Revised 03/15/2005

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 (MHI), primarily at Niihau. Genetic variation among NWHI 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. 1997, 2001). On average, 10-15% of the seals migrate among the NWHI subpopulations (Johnson and Kridler 1983; Harting 2002). Thus, the NWHI subpopulations are not demographically isolated, though 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. Genetic comparisons between NWHI and MHI seals has not been conducted, but observed interchange of individuals among the regions is extremely rare, suggesting these may be more appropriately designated as separate stocks. Further evaluation of a separate MHI stock will be pursued following additional population assessment and studies of movements of monk seals in the MHI. In the mean time, 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 1,304. This estimate is the sum of counts at the six 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 2002, identification efforts were conducted during two- to six-month studies at all main reproductive sites. A total of 1,156 seals (including 196 pups) were observed at the main reproductive subpopulations in 2002 (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 1998-2002 were 16.4 (± 6.4) at Necker Island and 15.4 (± 7.3) 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 48.3 (±18.5) at Necker Island and 47.3 (± 21.1) at Nihoa Island.

A 2001 aerial survey determined a minimum abundance of 52 seals in the MHI and remains the most recent available estimate (Baker and Johanos 2003). Seals in the MHI 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., 1,156 seals). Minimum population sizes for Necker and Nihoa Islands (based on the formula provided by Wade and Angliss (1997) are 35 and 33, 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 1,276 seals.

Current Population Trend

The total of mean non-pup beach counts at the six main reproductive NWHI subpopulations in 2002 is approximately 60% lower than in 1958. Counts declined from 1985 to 1993, then became rather stable. As a result, a log-linear trend through the entire time series results 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 4.2% yr^{-1} until 1993, then declined at 1.1% yr^{-1} thereafter (Fig. 1). The broken line regression fit significantly better than a single regression line (p = 0.03). Thus, current population trend is best estimated as minus 1.1% yr^{-1} (95% CI = -2.4% to 0.2% yr^{-1}).

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 -0.011 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 7% from 1989-2002. 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.

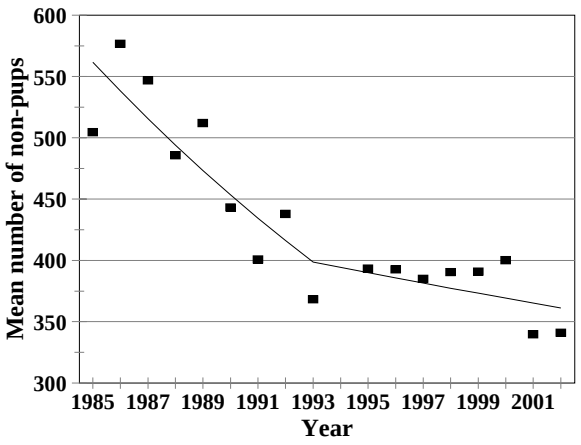

Figure 1. Mean beach counts of Hawaiian monk seals at the six main NWHI subpopulations, 1985-2002.

Until recently, the three westernmost subpopulations, Kure, Midway and Pearl and Hermes Reef, exhibited substantial growth. The subpopulation at Kure Atoll grew at an average rate of 5% yr^{-1} from 1983 to 2000 (loglinear regression of beach counts; R^2 = 0.85, p<0.001), due largely to decreased human disturbance and introduced females. However, since 2000, counts at Kure have declined coinciding with very low survival of the 2000-2001 cohorts from weaning to age 1 yr (15% and 18%, respectively). The subpopulation at Pearl and Hermes Reef increased after the mid-1970s. The average growth rate from 1983-2000 was 6%yr^{-1} (loglinear regression of beach counts; R^2 = 0.84, P<0.001), and prior to 1999, growth rates of up to 7%yr^{-1} were observed. This is the highest estimate of the maximum net productivity rate (R_{max}) observed for this species. Growth of this subpopulation has slowed recently and early survival has declined. Recovery of the small subpopulation at Midway Atoll appears to have slowed or stopped, also accompanied by relatively poor juvenile survival. These demographic trends at the western end of the NWHI do not bode well for recovery, especially if recent low juvenile survival rates become chronic. While the MHI monk seal population may be on the rise (Baker and Johanos 2003), this remains unconfirmed and abundance appears to be too low to strongly influence current total stock trends.

