Marine Mammal Commission. 2001. Hawaiian monk seal (*Monachus schauinslandi*). Pages 54-70 in Chapter III, Species of Special Concern, Annual Report to Congress, 2000. Marine Mammal Commission, Bethesda, Maryland.

Hawaiian Monk Seal (*Monachus schauinslandi*)

The Hawaiian monk seal is the most endangered seal in U.S. waters. The species is one of three in the genus *Monachus*. The Caribbean monk seal is now considered extinct. The Mediterranean monk seal probably numbers 300 to 500 animals and is on the verge of extinction. The Hawaiian monk seal, number-ing about 1,300 to 1,400 animals, also is in danger of extinction, but has a better chance of long-term survival.

Certain primitive features indicate that the Hawaiian monk seal may have evolved as long ago as 15 million years. Where the species evolved is unknown, but currently these seals are found only in the Hawaiian archipelago (Fig. 4). Within the archi-pelago, monk seals apparently were extirpated from the main Hawaiian Islands soon after the arrival of the first human settlers 2,000 years ago. Thus, their present-day distribution is confined largely to the remote Northwestern Hawaiian Islands, a chain of small islands and atolls stretching more than 2,000 km to the northwest of the main Hawaiian Islands. Even at these remote locations, monk seals have been subjected to a variety of natural and human-related impacts that have contributed to their current endangered state. In the 1800s they were killed by sealers, explorers, and shipwrecked sailors for skins, oil, and food. In the 1900s they suffered more from disturbance and loss of habitat due to an increasing human presence.

Historical records of early expeditions to the Northwestern Hawaiian Islands indicate that by 1900 Hawaiian monk seals may have been extirpated at

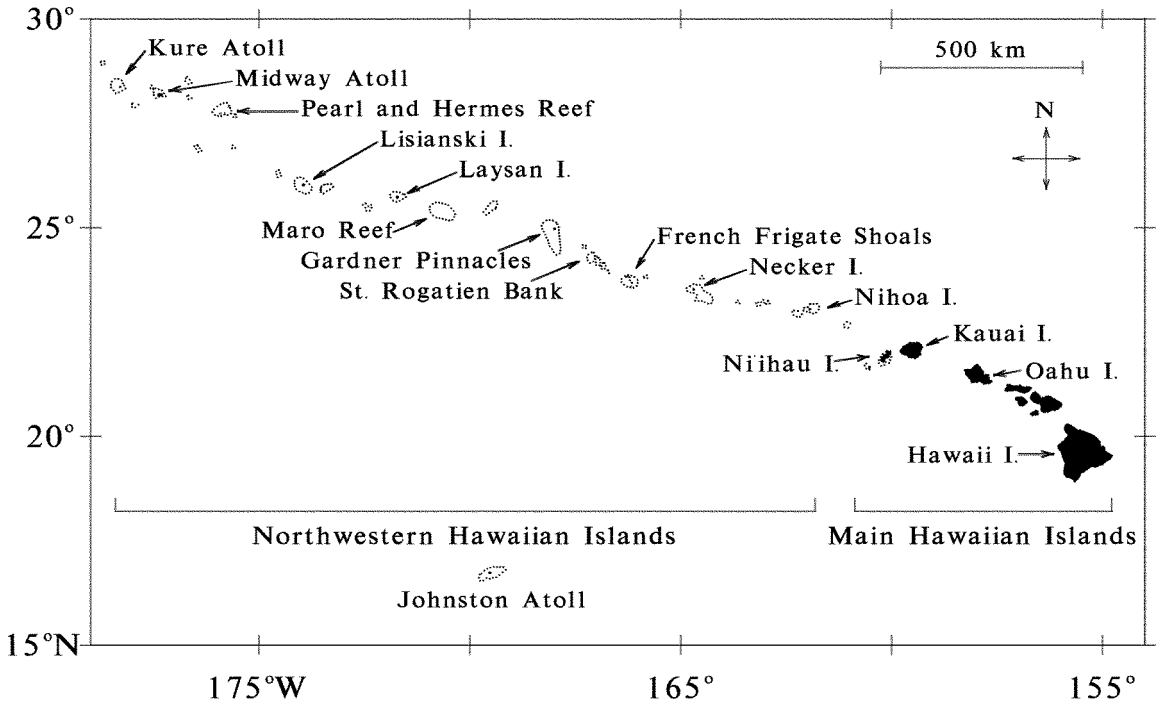

Figure 4. The Hawaiian Archipelago. The Northwestern Hawaiian Islands provide pupping beaches for all major breeding colonies of Hawaiian monk seals.

two or possibly three sites (Laysan Island, Midway Atoll, and French Frigate Shoals) in the chain. Some recov-ery must have occurred by the 1950s although abund-ance and trends before that time are poorly known. The first range-wide count was conducted in the 1950s, well after the species' distribution had been reduced to its current range. The count provided an index of total population size rather than a population estimate, because it did not include seals at sea during the count. Generally, about one-third of the seals are on land during a typical count. By the 1970s the abundance of Hawaiian monk seals had declined considerably (Fig. 5) and in 1976 the species was listed as endangered under the Endangered Species Act. Subsequent counts indicate that the total population declined by about 60 percent from the mid-1950s to the early 1990s, but has remained at about the same low level since (Fig. 5). The decline appears to have leveled off in the 1990s.

During the past four decades the six existing colonies have exhibited varying demographic trends. Numbers declined at Kure Atoll, Midway Atoll, Pearl and Hermes Reef, Lisianski Island, and Laysan Island. In contrast, the colony at French Frigate Shoals grew perhaps as much as four- to sixfold during this period, and by the mid-1980s approxi-mately half of the total population occurred at that site. Since the late 1980s, however, this colony has declined sharply in numbers, and it is expected to continue declining in the near future due to a lack of recruitment of young animals into the breeding age groups (described later).

Site-Specific Status and Trends

A review of the status and trends of the existing colonies is necessary to understand the past decline of the Hawaiian monk seal and the challenge of promoting recovery of the species in the future.

French Frigate Shoals – Based on its abundance, the colony of Hawaiian monk seals at French Frigate Shoals has dominated trends for the species over the past several decades. The oscillation in abundance at this site (Fig. 6) is likely due to a combination of factors. The growth observed from the late 1950s to the 1980s probably occurred as a result of decreased human disturbance at French Frigate Shoals. Military operations in the late 1930s and 1940s must have had a considerable effect on the local seal colony, both through disturbance and the loss of seal haul-out areas to human activities, and possibly through the incidental injury or killing of seals. Since the late 1950s human activities have been reduced considerably, which has lessened the impact on the seals and allowed a period of local growth and recovery. By the mid- to late 1980s, however, the number of seals at this atoll may have reached the environmental carrying capacity. Since the late 1980s the French Frigate Shoals colony has declined by 60 percent or more due to poor survival of pups and juveniles, slow growth and maturation of

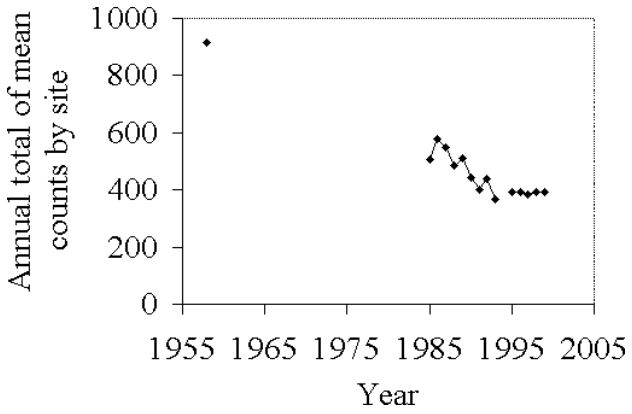

Figure 5. Combined annual mean beach counts for all major Hawaiian monk seal breeding colonies, 1958–2000.

