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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 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). At present, their pelagic distribution and behavior (and any seasonal or temporal variation therein) can not be reliably 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 currently under investigation (Kretzmann et al., in press).

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 1996, identification efforts were conducted on a daily basis during three- to five-month studies at all main reproductive sites except Midway Atoll, where the study period was limited to five weeks. A total of 1238 seals (including pups) were observed at the main reproductive populations in 1996 (NMFS, unpubl. data). Removal analyses 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 studies were last conducted in 1993. Those 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. 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 1996 is unknown. In addition, the number of seals that occur naturally in the main Islands is also unknown. A best guess for abundance in the main Islands (including the seals released in 1994) is 40 animals.

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., 1238 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, ±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 1366 seals.

Current Population Trend

Between 1958 and 1996, the total of mean beach counts at the main reproductive populations declined by 60%. From 1985 to 1996, the rate of decline was ca. 4% yr^{-1} (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).

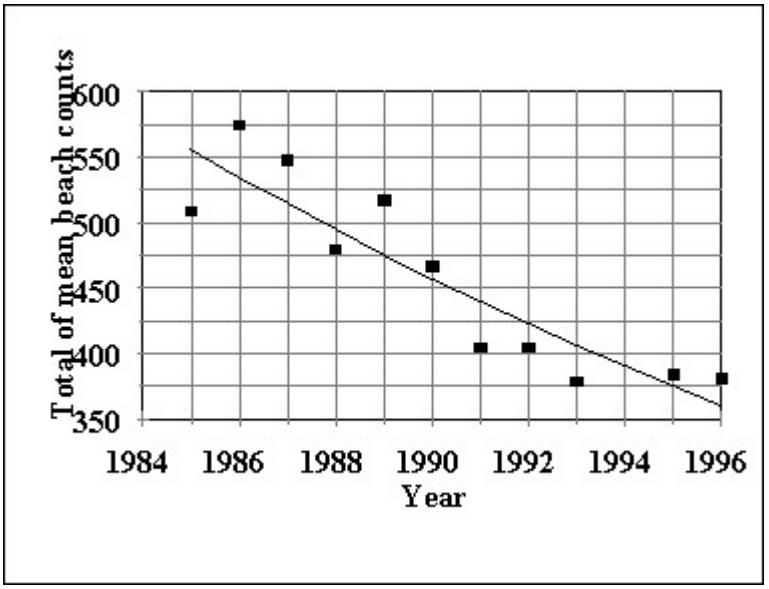

Figure 1. Total of mean beach counts at the main reproductive population (excluding Midway) of the Hawaiian monk seal. 1985-96.

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, 1985-96; R^2 = 0.83, P<0.001). Again, this trend is largely due to a catastrophic decline at French Frigate Shoals, where beach counts have decreased by 56% since 1989. In addition, populations at Laysan and Lisianski Islands continue to decline slowly.

Contrary to the decline at the above sites, the population at Kure Atoll has grown at ca. 5% yr^{-1} since 1983 (loglinear regression of beach counts, 1983-96; R^2 = 0.69, P<0.001), due largely to decreased human disturbance and introduced females. And the population at Pearl and Hermes Reef has grown at approximately 7% yr^{-1} since 1975 (loglinear regression of beach counts, 1975-1996; R^2 = 0.89, P<0.001). This 7% annual growth rate is the best indicator of the maximum net productivity rate (R_{max}) for this species.

POTENTIAL BIOLOGICAL REMOVAL

Using the values of N_{min} and R_{max} given above (1366 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 1366 * (0.07 * (0.5)) * 0.1 = 4.8 seals. However, the Endangered Species Act takes precedence in the management of this species and, under the Act, allowable take is zero.

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Human-related mortality has caused two major declines of the Hawaiian monk seal, and may continue to be an important factor impeding its recovery. 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, will be vacated in June, 1997. Jurisdiction of Midway Atoll is being transferred to the U.S. Fish and Wildlife Service, which will manage the atoll as a National Wildlife Refuge. The refuge station and the atoll runway will be maintained cooperatively with a commercial aircraft company, which will support its Midway operations, in part, by establishing an "ecotourism" center at the site. Strict regulations will be 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

Since the late 1970s, development and expansion of fisheries in the NWHI has lead to interactions detrimental to monk seals. The interactions fall into four categories: operations/gear conflict, entanglement in fisheries debris (which could have originated from other fisheries in the North Pacific), seal consumption of potentially toxic discard, and competition for prey. Since 1982, a total of six fishery-related monk seal deaths have been recorded, including three from entanglement in fisheries debris (Henderson 1990), 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 uncharacteristic wounds attributed to interactions, and 138 seals have been observed entangled in fisheries or other debris. Importantly, the majority of these deaths and injuries have been observed incidentally during land-based research or other activities; monk seal/fisheries interactions have not been adequately studied and the rate of fisheries-related injury or mortality for this species can not be reliably characterized.