POTENTIAL BIOLOGICAL REMOVAL

Potential biological removal (PBR) is designed to allow stocks to recover to, or remain above, the maximum net productivity level (MNPL) (Wade 1998). An underlying assumption in the application of the PBR equation is that marine mammal stocks exhibit certain dynamics. Specifically, it is assumed that a reduced stock will naturally grow toward OSP, and that some surplus growth can be removed while still allowing recovery. The Hawaiian monk seal population is far below historical levels and has declined 1.1% yr^{-1} on average for the past decade. Thus, for unknown reasons, the stock's dynamics do not conform to the underlying model for calculating PBR. The prescribed PBR calculation for this stock would be the minimum population size (1,276) times one half the maximum net growth rate (½ of 7%) times a recovery factor of 0.1 (for an endangered species, Wade and Angliss 1997), which yields 4.5 monk seals per year. However, given the stock's current status and trend, the intended standard for determining PBR, i.e., recovery to MNPL, will not be achieved in the foreseeable future if a take of 4.5 seals a year is realized. Meanwhile, it also appears unlikely that some non-zero level of removal below 4.5 animals could explain the lack of recovery of this stock. Given this unique set of circumstances, PBR for the Hawaiian monk seal is undetermined.

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; Bailey 1952; Clapp and Woodward 1972). Following a period of at least partial recovery in the first half of the 20th century (Rice 1960), most subpopulations again declined. This second decline has not been fully explained, but trends at several sites appear to have been determined by human disturbance from military or U.S. Coast Guard activities (Ragen 1999; Kenyon 1972; Gerrodette and Gilmartin 1990).

Fishery Information

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 1976, known fishery-related monk seal deaths have included the following (NMFS unpubl. data): one seal drowned in a nearshore gillnet off Kauai (1976), another seal died from entanglement in the bridle rope of lobster trap near Necker Island (1986), another died from entanglement in an illegally set gill net off Oahu (1994), and one ingested a fish hook and likely drowned off Kauai (1995). A total of 26 seals have been observed with embedded fish hooks during 1982- 2002. 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 state-managed nearshore fisheries (esp. for *Caranx* sp. in the main Hawaiian Islands), federal and state bottomfish and federal longline fisheries (NMFS unpubl. data). A recent Biological Opinion summarized hookings and entanglements (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 have potential to interact with Hawaiian monk seals. The NWHI lobster fishery was closed in 2000 due to uncertainty in the estimates of biomass, and the fishery remains closed to date. Neither incidental mortality nor serious injury were observed by NMFS observers of the lobster fishery through 2001, though one mortality was documented in 1986. The potential for indirect interaction due to competition for prey is being investigated (see Habitat Issues below).

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 95 - 201 metric tons per year from 1989-2002 (Kawamoto 1995; Kawamoto, pers. comm.). The number of vessels rose from 19 in 1984 to 28 in 1987, and then varied from 9 to 17 in 1988 through 2002 (Kawamoto 1995; Kawamoto, 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). NMFS has prepared an Environmental Impact Statement and 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 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. In October 1991, in response to 13 unusual seal wounds thought to have resulted from interactions with this fishery, 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 have found no further evidence of interactions with the longline fishery. Until 2000, interactions with protected species were assessed using Federal logbooks and

observers (4-5% coverage) Since 2001, the observer program has maintained observer coverage levels for the Hawaii-based longline fleet above 20%. However, since 1991, there have been no observed or reported interactions of this fishery with monk seals.

There have also been interactions between nearshore fisheries and monk seals in both the NWHI and the MHI. 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 (MHI), one seal was found dead in a nearshore (non-recreational) gillnet in 1994 and a second seal was found dead with a hook lodged in its esophagus. A total of 16 seals have been observed with embedded hooks in the MHI during 1989-2002. Several incidents, including the dead hooked seal mentioned above, involved hooks used to catch ulua (jacks, *Caranx* spp.). Interactions in the MHI appear to be on the rise, as half the observed hookings have occurred since 2000, and a seal was also entangled in an actively fished nearshore gillnet off Oahu in 2002 (NMFS unpubl. data).