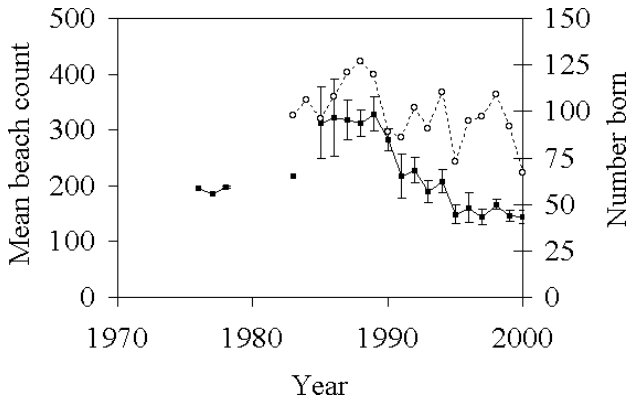

Figure 6. Annual mean beach counts (filled squares) and pups born (open circles) at French Frigate Shoals.

survivors, and low reproductive success of mature females. Important known sources of juvenile mortality include food limitation or starvation, shark predation, and adult male aggression. Slow growth and maturation, as well as low reproductive success, are also consistent with food limitation. Thus, the existing evidence suggests that the growing colony of seals may have reached the environmental carrying capacity by depleting food resources at the atoll and nearby banks where they feed.

At the same time, however, the environmental carrying capacity itself may have declined. Climate studies indicate the occurrence of decadal-scale shifts in North Pacific oceanographic and atmospheric conditions, which may have decreased productivity in the 1980s and 1990s and, subsequently, reduced prey availability for higher-level predators such as the Hawaiian monk seal. In effect, the demands of a growing colony may have overshot a waning food supply, exacerbating the demographic problems described earlier.

This scenario may have been further complicated in the late 1970s and 1980s by development of the Northwestern Hawaiian Islands lobster fishery. The fishery took its largest catches in the early 1980s and focused its effort at banks within the foraging range of monk seals from French Frigate Shoals. The fishery reduced considerably the standing biomass of lobster and may well have seriously reduced the available biomass of octopus, which is taken as bycatch. Both lobster and octopus are known prey of Hawaiian monk seals, and the fishery may thereby have contributed to the seals' nutritional limitation.

Finally, the decline of this colony also has been exacerbated by shark predation and adult male aggression. Sharks are known to attack monk seals of all sizes and are a particular threat to pups and juveniles. In recent years tiger and Galápagos sharks have frequented the nearshore waters off several main pupping islets at French Frigate Shoals. These sharks are known to have killed some pups and are suspected to have killed others. In 1999 a total of 92 pups was born, of which 25 are believed to have died from shark predation. Aggressive adult males also have contributed to pup mortality at this site. In 1991 and in 1998 adult males were removed from this colony after they were observed harassing and, in some cases, killing pups.

All of these factors together have not only reduced the French Frigate Shoals colony by more than 60 percent over the last decade but have also destabilized its age structure. Due to extremely low survival of pups and juveniles, few young females have reached maturity at this site in recent years and few are expected to do so in the next 5 to 10 years. Thus, the reproductive potential of the colony has been diminished considerably. In 2000 the number of births recorded dropped to 67, approximately half the annual number in the mid-1980s. The number of seals will probably continue to decline in the near future.

The National Marine Fisheries Service has conducted extensive research at the site. With the assistance of Sea Life Park, the Fish and Wildlife Service, the Coast Guard, and the Navy, the Service also carried out several captive care and relocation programs in an effort to salvage the reproductive potential being lost. These programs were intended to return emaciated pups and juveniles to good health and condition, protect them from sharks and aggressive adult males, and (in the majority of cases) relocate them to areas where availability of prey would be adequate to support normal growth, maturation, and reproduction. A number of pups were relocated to Kure Atoll and successfully bolstered recovery of that colony. In the early 1990s relocation efforts were redirected to Midway Atoll, but after several unsuccessful efforts at that site, the release site for young animals in captive care was changed back to Kure Atoll. In 1995, however, 12 pups taken from French Frigate Shoals contracted an eye disease that precluded their release. Although these seals have since been transferred to another captive facility, this ailment and, more generally, the potential for disease transmission between colonies have emphasized the need for caution in future relocation efforts. As discussed below, the variability of juvenile survival as observed at this site and earlier at Kure Atoll and the need to prevent the loss of the species' reproductive potential will likely be important considerations for monk seal research and recovery efforts for some time to come.

Laysan Island – By the late 1800s the Hawaiian monk seal colony on Laysan Island was virtually, if not totally, extirpated. Few seals were seen on the island, probably because they had been killed for food or disturbed by feather collectors and guano miners. Schauinsland, the scientist who initially described the species, failed to see a single living seal during a three-month visit to the island in 1896. Other visitors recorded a similar absence of seals. However, the colony must have recovered to some degree by the 1950s and 1960s, when counts revealed between 200 and 300 seals on the beach. Thereafter, the counts declined erratically to a low point in 1990. Since 1990 the colony has shown a slow increase in both the mean annual count and the number of pups born (Fig. 7).

In 1978 the decline of the Laysan Island population was accelerated by a die-off of at least 50 seals. Poisoning by ciguatoxin (a naturally occurring biotoxin) was suspected, but the cause remains unknown. The remainder of the decline also has not been explained. Military activities took place on Laysan Island during the period of decline, but the nature of those activities and their potential effect on monk seals have not been described. Research activities conducted since the late 1970s suggest that at least the later part of the decline might have been due to increased mortality of adult females and juveniles by mobbing or male aggression. The term "mobbing" is used to describe incidents where multiple males attempt to mount and mate with a single female (or in some cases a juvenile animal of either sex) at the same time. During mating, which occurs in the water, a male bites the female's back to help him attain and maintain his position. When repeated by multiple males, such bites can cause severe and even lethal wounds. Evidence of mobbing has been observed at several sites but has been best studied at Laysan Island. Between 1984 and 1992 mobbing was a factor in 45 of the 63 monk seal deaths (70 percent) confirmed at this site.

Mobbing is thought to result, at least in part, from an imbalance in the adult sex ratio. Data from the late 1970s and early 1980s suggest that the adult sex ratio in the colony was heavily skewed with as many as 2.5 to 3 males for each female. In effect, the "functional" sex ratio may have been even more extreme. During the species' prolonged reproductive season, females with pups are antagonistic to adult males and are generally unavailable for mating. Estrus for the remaining females is relatively asynchronous (although estrus is not always a factor in mobbing), and the result is a functionally skewed sex ratio with multiple males vying for the mating rights with relatively few available females. To the extent that mobbing increases female mortality, it also creates a feedback loop: a skewed sex ratio increases the likelihood of mobbing, and mobbing-related mortality further reduces the number of females, further skewing the sex ratio. Studies conducted at Laysan Island since the early 1980s indicate, however, that the sex ratio of adult animals has been steadily changing from one skewed toward males to one approaching parity or slightly biased toward adult females.

