NOAA Technical Memorandum NMFS

AUGUST 2002

THE HAWAIIAN MONK SEAL IN THE NORTHWESTERN HAWAIIAN ISLANDS, 2000

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NOAA-TM-NMFS-SWFSC-340

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Southwest Fisheries Science Center

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EXECUTIVE SUMMARY

In 2000, field studies of the endangered Hawaiian monk seal (*Monachus schauinslandi*) were conducted at all of its main reproductive sites in the Northwestern Hawaiian Islands. These studies provide information necessary to identify and mitigate factors impeding the species recovery by evaluating (1) the status and trends of monk seal subpopulations, (2) natural history traits such as survival, reproduction, growth, behavior, and feeding habits, and (3) the success of various activities designed to facilitate population growth.

Results of these studies are best described on a site-by-site basis, and the information presented in this document is organized accordingly. Site-specific data pooled for all sites, however, provide useful indices of the status and trends of the species as a whole, including the total number of pups at all main reproductive sites, the total of the site-specific mean beach counts, and the size composition of the seals observed during the counts (Fig. 1).

Since 1983, the number of pups born at the main reproductive sites (excluding Midway Atoll) has been highly variable, and the variability has been largely determined by the number born at French Frigate Shoals (Fig. 1a), the largest subpopulation. In 2000, 177 pups were counted at these sites, 67 of which were born at French Frigate Shoals. Although a record number of pups were born at Midway Atoll, pupping was lower than in 1999 at all the other sites; 25 fewer pups were born at French Frigate Shoals, and 54 fewer pups were born overall. Mean beach counts, excluding pups, from the main reproductive sites (again, excluding Midway Atoll) totaled 382 seals and have remained essentially unchanged since 1993 (Fig. 1b).

From the mid-1980s to the mid-1990s, adults and pups have comprised a growing portion of the animals counted while juveniles and subadults declined (Fig. 1c) and, in 2000, the composition of the counts again was dominated by adults and pups. This shift in composition bodes poorly for reproduction in the near future if older adult females are not replaced by young females reaching reproductive age. The overall impact of this shift in age composition will be determined by the magnitude of its change and the length of time that it persists. The drop in number of births in 2000 may signal the beginning of this trend toward reduced reproduction. High mortality of immature seals appears to have led to the shift in age composition, particularly at French Frigate Shoals.

In 2000, four management activities were conducted by the Marine Mammal Research Program (Honolulu Laboratory, National Marine Fisheries Service) and cooperating scientists to enhance recovery of the species. First, debris capable of entangling seals was removed from all study sites, and four seals were disentangled by field biologists. Second, debris was removed from coral reefs at Lisianski Island, Pearl and Hermes Reef, Midway Atoll, and Kure Atoll to reduce hazards to the seals and assess the extent of reef debris fouling. Third, observers monitored beaches on Midway for disturbance and sought to mitigate human impacts through education. And fourth, a

Galapagos shark was removed after it exhibited predatory behavior toward monk seal pups at French Frigate Shoals.

This document describes these and other field studies conducted during 2000 and provides complete, standardized, and timely summaries of the research activities and findings at each study site. The ready availability of such information is essential for ongoing efforts to enhance the recovery of this species.

