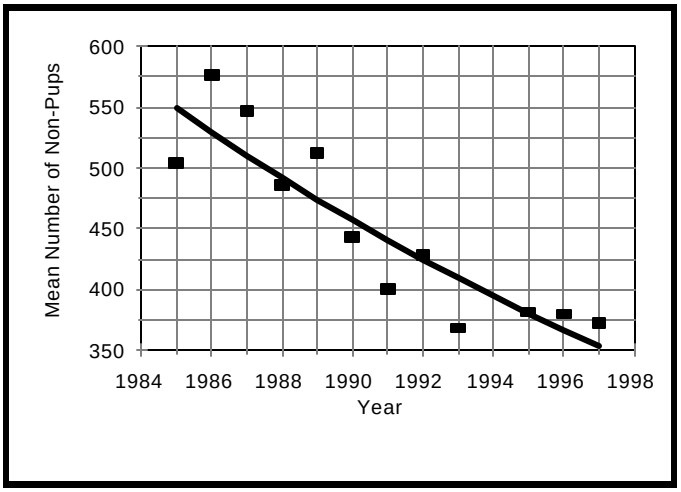

Figure 1. Total of mean beach counts (non-pups) at the main reproductive populations (excluding Midway Atoll) of the Hawaiian monk seal, 1986-97.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

Assuming mean beach counts are a reliable index of total abundance, then the current net productivity rate for this species is -0.04 yr^{-1} (loglinear regression of beach counts of non-pups, 1985-97; R^2 = 0.82, P<0.001). This trend is largely due to a catastrophic decline at French Frigate Shoals, where beach counts decreased by 56% between 1989 and 1997. Populations at Laysan and Lisianski Islands have not grown, but have remained relatively stable since approximately 1990.

Contrary to trends at the above sites, the population at Kure Atoll has grown at ca. 5% yr^{-1} since 1983 (loglinear regression of beach counts, 1983-97; R^2 = 0.75, P<0.001), due largely to decreased human disturbance and introduced females. The population at Pearl and Hermes Reef has grown at approximately 7% yr^{-1} since 1975 (loglinear regression of beach counts, 1975-1997; R^2 = 0.91, P<0.001). The latter annual growth rate is the best indicator of the maximum net productivity rate (R_{max}) for this species. Finally, the small population at Midway Atoll is showing signs of incipient recovery.

POTENTIAL BIOLOGICAL REMOVAL

Using the values of N_{min} and R_{max} given above (1423 and 0.07 yr^{-1}, respectively) and a recovery factor (F_R) of 0.1 (the Hawaiian monk seal was designated as both endangered and depleted in 1976), the potential biological removal (PBR) for this species is calculated as 1423 * (0.07 * (0.5)) * 0.1 = 5.0 seals. However, the Endangered Species Act takes precedence in the management of this species and, under the Act, allowable take is zero.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Human-related mortality has caused two major declines of the Hawaiian monk seal. 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 populations 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 populations 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 caused pregnant females to abandon prime pupping habitat and nursing females to abandon their pups (Kenyon 1972, Gerrodette and Gilmartin 1990). The result was a decrease in pup survival, which led to poor reproductive recruitment, low productivity, and population decline.

Since 1979, disturbance from human activities on land has been limited primarily to Kure and Midway Atolls. The U.S. Coast Guard LORAN station at Kure Atoll was closed in 1992 and vacated in 1993. The U.S. Naval Air Facility at Midway was closed in 1993 and, following clean-up and restoration activities, jurisdiction was transferred in 1997 to the U.S. Fish and Wildlife Service, which manages the atoll as a National Wildlife Refuge. The refuge station and the atoll runway are maintained cooperatively with a commercial aircraft company, which supports its Midway operations, in part,

by establishing a tourism center at the site. Strict regulations have been established to prevent further human disturbance of the seals, but careful monitoring of human activities will be essential to ensure that the regulations are both adequate and observed (see Habitat Issues below).

In addition to disturbance on land, disturbance at sea (e.g., direct and indirect fisheries interactions) may also impede recovery. As described below, however, the possible types of disturbance at sea can not yet be characterized or quantified.

Fishery Information

Detrimental fishery interactions with monk seals fall into four categories: operations/gear conflict, entanglement in fisheries debris (most of which likely originate in North Pacific fisheries outside the NWHI), seal consumption of potentially toxic discards, and competition for prey. Since 1982, a total of seven fishery-related monk seal deaths have been recorded, including four from entanglement in fisheries debris (Henderson 1990; NMFS, unpubl. data), one from entanglement in the bridle rope of lobster trap (1986; NMFS, unpubl. data), one from entanglement in an illegally set gill net off the western shore of Oahu (1994; NMFS, unpubl. data), and one from ingestion of a recreational fish hook and probable drowning off the island of Kauai (1995; NMFS, unpubl. data). In addition, 16 other seals have been observed with embedded fish hooks, 23 seals have been observed with wounds attributed to interactions with fishing gear, and 154 cases of seals entangled in fishing gear or other debris have been observed. 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 studied more thoroughly to assess the rate of fisheries-related injury or mortality for this species.