In 1984 nine adult males were relocated from Laysan Island to Johnston Atoll and in 1994 a total of 22 males was relocated to the main Hawaiian Islands to facilitate this transition and reduce the incidence of male aggression. None of the males returned to Laysan Island, and data collected after the 1994 relocation revealed a significant reduction in injuries and mortality resulting from such aggression. In 1999 and 2000 the adult sex ratio was 0.9:1.0 (M:F). Nevertheless, in 1999 mobbing or single-male aggression resulted in five injuries and two deaths, indicating that such aggression still may occur with lethal consequences. In 2000 only a single nonlethal injury was attributed to male aggression. The recovery team has recommended that individuals males exhibiting excessively aggressive behavior be removed from Laysan and Lisianski Island (described later), as was done at Laysan Island in 1994 and at French Frigate Shoals in 1991 and 1998.

At present the Laysan colony seems poised for continued recovery. The number of pups born annually (Fig. 7) has increased, albeit variably, over the past decade. A total of 58 pups was born at Laysan Island in 1999, the largest number of births recorded since intensive monitoring began in the late 1970s. In 2000 the number of pups born was 43. Unfortunately, the increase in number of pups born in

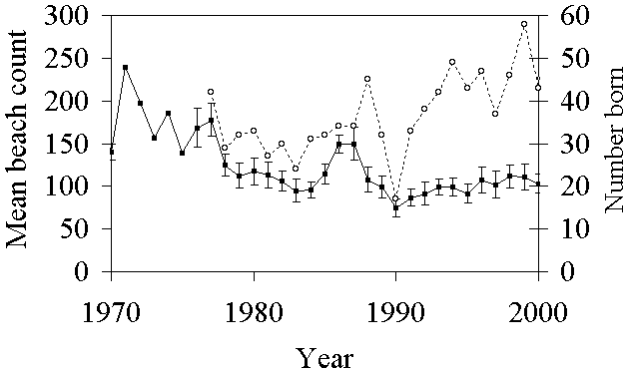

Figure 7. Annual mean beach counts (filled squares) and pups born (open circles) at Laysan Island.

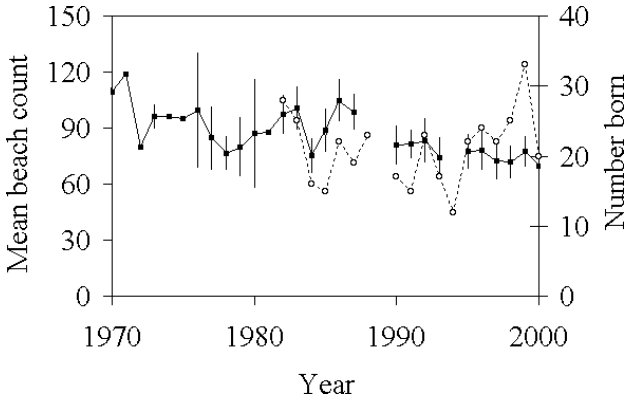

Figure 8. Annual mean beach counts (filled squares) and pups born(open circles) at Lisianski Island.

1999 was offset somewhat by a decrease in pup and juvenile survival. Due to its small size, recovery of this colony will likely occur slowly. However, in the absence of excessive mortality due to mobbing and male aggression, recovery can reasonably be expected to continue in the near future.

Lisianski Island – From the late 1950s to the 1980s the monk seal colony at Lisianski Island exhibited a decline similar to that observed at Laysan Island. In contrast to the colony at Laysan Island, counts at Lisianski Island have continued to decline slowly (Fig. 8). The number of pups born has increased slowly since 1991, but juvenile mortality has increased. At least two problems are known to be impeding recovery at the site: male aggression and entanglement in marine debris. In the late 1970s and early 1980s the colony at Lisianski may have contained as many as three adult males per adult female. This imbalance has been correcting itself over the past two decades, but has not yet reached parity. In 2000 the adult sex ratio was 1.6:1.0 (M:F). The imbalance is observed in the older adults (>18 years of age), and parity should be reached when these older animals die and are replaced by younger cohorts. Still, in 1999 a total of 10 observed injuries was attributed to single-male aggression or mobbing, indicating that male aggression may impede the colony's recovery. In 2000 this number declined to 4. Because studies at Lisianski Island have not been as consistent as those at Laysan Island, the signifi-cance of male aggression at this site is less well known.

Entanglement in marine debris is a serious problem at all sites, but has been particularly serious at Lisianski Island. Historically, researchers have found greater deposition of debris and more entanglement of seals at Lisianski Island than at any other site in the Northwestern Hawaiian Islands. In 1999 seven seals were observed entangled at this site; three escaped independently and four were re-leased by the researchers. In contrast to past trends, no entangled seals were observed as this site in 2000.

An unknown number of entangled seals are unable to return to the island where they might be observed and freed. In 1999 a cooperative effort removed debris from three sites, including Lisianski Island, to reduce the damage done to coral reefs and the threat to wildlife, including monk seals (see later in this section and Chapter VII). The continued removal of debris from this site, as well as other sites in the chain, remains a high priority. Because both entanglement and male aggression may contribute significantly to increased mortality at this site, recovery of this colony will remain uncertain until the incidence of both is understood and management actions have been taken to mitigate the impacts.

Pearl and Hermes Reef – The colony of Hawaiian monk seals at Pearl and Hermes Reef declined from the late 1950s to the mid-1970s, but has been recovering gradually since then (Fig. 9). In the 1950s the local abundance of seals was probably depleted by military excursions from Midway Atoll. Such activities no longer occur and this colony is now

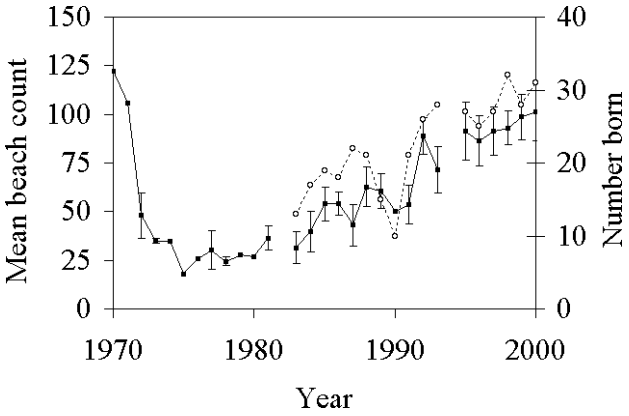

Figure 9. Annual mean beach counts (filled squares) and pups born (open circles) at Pearl and Hermes Reef.

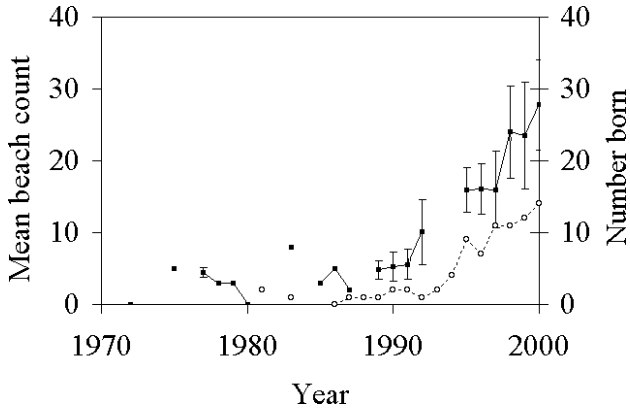

Figure 10. Annual mean beach counts (filled squares) and pups born (open circles) at Midway Atoll.

largely free from human disturbance. Male aggression and mobbing appear to be rare at Pearl and Hermes Reef, survival rates of young animals appear to be good, and the age structure is stable and poised for further growth in the future (i.e., the colony has a high proportion of young animals that are reaching maturity and beginning to contribute to the productivity of the colony). Monk seals tagged at Pearl and Hermes Reef are frequently sighted at Midway and Kure Atolls, and appear to contribute to the growth of those colonies, particularly at Midway Atoll. In the recent past, recovery at these three western sites has partially offset the decline at French Frigate Shoals.