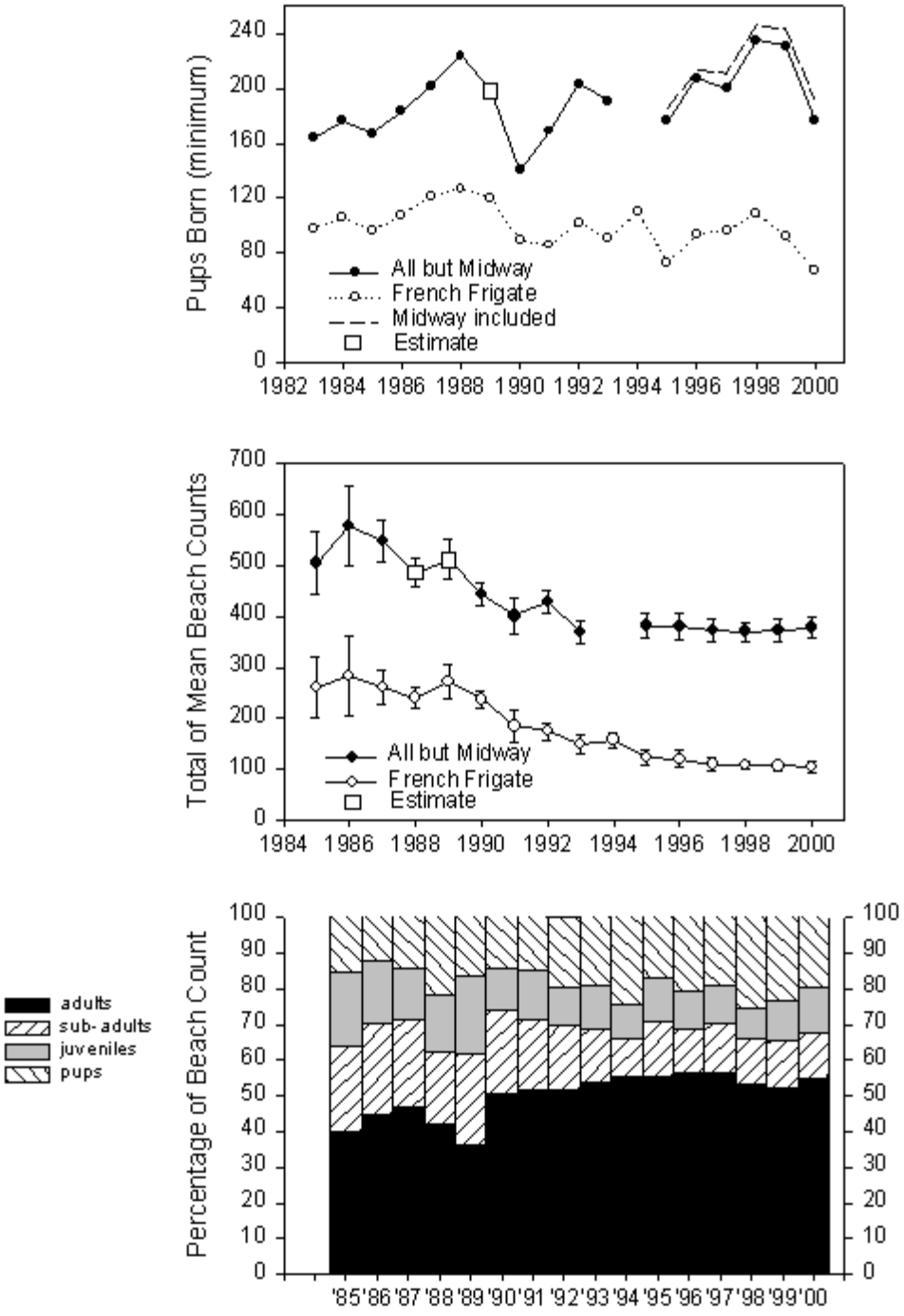

Fig. 1. Demographic trends of the Hawaiian monk seal, based on the main reproductive sites (excluding Midway Atoll). A) Number of pups born (minimum). B) Total of mean beach counts, excluding pups, with 1 standard deviation. C) Percentage of counts comprised of adults, subadults, juveniles, and pups.

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CHAPTER 1. GENERAL INTRODUCTION