Interest in the harvest of precious coral in the NWHI represents a potential for future interactions with monk seals. However, some seals forage at patches of precious gold corals occurring over 500m in depth (Parrish et al., 2002). 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	1991-2000	0-12	Observer Log book	0-100%	0	n/a	n/a
NWHI Bottomfish	1991-2002	9-17	n/a	n/a	n/a	n/a	n/a
Pelagic longline	1991-2002	100-141	Observer Log book	3-28%	0	n/a	n/a
Recreational	1991-1995	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 222 cases of seals entangled in fishing gear or other debris have been observed through 2002 (Henderson 2001; NMFS, unpubl. data), including seven documented mortalities resulting from entanglement in fisheries debris (Henderson 1990, 2001; NMFS, unpubl. data). The fishing gear fouling the reefs and beaches of the NWHI and entangling monk seals only rarely includes types used in Hawaiian fisheries. 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. During 1996-2002 debris survey and removal efforts, over 360,000 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).

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 may impede recovery 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 (1995-2002).

In addition, 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 translocated to Johnston Atoll, 870 km to the southwest. Subsequently, mounting injury to pups have 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 recent years. At French Frigate Shoals in 1999, 17 pups were observed injured by large sharks, and at least 3 were confirmed to have died from shark predation (Johanos and Baker, 2001). 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 healthy 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. Notably, while fewer dead seals were observed in 2002, overall yearling survival rates (2001 cohort) were comparable to those observed during the Unusual Mortality Event.

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, through potential physical damage to reefs, oil spills, and release of debris into habitats. Two relatively recent groundings include the *Paradise Queen II*, a lobster fishing vessel, at Kure Atoll in 1998, and the 77 ft longliner *Swordman I* at Pearl and Hermes Reef in 2000.

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 1999). Similarly, recently observed poor juvenile survival rates suggest that prey availability may be limiting recovery of other NWHI subpopulations.

Goodman-Lowe (1998) provided information on prey selection using hard parts in scats and spewings. Information on at-sea movement and diving is available for seals at all six main subpopulations in the NWHI using satellite telemetry (Stewart 2004*a*,*b*; Stewart and Yochem 2004 *a*,*b*,*c*). Preliminary studies to describe the foraging habitat of monk seals in the MHI are underway in 2004.

Currently, human activities in the NWHI are limited and, consequently, human disturbance, which impacted monk seals in the past (Ragen 1999), is relatively rare.

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 2004.

There are indications that monk seal abundance is increasing in the main Hawaiian Islands (Baker and Johanos 2003). 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 MHI, 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 MHI is approximately 1.2 million compared to less than 100 in the NWHI, so that the potential impact of disturbance in the MHI 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 MHI 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.

REFERENCES

Bailey, A. M. 1952. The Hawaiian monk seal. Museum Pictorial, Denver Museum of Natural History 7:1-32.

Baker, J. D. and T. C. Johanos. 2003. Abundance of Hawaiian monk seals in the main Hawaiian Islands. Biological Conservation 116:103-110.

Baker, J. D. and T. C. Johanos. 2002. Effects of research handling on the endangered Hawaiian monk seal. Mar. Mammal Sci. 18:500-512.

Clapp, R. B., and P. W. Woodward. 1972. The natural history of Kure Atoll, Northwestern Hawaiian Islands, Atoll Res. Bull. 164:303-304.

Craig, M. P. and T. J. Ragen. 1999. Body size, survival, and decline of juvenile Hawaiian monk seals, Monachus schauinslandi. .Marine Mammal Science 15(3): 786_809.

Dill, H. R., and W. A. Bryan. 1912. Report on an expedition to Laysan Island in 1911. U.S. Dept. of Agric. Surv. Bull. 42:1-30.

Donohue, M.J., R. Brainard, M. Parke, and D. Foley. 2000. Mitigation of environmental impacts of derelict fishing gear through debris removal and environmental monitoring. Issue paper in International Marine Debris Conference on Derelict Fishing Gear and the Ocean Environment, 6_11 August 2000, Honolulu, Hawaii. Hawaiian Islands Humpback Whale National Marine Sanctuary publication, 726 S Kihei Road, Kihei, HI 96753, hawaiian@nms.noaa.gov.