In October 1999 this atoll was partially cleared of debris by the cooperative effort mentioned earlier. Nevertheless, entanglement in marine debris continues to be a threat to recovery of this colony. In 2000 two entangled seals were observed and successfully disentangled by field personnel.

In June 2000 the longline fishing vessel *Swordman I* ran aground near Pearl and Hermes Reef, spilling an estimated 2,200 gallons of diesel fuel. It also had additional fuel and oil on board, holds full of eventually rotting fish and bait, and large amounts of line and fishing gear that could have been lost to the sea if not cleaned up. Researchers from the monk seal program were conducting studies at Pearl and Hermes Reef and rescued crew members from the *Swordman I.* A natural resource assessment crew from the Fish and Wildlife was on the scene one week later. The vessel was eventually pulled from the reef and sunk in deep water. The assessment crew estimated that damage to the reef and its inhabitants was minimal. Although no effects on Hawaiian monk seals were documented at the atoll, such incidents pose a serious threat to local ecosystems and their inhabitants, including monk seals.

Midway Atoll – The colony of Hawaiian monk seals at Midway Atoll probably has been affected more by human activity and disturbance than any other colony. The atoll was visited on multiple occasions in the 1800s, and by the end of the century the local colony of monk seals had been extirpated. The atoll was permanently settled in the early 1900s and, in spite of the human presence, some recovery of the monk seal colony occurred in the early 1900s. The seals were exposed to considerable disturbance during World War II and the postwar period, but as many as 60 animals were still observed at the atoll in the mid-1950s. By the early 1960s, however, the colony had all but disappeared a second time. Since then, the colony has been slow to recover, and the first real signs of recovery were not apparent until the early 1990s after the Navy drastically curtailed its activities on Midway.

Data collected over the past decade indicate that recovery continues as a consequence of reproduction by seals at the atoll, immigration from Kure Atoll and Pearl and Hermes Reef, and protection associated with the 1996 transfer of ownership of the atoll to the Fish and Wildlife Service. In 2000 a total of 14 pups

was born, the most recorded at this site since the first counts were conducted in the 1950s. The mean beach count in 2000 was a little over 25 animals (Fig. 10).

The Navy operated an air station at Midway Atoll until 1996 when it was closed and the atoll was relinquished to the Fish and Wildlife Service. To maintain the atoll's runway, the Service contracted with a commercial company interested in using the atoll as a refueling point and emergency runway for aircraft traveling between the United States and Asia. To subsidize operation of the runway, the company established an ecotourism center on Sand Island, the largest of the atoll's islands. The venture provides an opportunity for tourists to observe monk seals, seabirds, and other marine life in the wild, and thus serves as an opportunity to educate the public about the Hawaiian monk seal.

At the same time, ecotourism has raised concern about the potential for disturbance of the vitally important seal colony at Midway Atoll. Through the late 1990s, cooperative efforts by the Fish and Wildlife Service, the National Marine Fisheries Service, and the Hawaii Wildlife Fund have sought to prevent disturbance of seals through a management plan, educational programs, and monitoring of human-seal interactions. Trends in seal counts and numbers of pups born suggest that disturbance has been managed so as not to preclude recovery. Nevertheless, monitoring and prevention of disturbance are essential to ensure that recovery continues. The potential for disturbance may increase if enforcement and education efforts are not maintained, if more visitors are allowed at the atoll, or if visitors and residents change or increase their activities in ways that disturb seals, either on land or in the water.

The establishment of Midway as a tourist destination also may increase human visitation to nearby sites (i.e., Kure Atoll and Pearl and Hermes Reef) or to sites intermediate between Midway and the main Hawaiian Islands (i.e., French Frigate Shoals and Laysan and Lisianski Islands). Careful monitoring and precautionary management are therefore essential to ensure that all human activities are compatible with the full recovery of the Midway colony of Hawaiian monk seals and colonies at neighboring sites.

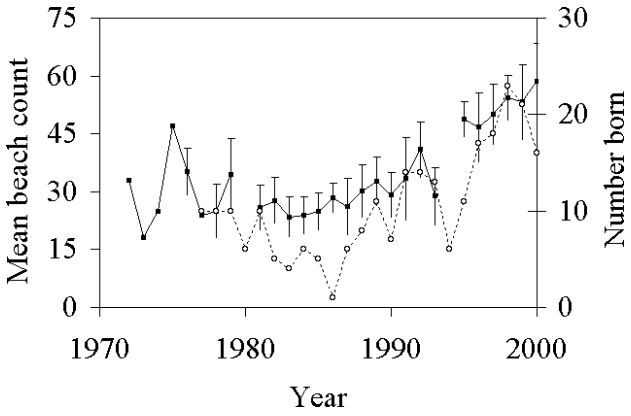

Figure 11. Annual mean beach counts (filled squares) and pups born (open circles) at Kure Atoll.

Kure Atoll – The colony of Hawaiian monk seals at Kure Atoll also has a long history of human disturbance. The U.S. Coast Guard established a loran station at this site early in the 1960s. The activities of Coast Guard personnel and their dogs led to considerable disturbance of seals until the Coast Guard adopted more stringent rules designed to avoid disturbance of seals. The atoll's monk seal colony also experienced an imbalanced adult sex ratio, with evidence of mobbing and adult male aggression and poor juvenile survival. The com-bined effects of human activities, male aggression, and shark predation led to a severe decline of this colony to a level where, in 1986, only a single pup was born. Recovery programs initiated by the National Marine Fisheries Service and modification of Coast Guard rules and regulations reversed the decline and allowed the colony to begin rebuilding. Since the mid-1980s the colony has grown steadily, and in 2000 the mean beach count was 59 animals and 16 pups were born (Fig. 11). The Coast Guard closed its station in 1992 and the atoll is currently uninhabited. Unlike the remainder of the North-western Hawaiian Islands, Kure Atoll is owned and managed by the State of Hawaii. To date the state's major management activities at the atoll have involved conservation efforts to return the atoll to its natural state.

In October 1998 the *Paradise Queen II* (a lobster fishing vessel) ran aground on the eastern edge of Kure Atoll. Debris from the wreck was dispersed

throughout portions of the atoll including Green Island, the main island in the atoll. Among other things, the debris included lobster traps and extensive amounts of line. In 1999 and 2000 some of the traps were recovered and some line was collected and burned. In 1999 and 2000 a total of three seals was found entangled in debris, one in a white plastic ring of unknown origin, one in a large net fragment, and one in an eel trap cone. Although no seals were known to have become entangled in the debris from the *Paradise Queen II*, the debris posed a significant risk of such entanglement. Field researchers cleaned the debris from beaches during the summer, but debris has continued to wash ashore. As of the end of 2000 the hull was still grounded, and debris in the water and on the beaches continues to pose a threat of entanglement to seals and other wildlife.