Four fisheries 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. Since 1994, landings remained lower than in the mid- to late 1980s, while abundance of slipper lobster have increased in some areas. The number of vessels in the fishery increased from four in 1983 to 17 in 1985, then declined to 9, 12, 0, 5, 1, 5, and 9 in 1991through 1997, respectively (Dollar 1995, DiNardo et al.1998). Both effort and landings have been concentrated at Gardner Pinnacles, Maro Reef, Necker Island, and St. Rogatien Bank (Clarke and Todoki 1988, Polovina and Moffitt 1989). Seasonal and area differences in direct and indirect fisheries interactions remain to be evaluated, but neither incidental mortality nor serious injury were observed in 1997. 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. However, the potential for indirect interaction due to competition for prey has not been thoroughly investigated (see Habitat Issues below).

The NWHI bottomfish fishery also interacts with monk seals. This fishery occurred at low levels (< 50 t per year) until 1977, steadily increased to 460 t in 1987, and then dropped to ca. 140 to 190 t per year from 1988 to 1994 (Kawamoto 1995). During 1995-1997 landings again increased to 384 to 486 t per year (Kawamoto, 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 1997 (Kawamoto 1995, Kawamoto pers. comm.). 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. Importantly, the State logbook *does not include information on protected species* and, therefore, the nature and extent of interactions with monk seals cannot be reliably assessed. 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 events included seals damaging and removing hooked catch, seals being hooked in the process, and seals consuming discarded fish, which may contain high levels of ciguatoxin or other biotoxins. Mortality rates resulting from hooking or consumption of toxic discards cannot be estimated with the available data. 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.

A third fishery which interacts with monk seals is the pelagic longline fishery. 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). Entry is currently limited to a maximum of 167 vessels, and 124, 110, 103, and 105 vessels were active in 1994-1997, respectively (Ito, pers. comm.). Total landings ranged from 9,100-13,500 tons during 1991-1997. While much of the fishery has operated outside of the NWHI Exclusive Economic Zone, the rapid expansion raised concerns about the potential for interactions with protected species, including the monk seal. Evidence of interactions began to accumulate in 1990, including three hooked seals and 13 unusual seal wounds thought to have resulted from interactions. In October 1991, NMFS established a permanent Protected Species Zone extending 50 nautical miles around the NWHI and the corridors between the islands. Subsequent shore-based observations of seals suggest

that interactions decreased substantially after establishment of the Protected Species Zone, although they may still be occurring; at French Frigate Shoals in 1994, a parturient female was observed with a hook in her mouth. 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.

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	Current est. # of vessels	Date type	Range of observer coverage	Observed mort. (in given years)	Estimated mort. (in given years)	Mean annual mort.
NWHI lobster	91-97	9, 12, 0, 5, 1, 5, 9	Log book	n/a	n/a	n/a	n/a
NWHI Bottomfish	91-97	17, 13, 12, 16, 17, 16, 14	n/a	n/a	n/a	n/a	n/a
Pelagic longline	91-97	141, 123, 122, 125, 110, 103, 105	Observer Log book	4-5%	0	n/a	n/a
Recreational	91-95	n/a	n/a	n/a	[0,0,0,1,1][†]	n/a	n/a

[†] Data collected incidentally.

There have also been interactions between recreational fisheries and monk seals in both the NWHI and around the main Hawaiian Islands. At least three seals have been hooked at Kure Atoll, but such incidents should no longer occur at this site because the atoll was vacated by the U.S. Coast Guard 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. At least seven other seals have been hooked. Three of these incidents involved hooks used to catch ulua (Caranx spp.). One hooked seal had been translocated from Laysan Island to the main Hawaiian Islands in July 1994. The recent establishment of sport fishing at Midway clearly increases the potential for monk seals to be harmed by hooks at that site.

Recent interest in the harvest of precious coral in the NWHI represents a potential for future interactions with monk seals. The removal of coral and the subsequent impact on monk seal prey resources is currently unknown.

Fishery Mortality Rate

Because monk seals continue to die as a result of entanglement in fishing debris and data are unavailable to assess interaction with specific fisheries, one must conclude that the total fishery mortality and serious injury for this stock is greater than 1) zero allowable take under the Endangered Species Act and 2) 10% of the calculated PBR. Therefore, total fishery mortality and serious injury can not be considered to be insignificant and approaching a rate of zero.

Importantly, fishery interactions with this species have not been adequately studied and, therefore, the information above represents only the minimum level of interactions, not the true level. Without further study, the true level of interaction cannot be estimated. 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 have not been evaluated.

Other Mortality

Since 1982, 19 seals have died during rehabilitation efforts, five during research activities, three while held in permanent captivity, and two when captured for translocation.