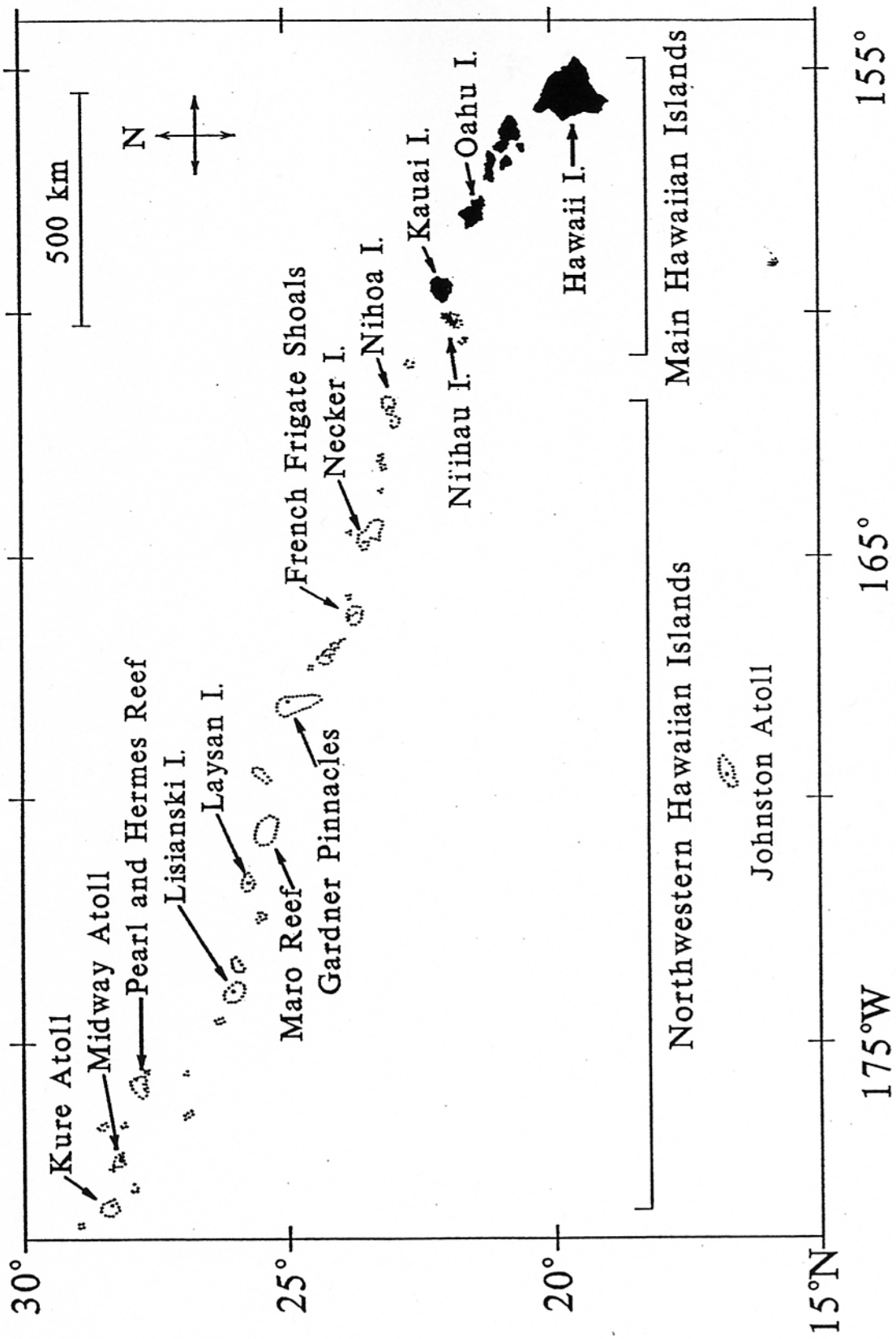

Fig. 1.1 The Hawaiian Archipelago.

The endangered Hawaiian monk seal (*Monachus schauinslandi*) hauls out and breeds in the Northwestern Hawaiian Islands (NWHI, Fig. 1.1). The National Marine Fisheries Service (NMFS) is the lead agency for the recovery of the Hawaiian monk seal. Each year the NMFS Southwest Fisheries Science Center, Honolulu Laboratory, Marine Mammal Research Program conducts studies at the main breeding sites to provide information necessary to evaluate (1) the status and trends of the monk seal subpopulations; (2) natural history traits such as survival, reproduction, growth, behavior, and feeding habits; and (3) the success of various activities designed to facilitate population growth.

The Marine Mammal Research Program began research on Hawaiian monk seals at most major reproductive sites in the NWHI during 1981 (Kure Atoll, Laysan Island, and Lisianski Island), 1982 (French Frigate Shoals (FFS) and Pearl and Hermes Reef), and 1983 (Midway Atoll). Nearly every year thereafter, field camps of several days to 9 months were established to monitor and enhance the recovery of this species. Limited monitoring has also been conducted at Nihoa and Necker Islands, where subpopulations may be limited to a small number of animals by availability of haulout area. Reports summarizing past NMFS research are listed in Appendix A.

In 2000, Hawaiian monk seal research activities included (1) conducting beach counts (censuses); (2) tagging weaned pups and other seals for permanent identification and retagging animals to maintain identification; (3) identifying other seals by previously applied tags and by natural or applied markings; (4) monitoring reproduction, survival, injuries, entanglements, interatoll movements, disappearances, and deaths; (5) performing necropsies; (6) collecting scat and spew samples for food habits analysis; (7) collecting skin punches and shed molt samples for a DNA tissue bank; (8) collecting samples of placentas found with or from "aborted fetuses" or with deceased perinatal pups for histological and bacteriological examination; (9) applying satellite-linked dive recorders to track animals at sea and to investigate diving behavior; (10) screening health and collecting blubber biopsies for fatty acid analysis; (11) disentangling seals; and (12) inventorying and removing debris capable of entangling seals. Location-specific objectives and summaries of data collected during the 2000 field season are described in the following chapters. Much of the information presented in this memorandum is incorporated into larger data sets for additional analysis and publication elsewhere. Research was conducted under the authority of the following permits: Special Use Permits 12521-01-00, 12521-07-00, 12521-00011, and Marine Mammal Permit 848-1335.

MATERIALS AND METHODS

Censuses and Patrols

The primary means of data collection were censuses and patrols. Censuses consisted of timed, standardized beach counts during which an entire island or atoll was surveyed for seals on foot. Although data were collected on all seals, animals that were in the water or dead were excluded from the beach count totals. Identified individuals were counted only once if they were resighted during the survey. The resulting counts did not reflect total subpopulation size but provided an index of subpopulation size for comparison among years and locations. Data collected on each seal observed during censuses included size class (ranging from pup, juvenile, subadult, and adult size as described in Stone, 1984 and Appendix B); sex; location on the island; beach position (indicating whether the seal was in the water or on land); body condition (a subjective estimate; e.g., fat, medium, or thin); identification information (permanent or temporary identification numbers and tag numbers); molting status (an estimate of the percentage completed); and disturbance index (the extent that the observer disturbed the seal). Further data were collected if any of the following events occurred: (1) factors affecting survival (e.g., entanglements, mobbings, or shark injuries); (2) animal handling; (3) photography; and (4) documentation of tag condition (e.g., good or broken). In addition, behavioral data (seal associations and interactions) were collected on Laysan and Lisianski Islands. A sample census form and guidelines for its completion are included in Appendix B. Censuses were conducted once at Necker Island, Nihoa Island, and Gardner Pinnacles, and every 4 to 7 days at all other locations, starting at 1300 Hawaii standard time when possible, using census methods and criteria outlined in Johanos et al. (1987). Atoll-wide counts for locations with more than a single island (French Frigate Shoals, Pearl and Hermes Reef, Midway Atoll, and Kure Atoll) were completed within 2 days. The perimeter of each study area was divided into sectors to facilitate the analysis of data and detection of demographic trends in different geographic areas. Census methods specific to each location are detailed in the following chapters.