Population-Wide Status and Trends

As indicated earlier, the status and trends of individual Hawaiian monk seal colonies present a mixed picture. The most obvious overall trend over the past four decades is one of declining beach counts. Although the counts indicate that the decline was halted in the 1990s, poor pup and juvenile survival remains a serious problem impeding population recovery. This poor survival has effectively created an aging population. That is, the proportion of adults in the population has grown over recent years, while the proportion of juveniles and subadults has declined. As a consequence, pup production has remained relatively high, but recruitment of breeding animals into the population has decreased. Because of this shift, pup production may decrease in the near future as productive adult females are lost to the population through aging and mortality and are not replaced by maturing females. This pattern was observed at Kure Atoll, where pup production declined from about 30 pups per year in the early 1960s to a single pup in 1986. The same pattern appears to be occurring at French Frigate Shoals, where recruitment has been poor for a decade and pup production is expected to drop considerably in the near future. Because of the numerical importance of the French Frigate Shoals colony, these changes will strongly influence the dynamics of the whole population.

On the other hand, positive growth is occurring at Pearl and Hermes Reef, Kure Atoll, Midway Atoll, and Laysan Island. The colony at Lisianski Island also has shown a recent increase in the number of births. The far-western colonies, in particular, have relatively high proportions of young seals and, with good recruitment into the breeding age classes, one can reasonably expect continued growth at these sites in the future. Thus, the status and trends of the whole population will be determined by the balance between positive growth at the more western colonies and the decline at French Frigate Shoals. The need for growth to offset expected losses at French Frigate Shoals underscores the importance of careful, precautionary management of the western colonies.

Hawaiian Monk Seal Research and Management Activities

The National Marine Fisheries Service is the lead agency responsible for recovery and conservation of the Hawaiian monk seal. The Service conducts or oversees most of the research and management activities on the species and its efforts in this regard are guided, in part, by the Hawaiian Monk Seal Recovery Plan and Recovery Team. The team annually reviews research and management plans and makes recommendations to the director of the Service's Southwest Region. Additional recommendations are provided by the Marine Mammal Commission based on periodic reviews of the Hawaiian monk seal recovery program. The Service works closely with the Fish and Wildlife Service, which manages most of the terrestrial habitat in the Northwestern Hawaiian Islands, and with the Western Pacific Regional Fishery Management Council, which oversees management of commercial fisheries that may affect the Hawaiian monk seal. The Service also works closely with Sea Life Park, the Waikiki Aquarium, and Sea World to conduct captive care and research programs, and with the State of Hawaii, which manages Kure Atoll. The Coast Guard, the Navy, and the Air Force have provided important logistic support for past research and recovery efforts, and the Army Corps of Engineers has been involved in efforts to rebuild the Tern Island seawall. Important management and recovery issues are discussed below.

Loss of reproductive potential at French Frigate Shoals – Probably the single most obvious factor currently impeding the recovery of the Hawaiian monk seal is the loss of reproductive potential at French Frigate Shoals. Since the late 1980s pup and juvenile survival rates have plummeted at that site due to nutritional stress, adult male aggression, and shark predation. Declines in the number of breeding adults due to low recruitment over the past decade will lead to a marked drop in pup production in the near future. The severity of the drop will depend in part on the longevity of adult females currently in the colony and in part on the length of time that pup and juvenile survival remains low. If adult females are long-lived and survival of young animals improves in the near future, the drop in productivity may be relatively small. On the other hand, if the number of adult females decreases sooner, and if recent improvements in juvenile survival are not sustained, then the French Frigate Shoals colony could experience a severe collapse.

The population trend observed at Kure Atoll in the past and now being observed at French Frigate Shoals creates a challenge for managers who must interrupt the pattern and prevent the loss of reproductive potential through programs to protect or salvage young seals. Captive care and relocation programs and removal of adult males have already been implemented with a considerable degree of success. However, important problems or obstacles to program implementation also have been identified, including the difficulty of conducting remote captive care efforts at Midway Atoll in 1992 and 1993, the occurrence of an unknown and undiagnosed eye disease that precluded the relocation of 12 captive pups from French Frigate Shoals, the initial (and later refuted) evidence of exposure to morbillivirus in several wild seals that temporarily halted relocation efforts, and the more general need to evaluate potential diseases in donor and recipient populations. Continued efforts to resolve these problems are essential to allow a more precautionary, responsive management approach in the future.

Tern Island – Since the early 1980s research and management activities for the French Frigate Shoals colony have depended heavily on access to the runway and the old Coast Guard station on Tern Island, one of the islands in the atoll. In 1942 Tern Island was enlarged approximately threefold to provide a runway for military operations. This involved construction of a sheet-metal seawall and backfilling with material dredged from the surrounding reef and various military debris. In recent years, the seawall has fallen into serious disrepair. Sections have collapsed or corroded, leaving the island exposed to wave action and creating entrapment hazards for monk seals, turtles, seabirds, and other marine life. Erosion threatens to wash out the runway and buildings on the island, and could expose buried waste materials. These materials may be contaminated with toxic chemicals, such as polychlorinated biphenyls (PCBs) that were recently discovered in high concentrations in some marine life around Tern Island. Because Tern Island is the primary base for research and management activities at French Frigate Shoals, its loss would severely compromise future efforts to protect Hawaiian monk seals and other species (e.g., the threatened green sea turtle) at the atoll.

As noted in past annual reports, the Commis-sion has strongly recommended that the Fish and Wildlife Service and other agencies take steps to replace the seawall as quickly as possible. In 1993 the Service contracted with the Army Corps of Engineers to develop detailed construction plans for a new seawall. Although designs were completed in 1995, the Service was unable to obtain funding for construction at that time. By mid-1997 the foundations of island buildings were in imminent danger due to erosion, and the Army Corps of Engineers was contracted to make emergency repairs. In 1999 the Service received $1 million as an initial investment for the new seawall, with additional funding expected in the following years. Additional money was provided in fiscal years 2000 and 2001, and at the end of 2000 a total of about $10 million had been appropriated for construction. Because of further erosion of the island since the initial construction plan was prepared, the Fish and Wildlife Service contracted with the Army Corps of Engineers to update the plan. To move ahead with the project, the Service entered into discussions with the Army

Corps of Engineers and the Navy to secure help in overseeing contract work. As of the end of 2000 it was hoped that construction of the seawall might begin in 2002.

Marine Debris – Marine debris, particularly lines and nets discarded or lost by commercial fishermen, is a serious problem that threatens monk seals and their habitat on land and at sea. More than 200 seals have been found entangled since the mid-1980s, and in recent years the number found entangled has been increasing. Although a record high number of 25 seals were found entangled in 1999, the number declined to only 5 in 2000, one of the lowest counts since 1985 when records were first kept (Fig, 12). Overall, these results indicate a rate of entanglement that is higher than for any other pinniped. Most assessments of the effects of debris have been based on observations from land, which fail to detect effects at sea. Thus, entanglement rates recorded to date almost certainly underrepresent the total impact. Still, the minimum estimates available for the amount of debris and the number of entangled seals are sufficient to demonstrate that monk seal entanglements have contributed to the population decline and continue to threaten its long-term conservation. Due to the small size of monk seal colonies and the low total abundance of all colonies combined, the species can ill afford the entanglement-related losses of even a few individuals.

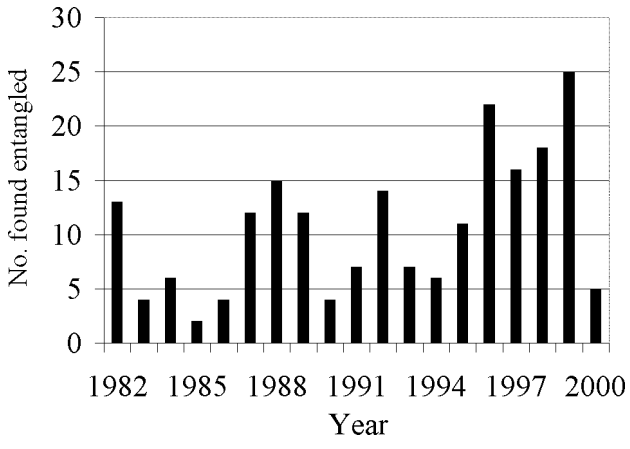

Figure 12. Number of Hawaiian monk seals found entangled annually, 1982–2000.