Donohue, M.J., R.C. Boland, C.M. Sramek, and G.A. Antonelis. 2001. Derelict fishing gear in the Northwestern Hawaiian Islands: diving surveys and debris removal in 1999 confirm threat to coral reef ecosystems. Marine Pollution Bulletin 42(12):1301_1312.

Forney, K.A., J. Barlow, M.M. Muto, M. Lowry, J. Baker, G. Cameron, J. Mobley, C. Stinchcomb, and J.V. Carretta. 2000. U.S. Pacific Marine Mammal Stock Assessments: 2000. U.S. Dep. Commer. NOAA Technical Memorandum. NMFS_SWFSC_300. 276 p.

Gerrodette, T. M., and W. G. Gilmartin. 1990. Demographic consequences of changed pupping and hauling sites of the Hawaiian monk seal. Conserv. Biol. 4:423-430.

Goodman-Lowe, G. D. 1998. Diet of the Hawaiian monk seal (*Monachus schauinslandi*) from the northwestern Hawaiian islands during 1991 to 1994. Marine Biology 132:535-546.

Harting, A.L. 2002. Stochastic simulation model for the Hawaiian monk seal. PhD thesis, Montana State University, 328 p.

Henderson, J. R. 1990. Recent entanglements of Hawaiian monk seals in marine debris. In R. S. Shomura and M. L. Godfrey (eds.), Proceedings of the Second International Conference on Marine Debris, April 2-7, 1989, Honolulu, Hawaii, p. 540-553. U.S. Dep. Commer., NOAA, Tech. Memo. NMFS-SWFSC-154.

Henderson, J.R. 2001. A Pre_ and Post_MARPOL Annex V Summary of Hawaiian Monk Seal Entanglements and Marine Debris Accumulation in the Northwestern Hawaiian Islands, 1982_1998. Marine Pollution Bulletin 42:584_589.

Johanos, T. C. and J. D. Baker (editors). 2000. The Hawaiian monk seal in the Northwestern Hawaiian Islands, 1998. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFSC-292, 125 p.

Johanos, T. C. and J. D. Baker (editors). 2001. The Hawaiian monk seal in the Northwestern Hawaiian Islands, 1999. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFSC-310, 130 p.

Johanos, T. C. and J. D. Baker (editors). 2002. The Hawaiian monk seal in the Northwestern Hawaiian Islands, 2000. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFSC-340, 100 p.

Johanos, T. C. and J. D. Baker (editors). In press. The Hawaiian monk seal in the Northwestern Hawaiian Islands, 2001. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFSC-XXX, XXX p.

Johanos, T. C. and J. D. Baker (editors). In press. The Hawaiian monk seal in the Northwestern Hawaiian Islands, 2002. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFSC-XXX, XXX p.

Johnson, A. M., and E. Kridler. 1983. Interisland movement of Hawaiian monk seals. 'Elepaio 44(5):43-45.

Kawamoto, K. E. 1995. Northwestern Hawaiian Islands bottomfish fishery, 1994. Admin. Rep. H-95-07. Southwest Fisheries Science Center, National Marine Fisheries Service, 2570 Dole St., Honolulu, HI 96822-2396. 26 pp.

Kenyon, K. W. 1972. Man versus the monk seal. J. Mammal. 53(4):687-696.

Kretzmann, M. B., W. G. Gilmartin, A. Meyer, G. P. Zegers, S. R. Fain, B. F. Taylor, and D. P. Costa. 1997. Low genetic variability in the Hawaiian monk seal. Conserv. Biol. 11(2):482-490.

Kretzmann, M. B., N. J. Gemmell, and A. Meyer. 2001. Microsatellite analysis of population structure in the endangered Hawaiian monk seal. Conserv. Biol. 15(2):457-466.

Goodman-Lowe, G. D. 1998. Diet of the Hawaiian monk seal (*Monachus schauinslandi*) from the Northwestern Hawaiian islands during 1991 to 1994. Marine Biology 132:535-546.