Patrols consisted of untimed surveys of an entire island perimeter on foot. Information collected during patrols was similar to that collected during censuses. Because patrols were not timed, observers concentrated on documenting adult and subadult behavior, identifying and marking individuals, and collecting scat and spew samples. Island-specific standardized patrols were conducted at some locations and are described in the following chapters.

During all observation periods (i.e., censuses, patrols, and incidental sightings), observers attempted to minimize seal disturbance by walking above the beach crest and using vegetation as a visual barrier. On census days, activities that could disturb the animals and bias the count were not conducted until after the count was completed.

Additionally, the following were recorded whenever observed (1) births, pup exchanges, and weanings; (2) mating activities, adult male aggression, and post-mobbing aggregations (defined below); (3) entanglements in marine debris; (4) injuries; and (5) deaths.

Reproduction

Parturient females were identified when possible, and birth and weaning information were recorded. Because parturient females often nurse pups other than their own (Boness, 1990; Boness et al., 1998), efforts were made to identify pups and document changes in nursing relationships from birth to weaning. A pup exchange occurred when the pups of two lactating females were switched or one nursing female suckled multiple pups. Typically, such exchanges occur during an aggressive interaction between the two females. On other occasions, a mother and pup may become separated, and one or both seals will then actively seek and obtain another nursing relationship (Boness, 1990).

The average nursing period was calculated for some or all pups at each location. The average lactation period of parturient females was also calculated at FFS because higher subpopulation density and frequent pup exchanges (Boness, 1990; Boness et al., 1998) made it difficult to track individual pups and determine their nursing period. Nursing or lactation periods were defined as the number of days from birth until the end of the last nursing relationship. Temporary breaks (e.g., if a mother and pup became separated and one or both seals subsequently obtained another nursing relationship) were not subtracted from the total. When the exact birth or weaning date was not known, but occurred within a range of 4 days or less, the midpoint of that range was used as the start or end date for calculation of average nursing or lactation period. Nursing or lactation data were not included if the birth or weaning date range exceeded 4 days or if the pup died or disappeared before weaning.

Factors Affecting Survival

The origins of a wide range of injuries were distinguished based upon characteristic wound patterns described in Hiruki et al. (1993). Injuries were documented if they were related to mounting or entanglement or if they were considered severe enough to possibly affect survival. Injuries were considered severe and were summarized if they consisted of (1) three or more abscesses, each <8 cm in diameter, or one abscess with a diameter ≥ 8 cm; (2) an amputation of at least half a flipper (either foreflipper or hindflipper); (3) at least three punctures or gaping wounds, if largest dimension was <8 cm, or one gaping wound with a maximum diameter-largest dimension ≥ 8 cm; or (4) densely spaced (overlapping) scratches, abrasions, or lacerations covering an area equivalent to half the dorsum or evidence of extensive underlying tissue damage (e.g., an uneven or darkened surface of the injured area, leaching fluids), or if they impaired seal

movement. Major healed injuries incurred since the previous season were documented but not included in summaries.

A seal was listed as dead if its death or carcass was observed. Deaths summarized here include carcasses found at the beginning of the field season if the seal had clearly died during the calendar year. A seal was listed as probably dead if it sustained severe injuries or was emaciated (with skeletal structure clearly evident) and subsequently disappeared. In addition, one of the following conditions must have been satisfied to place a seal in the "probably dead" category: (1) the seal was lethargic, had difficulty moving, or floated listlessly in the water, and disappeared more than a week before the end of data collection or (2) the seal was in deteriorating condition (loss of weight, enlargement of abscesses, sloughing of skin) and disappeared at least 10 surveys or 1 month before the end of data collection (whichever was longer). Nursing pups were listed as probably dead if they disappeared within 3 weeks of birth.

Mobbing and other mating-related male aggressions were observed and recorded. By definition, mobbing occurred when multiple males attempted to mate with a single seal, usually an adult female or immature seal of either sex, causing injury or death of that seal (e.g., Alcorn, 1984). Mating-related aggression was defined as any incident where an adult or subadult male repeatedly bit the dorsum, attempted to mount, and tried to prevent the escape of another seal. These incidents were summarized in this report if they simultaneously involved more than one male aggressor or resulted in at least one puncture or gaping wound (missing skin or extending into the blubber layer) or $\geq$ 15 scratches to the dorsum or flanks. Post-mobbing aggregations were also summarized: these were groups of males congregated on the beach, attending a seal with new mounting injuries as described above.

Individual Identification

During censuses and patrols, individual seals were identified with tags, applied bleach marks, scars, or natural markings. After weaning, pups were tagged on each hind flipper with a colored plastic Temple Tag,®[1] uniquely coded to indicate island or atoll subpopulation, year of birth, and individual identification (Gilmartin et al., 1986). In addition, a passive integrated transponder (PIT) tag was implanted subcutaneously in the dorsum of most weaned pups (see Lombard et al., 1994, for detailed tagging procedures).