Collection of debris and disentanglement of monk seals are routine tasks for seasonal research personnel, but, for the most part, such efforts are limited to the beaches of the six main reproductive sites. The occurrence of entangled seals and the amount of debris deposited do not appear to be equally distributed over these sites, and certain areas (e.g., Lisianski Island) require more vigilant efforts to clean up debris and free entangled seals.

Recently, cleanup efforts have been extended to some coral reefs and the nearshore waters around emergent lands in the Northwestern Hawaiian Islands. These efforts have been directed at assessing the total amount of debris and the rate of deposition, and removing the debris. A cooperative multiagency reef cleanup was organized in 1998 with participation of a number of federal, state, military, civic, and private agencies and organizations. The effort is intended not only to protect coral reef ecosystems and their inhabitants, but also to raise local, national, and international awareness and concern about the impacts of such debris. Initial phases of the effort were aimed at assessing the extent of the problem and developing methods for removal. Actual cleanup efforts have been initiated and large amounts of debris were removed from the waters around Lisianski Island, Pearl and Hermes Reef, and Midway Atoll in 1999. Nonetheless, many areas have not been cleaned, and debris continues to accumulate. As of the end of 2000 additional work is being planned, and the multiagency effort is expected to continue for some time.

Interactions with Fisheries – Hawaiian monk seals may interact with or be affected by at least five fisheries. In the Hawaiian archipelago, recreational fishing occurs primarily around the main Hawaiian Islands. Recreational fishing occurred at Kure Atoll when the atoll was occupied by the Coast Guard and currently occurs around Midway Atoll as part of the ecotourism venture described earlier. Outings from Midway Atoll occasionally include visits to Kure Atoll and Pearl and Hermes Reef. Reported interactions between monk seals and recreational fishing primarily involve seals taking hooked fish from fishing gear and sometimes becoming hooked themselves. Hooks may become embedded in the

seal's mouth, esophagus, or stomach with negligible to lethal consequences. In addition, the occurrence of fishing activity may cause seals to abandon certain foraging sites due to disturbance.

Monk seals also may be affected indirectly by coral fisheries. Harvests of precious corals from deep banks in the Northwestern Hawaiian Islands can effectively remove or destroy the coral bed ecosystems where seals forage. Deepwater coral beds provide habitat for certain monk seal prey species, such as eels. Seals are known to dive to depths of at least 500 meters, and coral fisheries within this range may reduce the value of coral beds as habitat for potential monk seal prey.

Swordfish and other large marine fish are taken with longline gear in the North Pacific. The longline fishery expanded fourfold in the late 1980s and early 1990s, leading to direct interactions between monk seals and fishing gear in areas near the Northwestern Hawaiian Islands. Seals were found with embedded longline hooks and with unusual head injuries that suggested that they may have been bludgeoned. The National Marine Fisheries Service and the Western Pacific Regional Fishery Management Council responded in 1991 by establishing a protected species zone extending 50 nmi out from the Northwestern Hawaiian Islands and the corridors connecting those islands. Since the creation of the protected species zone, no additional interactions have been reported.

Monk seals interact directly with the Northwestern Hawaiian Islands bottomfish fishery. Seals may be attracted to fishing vessels, where they may either remove fish from hooks during gear recovery or consume discarded fish. Some discards (e.g., kahala and eels) may contain relatively high levels of ciguatoxins and may therefore pose a health threat to the seals. Because monk seals may consume some of these species naturally, the extent of this threat is unknown. Similarly, the extent to which the species taken by the fishery as targeted prey or bycatch overlap with the natural seal diet is unknown. The fact that the seals take fish from hooks and fish discarded overboard suggests that these fish species may be part of the seals' natural diet, but the fishery also targets large fish that may be uncommon prey for monk seals. Finally, on occasion seals also have been hooked, with unknown but potentially lethal consequences.

A brief bottomfish fishery for sharks was conducted by a single vessel in 1999 in the vicinity of French Frigate Shoals and Gardner Pinnacles. Using longline gear weighted to sink to the bottom, the fishery posed a serious threat to Hawaiian monk seals attracted to bait or to small sharks caught on the line. On 23 November 1999 the Marine Mammal Commission wrote to the National Marine Fisheries Service, noting that this fishery was being conducted without a fishery management plan and that monk seals could be hooked or entangled in longline gear. Therefore, the Commission recom-mended that the Service prohibit longline fishing for sharks within 50 nmi of the Northwestern Hawaiian Islands, pending the development of a fishery management plan. The Commission also recom-mended that no new fisheries be initiated within 50 nmi of the islands until an applicable fishery management plan has been prepared and reviewed for potential impacts on Hawaiian monk seals pursuant to section 7 of the Endangered Species Act. On 10 February 2000 the Service responded that the Commission recommendations would be considered by the Western Pacific Regional Fishery Manage-ment Council, and that the Council had already taken actions that would prohibit the use of any longline gear, including bottom longline gear, to take sharks near monk seal breeding sites. The shark fishery was not continued in 2000.

Monk seals also have interacted directly and indirectly with the Northwestern Hawaiian Islands lobster fishery. The only known mortality due to direct interactions resulted from entanglement of a seal in the bridle line of a lobster pot in 1986. Seals have been known to consume discarded lobsters or lobster parts, although discarding of lobsters is no longer permitted under current regulations. Finally, seals are potentially in danger of entanglement in deployed gear or lost traps. However, indirect interactions (i.e., competition for lobster) may be far more significant if monk seals and the fishery both exploit the same resource and use of the resource by one reduces the availability to the other. The fishery targets two species of lobster (i.e., spiny lobster and

slipper lobster) and operates primarily at Nihoa and Necker Islands, Gardner Pinnacles, and Maro Reef, all known to be foraging areas for monk seals from Nihoa and Necker Islands, French Frigate Shoals, and Laysan Island. Monk seals are known to eat lobster. Thus, the fishery and the seals use the same resource.

The management strategy for the lobster fishery assumes that the lobster stocks are not overfished unless the spawning biomass is less than 20 percent of the expected level in the absence of fishing. Thus, this strategy assumes that an 80 percent reduction of a potentially important monk seal prey item does not have a significant effect on monk seals and that lobsters are a prey item of negligible importance to monk seals. However, the importance of lobster in the monk seal diet cannot yet be described with any measure of confidence. The importance of lobster as a monk seal prey is difficult to evaluate because consumption rates may vary by season (e.g., they may be more important during the lobster molting period) or by monk seal size class (e.g., they may be more important to juveniles that are less adept foragers), and because monk seals may consume a diverse assemblage of prey, confounding analytical techniques to quantitatively assess the importance of any single prey type. Also, the assessment of the importance of lobster to monk seals is severely confounded by the fact that the availability of lobsters has already been reduced by as much as 80 percent by fishing. At the recommendation of the Commission, the Service is working with indepen-dent scientists to assess the importance of lobster in the diet of monk seals based on fatty acid analyses. The analyses are not yet complete.