National Marine Fisheries Service. 2002. Biological Opinion for the Management of the Bottomfish and Seamount Groundfish Fisheries in the Western Pacific Region According to the Fishery Management Plan for the Bottomfish and Seamount Groundfish Fisheries of the Western Pacific Region.

Nitta, E. T., and J. R. Henderson. 1993. A review of interactions between Hawaii's fisheries and protected species. Mar. Fish. Rev. 55(2):83-92.

Parrish, F. A., M. P. Craig, T. J. Ragen, G. J. Marshall, and B. M. Buhleier. 2000. Identifying diurnal foraging habitat of endangered Hawaiian monk seals using a seal-mounted video camera. Mar. Mamm. Sci. 16:392-412.

Parrish, F.A., K Abernathy, G.J. Marshall, and B.M. Buhleier. 2002. Hawaiian monk seals (Monachus schauinslandi) foraging in deepwater coral beds. Mar. Mamm. Science 18:244-258.

Polovina, J. J., G. T. Mitchum, N. E. Graham, M. P. Craig, E. E. DeMartini, and E. N. Flint. 1994. Physical and biological consequences of a climate event in the central North Pacific. Fish. Ocean. 3:15-21.

Pooley, S. G., and K. E. . 1998. Annual report of the 1995-97 western Pacific lobster fishery. Admin. Rep. H-98-09. Southwest Fisheries Science Center, National Marine Fisheries Service, 2570 Dole St., Honolulu, HI 96822-2396. 34 pp.

Ragen, T. J. 1993. Status of the Hawaiian monk seal in 1992. Admin. Rep. H-93-05. Southwest Fisheries Science Center, National Marine Fisheries Service, 2570 Dole St., Honolulu, HI 96822-2396. 79 pp.

Ragen, T.J. 1999. Human activities affecting the population trends of the Hawaiian monk seal. Pages 183-194 *in* J.A. Musick, ed. Life in the slow lane: Ecology and conservation of long-lived marine animals. American Fisheries Society Symposium 23, American Fisheries Society, Bethesda, MD.

Rice, D. W. 1960. Population dynamics of the Hawaiian monk seal. J. Mammal. 41:376-385.

Stewart, B. S. 2004*a*. Geographic patterns of foraging dispersion of Hawaiian monk seals (*Monachus*

schauinslandi) at the Northwestern Hawaiian Islands. Pacific Islands Fisheries Science Center Admin. Rep. H-04-05C.

Stewart, B. S. 2004*b*. Foraging ecology of Hawaiian monk seals (*Monachus schauinslandi*) at Pearl and Hermes Reef, Northwestern Hawaiian Islands: 1997-1998. Pacific Islands Fisheries Science Center Admin. Rep. H-04-03C.

Stewart, B. S., and P. K. Yochem. 2004*a*. Dispersion and foraging of Hawaiian monk seals (*Monachus schauinslandi*) near Lisianski and Midway Islands: 2000-2001. Pacific Islands Fisheries Science Center Admin. Rep. H_04_04C.

Stewart, B. S., and P. K. Yochem. 2004*b*. Use of marine habitats by Hawaiian monk seals (*Monachus schauinslandi*) from Laysan Island: Satellite-linked monitoring in 2001-2002. Pacific Islands Fisheries Science Center Admin. Rep. H_04_02C.

Stewart, B. S., and P. K. Yochem. 2004*c*. Use of marine habitats by Hawaiian monk seals (*Monachus schauinslandi*) from Kure Atoll: Satellite-linked monitoring in 2001-2002. Pacific Islands Fisheries Science Center Admin. Rep. H_04_01C.

Wade, P. R. and R. P. Angliss. 1997. Guidelines for Assessing Marine Mammal Stocks: Report of the GAMMS Workshop April 3-5, 1996, Seattle, Washington. U. S. Dep. Commer., NOAA Tech. Memo. NMFS-OPR-12. 93 pp.

Wade, P. R. 1998. Calculating limits to the allowable human-caused mortality of cetaceans and pinnipeds. Marine Mammal Science 14:1-37.

Wetmore, A. 1925. Bird life among lava rock and coral sand. The Natl. Geograp. Mag. 48:77-108.