Colored plastic Temple Tags have been applied to nearly all weaned pups since 1981 at Kure Atoll, 1982 at Lisianski Island, 1983 at Laysan Island and Pearl and Hermes Reef, 1984 at French Frigate Shoals, and 1995 at Midway Atoll. Pups at Midway Atoll, Necker and Nihoa Islands, and the main Hawaiian Islands have been tagged

[1]Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

opportunistically since 1983. Since 1991, PIT tags have also been implanted subcutaneously in the ankle (1991) or the dorsum (all subsequent years) of most weaned pups.

In 2000, untagged immature and adult seals were opportunistically tagged with Temple Tags uniquely coded to indicate that their ages and birth locations were unknown. These seals also received PIT tags. Seals with lost or broken tags were retagged to maintain their identities.

Seals were bleach-marked for individual identification (Stone, 1984), using the solution described in Johanos et al. (1987). Molting seals were re-marked with bleach to maintain their identities until the next molt. At French Frigate Shoals, Laysan Island, Lisianski Island, and Pearl and Hermes Reef, nursing pups were also bleach-marked prior to the postnatal molt to facilitate identification during the nursing period.

Tags, scars, other natural markings, and any applied bleach marks were sketched by hand on a scar card for each seal, and this card was revised throughout the field season to maintain a current description of the identifying marks of each seal. Photographs of scars and natural markings were added to individual identification files begun during 1981 or 1982.

Subpopulation size and composition were determined at locations where observers no longer encountered unidentified seals. These statistics included all individuals observed alive at the location from March through August and all known parturient females and pups born during the year.

The movement of seals between island or atoll subpopulations within and between years complicates the estimation of subpopulation size and composition. This is particularly true at Midway Atoll, where a number of the observed seals were tagged at other locations (primarily Kure Atoll and Pearl and Hermes Reef). Therefore, standardized rules for assigning each identified seal to just one subpopulation are applied as follows: If a seal was observed at more than one location during March-August, it was included in the subpopulation where it was sighted nearest to May 15, unless it pupped or molted at another location. A parturient female was always included in the subpopulation where she pupped, and a nonparturient seal was included in the subpopulation where it molted. Pups were always included in the subpopulation where they were born.

Measurements of Seals

Pups were measured to provide information on condition and maternal provisioning. Measurements were taken as soon after weaning as possible, and measurements taken within 2 weeks after weaning were included in summaries. Measurements included straight dorsal length (Winchell, 1990) and axillary girth (American Society of Mammalogists, 1967). Older animals captured for foraging ecology, health, or disease studies were also measured.

Collection of Samples

Samples were collected for a DNA tissue bank, pathology analysis, investigation of food habits, and documentation of marine debris. Tissue punches for DNA were collected during tagging efforts for all newly tagged or retagged seals and during necropsies on seals that had died recently. Samples of placentas found with or from "aborted fetuses" or deceased perinatal pups were also collected.

For each dead seal recovered, an external examination was made, photographs were taken, and external measurements and observations were recorded. For a recent death, an internal examination was made, and samples of tissue, organs, parasites, and stomach contents were collected. Necropsy procedures and sample collection methods are adapted from Winchell (1990).

Scat and spew samples were collected opportunistically for analysis of food habits (Alcorn, 1984). These samples were collected from seals of known sizes and sex classes, when possible.

Nets, lines, ropes, and other debris capable of entangling seals and turtles were documented and inventoried. From 1982 to 1998, potentially entangling marine debris was incinerated on site. Beginning in 1999, due to new Fish and Wildlife Service regulations, marine debris was not handled in this manner at most sites. At Kure Atoll, dangerous or entangling debris was destroyed by incineration, following the methods in Johanos and Kam (1986). At all other locations, debris was cut into manageable-sized pieces and placed in storage bins or secured piles at centralized locations for subsequent removal by ship.

CHAPTER 2. THE HAWAIIAN MONK SEAL ON FRENCH FRIGATE SHOALS, 2000

Brenda L. Becker, Albert L. Harting, Irene Kinan, Mitchell P. Craig, Melissa A. Shaw, and Scott F. Davis