For the past decade, the Marine Mammal Commission has repeatedly urged a more precautionary approach to the management of the lobster fishery. In the previous annual report, the Commission noted that it had written to the National Marine Fisheries Service on 23 November 1999, reiterating its past recommendations that the Service prohibit lobster fishing at all major monk seal breeding atolls until such time as information is sufficient to assess (1) the relative importance of lobsters and other monk seal prey species taken by fisheries in the diet of different age and sex classes of Hawaiian monk seals, and (2) the effects of lobster fishing on the availability of important monk seal prey resources. The Service responded on 10 February 2000, indicating that it would work with the Western Pacific Regional Fishery Management Council to address the Commission's recommendations and that it was considering expansion of areas closed to the lobster fishery as part of an effort to establish marine protected areas.

However, in 2000 new information came to the Commission's attention regarding the status of the lobster fishery. Specifically, the Hawaiian Monk Seal Recovery Team had met on 6–7 December 1999 and recommended that the Service close the Northwestern Hawaiian Islands lobster fishery for a minimum of three years to allow time for the region's depleted lobster stock to recover and to assess appropriate catch quotas. In a 22 February 2000 letter to the Service, the Commission supported the recovery team's recommendation and also recommended that the fishery not be reopened until available information is sufficient to assure that resumption of the fishery will not impede monk seal recovery. The Commission listed the minimum information required as (1) the relative importance of lobsters and other species taken as bycatch in lobster traps in the diets of different age and sex groups of monk seals at different colonies, (2) the locations where different age and sex classes of monk seals feed, (3) the abundance and likely carrying capacity levels of principal monk seal prey species in preferred monk seal foraging areas, and (4) the effects of lobster fishing on stocks of lobsters and other monk seal prey species taken as bycatch. On 28 April 2000 the Service proposed in the *Federal Register* to close the Northwestern Hawaiian Islands lobster fishery in 2000 due to concerns about the status of the lobster stocks. The proposed rule also noted that the Service might conduct an experimental fishing program during the closure. During May 2000 the Commission sent three letters to the Service (11 May, 12 May, and 15 May) supporting the Service's plan to close the fishery for 2000, but also recommending that the Service refrain from authorizing any experimental fishery. The Commission stated that if

the Service was to continue with plans for the experimental fishery, then it should provide (1) a substantive review of existing data and analyses, (2) analyses of data gaps and critical information, (3) proposed designs and protocols, (4) alternative methods for collecting data, and (5) assessment of the potential effects of the experimental fishery on monk seal prey resources. In addition, the Commission requested that, if the Service was planning to conduct an experimental fishery, it immediately provide the Commission with a draft research protocol for its review. The Com-mission also reminded the Service that if it was plan-ning to conduct the experimental fishery, then it must also meet its consultation and review responsibilities under the Endangered Species Act and the National Environmental Policy Act. The Commission did not receive a response from the Service by early June 2000 and, because the lobster fishery usually starts in July, the Commission reiterated its request to the Service for a draft research protocol in a 9 June 2000 letter to the Service.

On 26 June 2000 the Service published in the *Federal Register* a notice closing the 2000 Northwestern Hawaiian Islands lobster fishery. The notice stated that the rationale for the closure was based on concerns for the status of the lobster stocks and the potential for overfishing the stocks. In its responses to public comments on the closure, the Service stated that it was preparing a lobster research plan and that it intended to consult with the Western Pacific Regional Fishery Management Council before the implementation of an experimental fishery program. In a 9 October 2000 letter the Service informed the Commission that it was tentatively planning an experimental lobster fishery for the spring of 2001. With that letter, the Service also provided a document entitled "Guidance on Issues Associated with the NWHI Lobster Fishery," in which the Service reviewed briefly the methods for estimating exploitable lobster populations, described the shortcomings of those methods, and presented a "NWHI 3-Year Lobster Research and Monitoring Plan: 2000–2002" with a rationale for the plan. The Commission replied in a 12 December 2000 letter in which it commended the Service for closing the fishery and commented on the plan for the experimental fishery. The Commission (1) noted that the plan was already somewhat out of date, (2) requested confirmation that the fishery would be catch and release only, (3) pointed out that the Service's assumption that mortality of released lobsters would be minimal was inconsistent with previous observations and with the rationale for previous measures to require full retention of the commercial catch, (4) recommended that investigation of the mortality rate of released lobsters be included in the research protocol, (5) noted that an underestimate of such mortality could result in overestimation of stock size, (6) noted that the plan failed to take into account the effects of monk seal foraging on lobster stocks, and (7) encouraged the Service to consider the effects of monk seal predation when evaluating lobster recruit-ment, status and trends, and maximum sustainable yields.

Management of the bottomfish and lobster fisheries and their potential effects on Hawaiian monk seals also have been the subject of a lawsuit in the U.S. District Court for the District of Hawaii. On 26 January 2000 Greenpeace Foundation, the Center for Biological Diversity, and the Turtle Island Restoration Network sued the National Marine Fisheries Service, claiming that the implementation of the lobster and bottomfish fisheries in the Northwestern Hawaiian Islands violates the Administrative Procedures Act, the Endangered Species Act, and the National Environmental Policy Act. Among other things, the plaintiffs requested a permanent injunction on the lobster and bottomfish fisheries until the Service complies with the appropriate statutes and regulations. As the lawsuit was being considered, the Service closed the lobster fishery, citing concerns about the collapse of the Northwestern Hawaiian Islands lobster stocks.

On 15 November 2000 the court concurred that past consultation on the Crustacean Fishery Management Plan (under which the lobster fishery is implemented) violates section 7(a)(2) of the Endangered Species Act and the Administrative Procedures Act. The court did not concur that the evidence was sufficient to conclude that the implementation of the lobster fishery violated section 9 of the Endangered Species Act, but admonished the

Service for taking the position that it was not guilty because it is not aware of any data that confirm such a violation. The court granted the plaintiffs' motion for an injunction on the Crustacean Fishery Management Plan until a biological opinion and an environmental impact statement have been completed and issued. The court concurred with the plaintiffs that the bottomfish fishery is conducted in violation of section 9 of the Endangered Species Act because it results in the taking of monk seals. The court determined that it did not have sufficient information to rule on the plaintiffs' motion for a permanent injunction against the Bottomfish Fishery Management Plan and that it would conduct an evidentiary hearing to gather such information.

Main Hawaiian Islands – Although Hawaiian monk seals are relatively rare in the main Hawaiian Islands, sightings at some locations and the numbers of births appear to have been increasing over the past decade. Increased reproduction at and recolonization of the main islands could significantly improve prospects for long-term conservation of the species by establishing a larger, more widespread metapopulation.

The development of monk seal colonies in the main islands is not without risks. The primary human-related risks to individual seals in the water would be from interactions with fisheries and watercraft. As noted above, seals may become hooked in the process of taking caught fish, and they may be caught and drowned in fishing nets. Seals also have been observed with wounds indicative of propeller strikes. Beach habitats pose risks from disturbance by humans and domestic, feral, and introduced animal species. Terrestrial animals also may serve as vectors for diseases to which monk seals have not yet been exposed. Transmission of such diseases from the main Hawaiian Islands to the species' core population in the Northwestern Hawaiian Islands could have severe consequences.