Seals have also died after encounters with marine debris from sources other than fisheries. 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. This seawall continues to erode and poses an ongoing threat to the safety of seals and other wildlife.

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 population include mobbing, sharks, poisoning by ciguatoxin or other biotoxins, and disease/parasitism. Mobbing occurs when multiple males attempt to mount and mate with an adult female or immature animal of either sex, often leading to the injury or death of the attacked seal. Since 1982, at least 64 seals have died or disappeared after being mobbed. The resulting increase in female mortality appears to be a major impediment to recovery at Laysan and Lisianski Islands. It has also been documented at French Frigate Shoals, Kure Atoll (although not recently), and Necker Island. The primary cause of mobbing is thought to be an imbalance in the adult sex ratio, with males outnumbering females. In 1994, 22 adult males were removed from Laysan Island, and only one seal is thought to have died from mobbing at this site since their removal (1995-97). 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.

The incidence of shark-related injury and mortality may have increased in the late 1980s and early 1990s at French Frigate Shoals, but such mortality is probably not the primary cause of the recent decline at this site (Ragen 1993). The annual rate and number of shark-related mortalities is being investigated. Poisoning by ciguatoxin or related toxins is suspected as the primary cause of the Laysan die-off in 1978, and may have contributed to the high mortality of juvenile seals translocated to Midway Atoll in 1992 and 1993. While virtually all wild monk seals carry parasites after they begin to forage, the role of parasitism in monk seal mortality is unknown. The effect of disease on monk seal demographic trends is also uncertain.

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, since 1985, has declined 4% per year. Therefore, the Hawaiian monk seal is characterized as a strategic stock.

Habitat Issues

The catastrophic decline at French Frigate Shoals is thought to be related to lack of available prey and subsequent emaciation and starvation. The two leading hypotheses to explain the lack of prey are 1) the local population reached its carrying capacity in the 1970s and 1980s, and essentially diminished its own food supply, and 2) carrying capacity was simultaneously reduced by changes in oceanographic conditions and a resulting decrease in productivity (Polovina et al. 1994; Craig and Ragen, in press). Thus, this population may have significantly exceeded its carrying capacity, leading to a catastrophic increase in juvenile mortality. In addition, available prey also may have been reduced by competition with the NWHI lobster fishery. Monk seals forage at the four main banks where the fishery operates: Maro Reef, Gardiner Pinnacles, St. Rogatien Bank, and Necker Island. Thus, competition for prey merits investigation. This potential for competition cannot yet be evaluated because it is not known if lobster is an important component of the monk seal diet.

A second important habitat issue is the management of human activities at Midway Atoll. Historically, human activities have led to the near extinction of the resident monk seal population at Midway both in the late 1800s, and again in the 1960s. The seal population failed to recover in the 1970s and 1980s, but is finally beginning to show some signs of growth due to immigration from nearby sites. Management jurisdiction of Midway Atoll has been transferred from the U.S. Navy to the Fish and Wildlife Service. The Fish and Wildlife Service maintains a refuge station at Midway Atoll by cooperating with a commercial aircraft company that uses the runway on Sand Island (the largest island at Midway Atoll), and support its operations, in part, by establishing an on-site eco-tourism destination. Tourist activities include a range of land-based and marine recreational activities (e.g., scuba diving and sport fishing), as well as harbor services to visiting vessels. As the tourism venture develops, so does a potential conflict of interest. The economic success of the venture may depend on the nature and variety of human activities or privileges allowed at the site. Importantly, those activities that are intended to enhance the Midway experience may be disruptive or detrimental to the refuge and its wildlife. The issue is whether such potential conflicts can be identified and resolved in a manner that allows for

continuation of the ecotourism venture but does not impede monk seal recovery. The Fish and Wildlife Service and NMFS are working cooperatively to ensure that human activities do not impede recovery at this important site.

An important habitat issue is the degrading seawall at Tern Island, French Frigate Shoals. Tern Island is the site of the 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. The loss of the runway could lead to the closure of the Fish and Wildlife Service station at the site and would thereby reduce on-site management of the refuge. The loss of the runway and refuge station would also hinder research and management efforts to recover the monk seal population.

A fourth important habitat issue involves entanglement in marine debris as described above. Marine debris is removed from the beaches and from entangled seals during annual population assessment activities at the main reproductive sites. Efforts to remove potentially entangling marine debris from the reefs surrounding haulout sites utilized by monk seal have recently begun. In 1996, efforts commenced to assess and remove potentially entangling marine debris from reefs surrounding haulout sites utilized by monk seals. Preliminary surveys suggest a very large number of nets are fouled on nearshore reefs in the NWHI, and may pose a serious threat to seals foraging in these areas. During 1996-1998 debris survey and removal efforts, 11,000 kg of derelict net and other debris were removed from coral reefs at French Frigate Shoals and Pearl and Hermes Reef (Boland, pers. comm.). Efforts to remove nets from monk seal habitat are continuing and will include several cooperating agencies.

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