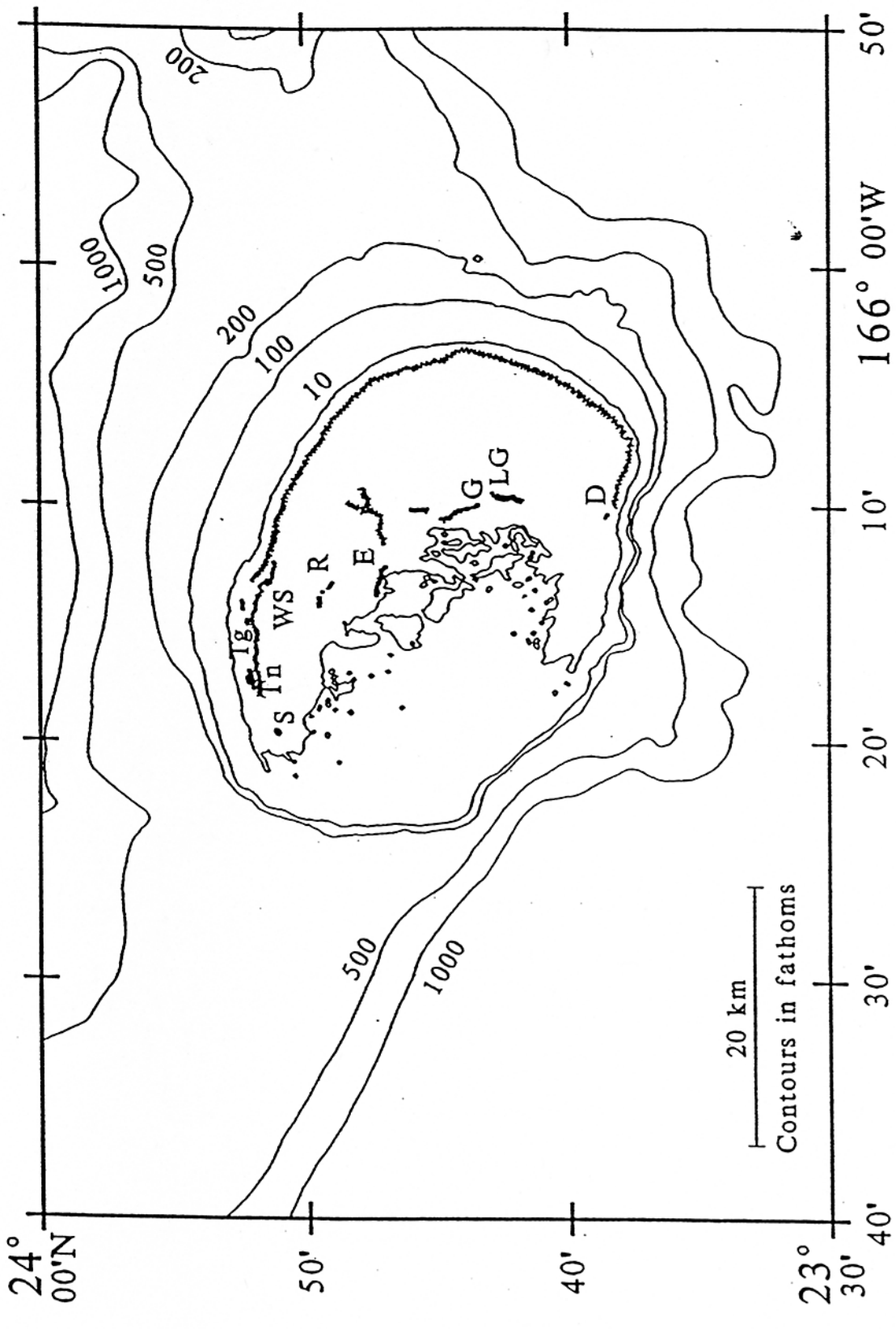

Fig. 2.1. French Frigate Shoals in the Northwestern Hawaiian Islands. Islands are: Disappearing (D), East (E), Gin (G), Little Gin (LG), Round (R), Shark (S), Tern (Tn), Trig (Tr), and Whaleskate (WS).

The largest subpopulation of Hawaiian monk seals is located at French Frigate Shoals (FFS, lat. 23°45'N, long. 166°10'W), ca. 830 km northwest of Oahu in the Northwestern Hawaiian Islands. This atoll is part of the Hawaiian Islands National Wildlife Refuge (Fig. 1.1) and consists of nine permanent islets (Disappearing, East, Gin, Little Gin, La Perouse Pinnacles, Round, Shark, Tern, and Trig), three semipermanent islets (Bare, Mullet, and Whaleskate), and several transient sand spits (Fig. 2.1).

RESEARCH

The National Marine Fisheries Service (NMFS) began research on Hawaiian monk seals at FFS in 1982. In 2000, research was conducted by NMFS during January 1-February 11, April 28-August 20, and October 17-29. Incidental observations were recorded by U.S. Fish and Wildlife Service (USFWS) personnel during the rest of the year. The perimeters of the five larger islets (East, Gin, Little Gin, Tern, and Trig) were divided into sectors using artificial or natural landmarks. Research activities specific to this subpopulation in 2000 included (1) investigating health, condition, causes of mortality, and habitat use of the 1999 cohort; (2) monitoring and removing Galapagos sharks preying on monk seal pups; (3) tagging of Galapagos and tiger sharks to determine movement patterns; (4) assessing nearshore reef fish abundance; (5) collecting reef vertebrates and invertebrates for a Hawaiian monk seal prey fatty acid analysis; and (6) assessing marine debris accumulation rates within the lagoon.

Censuses and Patrols

Atoll-wide censuses (n = 7) were conducted every 7 days, on average, from June 20 to August 2. Each atoll census required 2 days to complete, and data collection began between 1013 and 1255 and ended between 1331 and 1730 Hawaii standard time. Whaleskate Islet was censused from boat only; Bare, Disappearing, and Mullet Islets were surveyed either by boat or on foot; while the remaining islets (East, Gin, Little Gin, Round, Shark, Tern, and Trig) were censused on foot by one or two persons. La Perouse Pinnacles was not routinely surveyed as there are no seal haulout sites available.