Any risk-benefit analysis of colonization may well be moot because the issue of recolonization of the main Hawaiian Islands is likely to be settled by the seals themselves. A small colony appears to be established at Niihau Island and, over time, seals from this colony may disperse to other islands. A few seals are regularly seen at Kauai, Molokai, and other main Hawaiian Islands and pups are born occasionally, so the process of recolonization may already be occurring. Perhaps the most important question is whether management authorities are prepared for recolonization of the main islands and can ensure that the seals are protected and the public, including the fishing industry, is well educated about the seals and requirements for their protection. Examples of the need for such protection include incidents where females have pupped on beaches popular with the public. Such cases require considerable monitoring and management to ensure the safety of females and their pups. Existing research and management resources have been stretched thinly in the past, and protection of a growing monk seal presence in the main Hawaiian Islands would require a significant increase in funding for managers responsible for protection of these seals.

Funding – The majority of funds for research and recovery of the Hawaiian monk seal has generally been allocated to the Marine Mammal Research Program of the Honolulu Laboratory, National Marine Fisheries Service. Research programs include an extensive and essential field research effort to assess colony status and trends, composition or age structure, reproduction, survival and sources of injury and mortality, health and condition, rates of entanglement, prey species, foraging patterns, and behavior. In addition, researchers at the field sites remove debris from beaches, disentangle animals, and report illegal activities near the islands (e.g., unpermitted visitation to the islands, fishing in closed areas). These annual activities are central to the recovery effort because they provide basic information necessary to monitor each colony, identify impediments to recovery, and evaluate management efforts. In addition to these basic research tasks, other studies conducted at the major breeding sites provide greater insight into specific recovery issues (e.g., studies of at-sea habitat use and behavior, the effects of disturbance, male aggression, and shark predation).

In the 1980s Congress earmarked approximately $300,000 to $500,000 annually for the

Hawaiian monk seal program. In 1995 the Service began reprogram-ming money from other parts of its budget to bring the total amount available for the monk seal program to about $1.1 million. For 1996 to 1998, annual funding was about $1.3 million, including about $500,000 earmarked funds each year. In 1999 the budget was increased to just under $1.5 million. In 2000 the Service requested an additional $2.0 million in base funding and six additional employees for monk seal work. With this amount, plus funding in its base from fiscal year 1999 and the congressionally earmarked funds, available support seemed sufficient to meet the re-quirements of research and recovery efforts. However, the final funding for fiscal year 2000 was short of this expectation: about $1,944,000 base funding plus $150,000 emergency funding for foraging studies (about $2.1 million total). In addi-tion, $107,500 was provided for removal of debris from the Northwestern Hawaiian Islands. For 2001 the budget is expected to be about $2.0 million.

Recovery Planning – Hawaiian monk seal research and recovery activities are based largely on the Hawaiian Monk Seal Recovery Plan and recommendations provided by the Hawaiian Monk Seal Recovery Team. The recovery team was formed at the urging of the Marine Mammal Commission and has played an active role in the direction of the program for more than a decade. Recovery team meetings generally have been held in early December of each year so that the team can review results from the previous year's work and provide recommendations that can be incorporated into plans for the upcoming year. Because field camps start operations as early as March of each year, holding team meetings later than December may preclude timely implementation of the team's recommendations.

For 2000, as in past years, the team scheduled its annual meeting for early December. Due to scheduling conflicts, the Service later requested and the team agreed to postpone the meeting to mid-December. In November 2000, acting unilaterally, the Service rescheduled the meeting for 26–27 March 2001. Both the recovery team and the Marine Mammal Commission wrote to the Service expressing concern about the late date of the meeting. The Service cited staff workload as the reason for the postponement, but the recovery team and the Commission remain concerned that the late timing of the meeting will preclude meaningful recommendations for program activities in 2001.

Coral Reef Ecosystem Reserve

In June 1998 President Clinton signed Executive Order 13089, which established a coral reef task force and directed all federal agencies with coral reef-related responsibilities to develop a strategy for coral reef protection. On 7 July 2000 the Departments of the Interior and Commerce invited participation in planning efforts for conservation and management of the coral reef ecosystem of the Northwestern Hawaiian Islands. In a 28 July 2000 letter to the Departments of the Interior and Commerce, the Marine Mammal Commission reviewed the status of the Hawaiian monk seal, its interactions with commercial fisheries, and the importance of protecting these coral reef ecosystems for monk seals and other endangered and threatened marine species. Specifically, the Commission recommended that the Secretaries of Commerce and the Interior jointly propose that the President set aside all waters and federally owned bottom lands off the Northwestern Hawaiian Islands out to a distance of 50 nmi either as part of the Fish and Wildlife Service's Hawaiian Islands and Midway Islands National Wildlife Refuges or as a new national monument to be managed by the Fish and Wildlife Service. The Commission also recom-mended that a five-year moratorium be imposed on all commercial fishing within the 50-nmi boundary pending (1) assessment of the status of the area's target and nontarget fish stocks potentially affected by commercial fisheries, and (2) development of precautionary fishery management measures, including a system of no-take areas, that will ensure protection of Hawaiian monk seals and other significant wildlife species.

In December 2000 President Clinton signed Executive Order 13178 establishing the Northwestern Hawaiian Islands Coral Reef Eco-system Reserve. The establishment of the reserve, with its accompanying protection and conservation measures,

was intended to "ensure the compre-hensive, strong, and lasting protection of the coral reef ecosystem and related marine resources and species (resources) of the Northwestern Hawaiian Islands." The reserve shall include "sub-merged lands and waters of the Northwestern Hawaiian Islands, extending approximately 1,200 nautical miles (nm) long and 100nm wide." It will be adjacent to and seaward of the marine boundaries of the State of Hawaii and region's national wildlife refuges. The Department of Commerce will assume primary responsibility for management of the reserve and will begin the process to designate the reserve as a national marine sanctuary. The reserve will be managed under the National Marine Sanctuaries Act in accordance with eight principles emphasizing a conservative, precautionary management approach. The Secretary of Commerce, in consultation with the Secretary of the Interior and the Governor of Hawaii, will develop an operations plan to guide manage-ment and will establish a council to provide advice and recommendations on the reserve operations plan and the designation and management of the sanctuary. Pursuant to the executive order, a representative of the Marine Mammal Commission will serve on the council as a nonvoting member. Protection and conservation measures will be applied throughout the reserve and will include restrictions on commercial and recreational fishing and prohibitions of a suite of other activities including exploring, developing, or producing oil, gas, or minerals; anchoring on coral; drilling, dredging, and otherwise altering the seabed; discharging or depositing material; and removing, moving, taking, harvesting, or damaging living or non-living resources.

Restrictions on commercial fishing in the reserve will include caps on the number of permits (for each fishery type) and the aggregate level of catch and effort (for each fishery type), a ban on permits for any type of fishing not authorized by permit in the preceding year, and a prohibition on changing the type of fishing gear used by permit holders. With some exceptions for the bottomfish fishery, commercial fishing will also be prohibited in 15 preservation areas designated within the reserve. Restrictions on recreational fishing will prohibit increases in take, effort, or species targeted, and changes in gear types.

The 15 preservation areas to be established will extend from the seaward boundaries of state-managed areas and the Midway Atoll National Wildlife Refuge to a mean depth of 100 fathoms around the major islands, atolls, and banks of the Northwestern Hawaiian Islands. Bottomfishing will be allowed to limited depths around eight of these preservation areas. Additional protective measures will be applied to the reserve preservation areas.

The Commission strongly supports the establishment of the reserve and its designation as a national marine sanctuary to protect the coral reef ecosystems of the Northwestern Hawaiian Islands. The reserve is expected to contribute significantly to the conservation of the Hawaiian monk seal. It will provide important protection for the monk seal habitat, reduce the potential for direct and indirect interactions of seals with commercial and recreational fisheries, and preclude development that is inconsistent with the natural state and character of the coral reef ecosystems.