The Hawaiian monk seal interacts with four fisheries. 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 in 1993 due to low spawning stock biomass. Landings totalled 131,000 in 1994, dropped to 38,000 in 1995 (the fishery was open on an experimental basis only), and then increased to 186,000 in 1996 (DiNardo pers. comm.). Catch per unit effort (lobsters per trap haul) declined from 2.75 to 0.56 between 1983 and 1991, increased slightly to 0.59 in 1992, and increased again to 0.78 in 1994 (Haight and DiNardo 1995). The number of vessels in the fishery increased from four in 1983 to 16 in 1985-86, then declined to 9, 12, 0, 5, 1, and 5 in in 1991 through 1996, respectively (Dollar 1995, DiNardo, pers. comm.). 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 fisheries interactions, and total incidental mortality/serious injury, have not been evaluated. As just 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, indirect mortality due to competition for prey may be a more serious problem than direct interactions (see Habitat Issues below).

Monk seals also interact with the NWHI bottomfish fishery. 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). The number of vessels rose from 19 in 1984 to 28 in 1987, and then varied from 10 to 17 in 1988 through 1995 (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 discard 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 and unstudied.

The third fishery with which monk seals interact 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 vessels were active in 1994 (Ito 1995). 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, and the hook appeared to be from the swordfish fishery. At present, interactions with protected species are assessed using Federal logbooks and observers (4-5% coverage), which lack sufficient reliability or statistical power to estimate monk seal mortality/serious injury rates from longline interactions.

Finally, monk seals have interacted with recreational fisheries 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 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.

Fishery Mortality Rate

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, the most serious interactions may be indirect (i.e., involving competition for prey with the lobster fishery or consumption of discard from the bottomfish fishery) and, to date, the extent or consequences of such indirect interactions have not been evaluated.

Table 1. Summary of incidental mortality of Hawaiian monk seals due to commercial and recreational fisheries from 1990 to 1995 and calculation of annual mortality rate. n/a indicates that 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	91-96	9, 12, 0, 5, 1,5	log book	n/a	n/a	n/a	n/a
NWHI Bottomfish	91-95	17, 13, 12, 16, 17	n/a	n/a	n/a	n/a	n/a
Pelagic longline	91-95	141, 123, 122, 125, 110	observer log book	4-5%	n/a	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.

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 a 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 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 in 1995-96. Such imbalances in the adult sex ratio are more likely to occur when populations are reduced (Starfield et al. 1995). To the extent that human activity has reduced monk seal populations, such activity may have contributed to the mobbing problem.

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. In the NWHI, the danger of ciguatera poisoning is considered to be greatest at Midway Atoll (Hokama, University of Hawaii, pers. comm.), where nearshore construction and the reshaping of Sand Island may contribute to the probability of dinoflagellate blooms. 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 OSP and, since 1985, has declined at 4-5% per year. Therefore, the Hawaiian monk seal is characterized as a strategic stock. As noted above, the total fishery mortality and serious injury for this stock is greater than 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.

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). Thus, this population may have significantly overshot 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 eat lobster and forage at the four main banks where the fishery operates: Maro Reef, Gardiner Pinnacles, St. Rogatien Bank, and Necker Island. This information suggests that competition for prey is a reasonable hypothesis that merits investigation. This potential for competition cannot yet be evaluated because we do not know the importance of lobster as a component of the monk seal diet.

A second important habitat issue is the management of human activities at Midway Atoll. Historically, such activities have led to the near extinction of the resident monk seal population 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. At the same time, management jurisdiction of Midway Atoll is being transferred from the U.S. Navy to the Fish and Wildlife Service, which should lead to a substantial reduction in human activities that disturb monk seals. The Fish and Wildlife Service and NMFS are working cooperatively to ensure that human activities do not impede recovery at this important site.

The Fish and Wildlife Service will maintain a refuge station at the site by cooperating with a commercial aircraft company that will use the runway on Sand Island (the largest island at Midway Atoll), and will support its operations, in part, by establishing an on-site eco-tourism destination. Projected 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.

A third important habitat issue is the decaying 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. Decay of the seawall is creating entrapment hazards for seals and other wildlife, and 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. Marine debris is removed from the beaches and entangled seals during annual population assessment activities at the main reproductive sites. Little effort, however, has been devoted to the removal of potentially entangling marine debris from the reefs surrounding haulout sites utilized by monk seal. The continued accumulation of this debris may pose a serious threat to seals foraging in these waters. To date, no systematic efforts have been made to assess or remove this debris.

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