Individual islet censuses and patrols were scheduled to ensure the entire atoll was monitored at least once each week during June 15 to August 21. Frequency of surveys was higher at islets where most pups were born, or locations in close proximity to these islets (i.e., Bare and Mullet): thus East, Gin, Little Gin, Mullet, Round, and Trig were monitored on average every 2-4 days; Tern averaged every 4 or 5 days; Bare, Disappearing, and Shark Islets averaged every 6 or 7 days; and Whaleskate averaged every 8 or 9 days. Whaleskate, Bare, and Mullet were rarely above water during the sampling season.

Incidental patrols were conducted in January and February to monitor 1999 cohort survival and to document factors affecting survival. During October, patrols were conducted at all sites, except Disappearing Islet, to locate and tag late-born pups, to survey for nursing females, to document factors affecting survival, and to provide preliminary information on condition and survival of immature seals through October.

Individual Identification

A total of 372 individuals (305 excluding pups) were identified by existing or applied tags, bleach marks, scars, or natural markings. Bleach marks were applied to 60 seals, including 26 nursing pups. Fifty-seven weaned pups and one yearling were newly tagged with Temple Tags and passive integrated transponder (PIT) tags.

Collection of Samples

Sixteen scat and two spew samples were collected. Skin punches were collected from 58 seals during tagging and from 2 during necropsies. Shed molt samples were collected from three seals. Tissue and skeletal samples were collected from the two necropsied seals. In addition, skeletal samples were collected from three other seal carcasses. Various additional samples were collected from 33 yearlings during the first-year survival study. In total, 135 items of potentially entangling debris were inventoried and stored for later removal by ship.

Special Studies

1999 Cohort First-Year Survival

As part of a health, condition, habitat use, and survival study of the 1999 cohort, 33 yearlings were sampled (blood, fecal, blubber, and virology and bacterial swabs) and measured (axillary girth, dorsal straight length, and mass) during January through mid-February. Time-depth Recorders (TDRs) were recovered from six of these animals, and four animals were newly instrumented with TDRs. Three of these newly instrumented animals were later recaptured, re-measured, and TDRs were recovered; the fourth seal was not resighted.

Galapagos Shark Observations/Culling

From May through July, Trig Islet was monitored 6 days a week to document the presence of Galapagos sharks and their predatory behavior toward monk seal pups. One shark which exhibited this predatory behavior was removed.

Tagging of Tiger and Galapagos Sharks

During June and July, one Galapagos and seven tiger sharks were captured, measured, and instrumented with acoustic and highly visible identification tags to monitor each shark's movement within the atoll. The tagging was part of a study conducted in collaboration with the National Geographic Society, California State University Long Beach, Hawaii Institute of Marine Biology, and NMFS Narragansett Laboratory.

Prey Availability

In August, the Honolulu Laboratory, NMFS, conducted diving transects at nine stations around FFS to estimate densities of reef fishes. These surveys replicated those conducted at FFS during 1980-83, 1992, and 1995-99 (see DeMartini et al., 1993). In 1998 through 2000 this study was expanded to assess fish abundance at deeper sites (50-60 m). The results of this ongoing research will be reported elsewhere. In August, researchers also collected reef vertebrates and invertebrates for analysis of fatty acids in potential monk seal prey.

Marine Debris Accumulation Rates

In August, transect surveys were conducted to resurvey reef areas previously cleaned of marine debris to estimate accumulation rates.

RESULTS

Subpopulation Abundance and Composition

The mean (±SD) of seven atoll censuses was 144.6 seals (±12.0) including pups, and 106.1 seals (±9.7) excluding pups (Table 2.1). The total number of seals identified as part of the spring-summer subpopulation was 342 individuals, 275 excluding pups (Table 2.2). This number is a subset of the total identified in the calendar year and is an unknown proportion of the total subpopulation as many of the older, untagged seals could not be uniquely identified. The numbers of tagged known-age seals born at FFS during the period from 1984 to 1999, and resighted at any location in 2000, are summarized in Table 2.3.

Reproduction

At least 67 pups were born at FFS in 2000: 58 were successfully weaned and 9 died or disappeared prior to weaning (Table 2.4a). Nursing periods and measurements of weaned pups are summarized in Table 2.4b. The mean (±SD) lactation period for 27 females was 37.8 d (±4.4 days). Thirteen pup exchanges were documented between 13

adult females; two of these events were observed and another occurred when researchers intervened to improve the survival of a prematurely weaned pup.

Interatoll Movement

Interatoll movement was documented for nine seals that completed a total of 15 movements between FFS and either Necker, Laysan, or Lisianski Islands (Tables 2.5a and b). One adult female, last sighted in 1994 as a pup, was seen twice, once at FFS and subsequently at Necker Island in 2000.

Factors Affecting Survival

Attacks by large sharks, mounting attempts by male Hawaiian monk seals, emaciation, and other/unknown factors resulted in 29 life-threatening conditions, which led to the confirmed deaths of six animals and the probable death of 11 seals (seven of which were nursing pups) (Table 2.6). No incidents of adult male aggression were observed; however, one seal received injuries characteristic of male mounting, and two weaned pups received seal-inflicted injuries possibly caused by adult males. No seals were entangled in marine debris. In addition to incidents summarized in Table 2.6, one yearling had received an entanglement scar since the previous season. Five immature seals were found behind the deteriorating seawall at Tern Island. The seals were either removed or guided out by researchers. No aborted fetuses were found.

ACKNOWLEDGMENTS

We acknowledge the support of the U.S. Fish and Wildlife Service, Hawaiian Islands National Wildlife Refuge staff, particularly Brian Allen and Anthony Palermo at Tern Island for their unfailing support and assistance with data collection, particularly tagging weaned pups and monitoring and rescuing seals stranded behind the seawall. Special thanks to Suzanne Canja and Thea Johanos for their data collection and tagging of weaned pups, Brad Ryon for the health assessment sampling, and Don Hawn for his boat-handling skills and maintenance of boats and engines. Allison Veit is acknowledged for her advice on navigation within the atoll. We thank USFWS volunteer, Helen Resoup, for assisting with a seal necropsy. In addition, we thank Vanessa Pepi and Aaron Dietrich for documenting pupping on East Islet during turtle nesting studies. We thank the captain, officers, and crew of the NOAA ship *Townsend Cromwell* and the pilots of Pearl Pacific Enterprises for logistical assistance.

TABLES
for French Frigate Shoals

Table 2.1.--Summary statistics for atoll censuses (n = 7) of Hawaiian monk seals at French Frigate Shoals from June 20 to August 2, 2000.

Size/Sex	Mean number of individuals	Standard deviation
Adults	85.0	6.3
Male	24.4	4.8
Female	55.3	4.4
Unknown	5.3	2.5
Subadults	8.3	3.7
Male	3.0	1.4
Female	4.6	2.4
Unknown	0.7	1.0
Juveniles	12.9	3.8
Male	5.0	2.4
Female	7.0	2.6
Unknown	0.9	1.5
Pups	38.4	3.1
Male	15.9	3.2
Female	14.4	2.7
Unknown	8.1	3.4
Non-pup total	106.1	9.7
Grand total	144.6	12.0

Table 2.2.--Composition of the Hawaiian monk seal subpopulation at French Frigate Shoals during the spring and summer of 2000. These numbers are an unknown proportion of the entire subpopulation as many untagged adults could not be uniquely identified. All known parturient females and pups born during the calendar year are included.

	Number of seals				
Size	Male	Female	Unknown	Total	Sex ratio male:female
Adults	80[a]	123[a]	0	203	0.7:1
Subadults	10	15	0	25	0.7:1
Juveniles	21	26	0	47	0.8:1
Pups	30	32	5[b]	67	0.9:1
Non-pup Total	111	164	0	275	0.7:1
Grand Total	141	196	5[b]	342	0.7:1

[a] These numbers are an unknown proportion of the entire adult subpopulation.
[b] Includes one perinatal pup death.

Table 2.3.--Summary of tagged known-age seals born at French Frigate Shoals and resighted at any location in 2000.

Cohort year	Age (years)	Sex	Number originally tagged	Number resighted in 2000
1984	16	Male	49	9[a]
		Female	43	13[b]
1985	15	Male	48	5[a,c]
		Female	38	10[b]
1986	14	Male	52	8[a]
		Female	48	18[a,b]
1987	13	Male	55	10
		Female	51	8
1988	12	Male	52	4
		Female	62	5
1989	11	Male	51	6
		Female	50	6[b]
1990	10	Male	38	1
		Female	41	8[b]
1991	9	Male	24	0
		Female	44	4[b]
1992	8	Male	36	2
		Female	55	10[b]
1993	7	Male	40	3
		Female	39	2
1994	6	Male	47	1
		Female	48	7[b]
1995	5	Male	29	2
		Female	26	13[b]
1996	4	Male	39	4
		Female	30	3
1997	3	Male	32	1
		Female	19	1
1998	2	Male	49	13
		Female	39	12
1999	1	Male	30	21
		Female	30	22

[a] Cohort survivors include seals removed from French Frigate Shoals for rehabilitation that remain in permanent captivity (n = 14).

[b] Cohort survivors include seals removed from French Frigate Shoals for rehabilitation or direct translocation. These seals were released at Kure or Midway Atoll (n = 19).

[c] Survivors include a seal with broken tags that could be identified by cohort but could not be matched with its original identity.

Table 2.4a.--Summary of Hawaiian monk seals born at French Frigate Shoals in 2000.

Event	Number of pups			
	Male	Female	Unknown	Total
Born	30	32	5	67
Died/probably died prior to weaning	3	1	5	9
Weaned	27	31[a]	0	58
Tagged	27	30	0	57

[a] One pup was born prior to December 8, weaned in January 2001, and was not tagged.

Table 2.4b.--Summary of nursing periods and measurements of weaned pups at French Frigate Shoals in 2000. Nursing periods were calculated where birth and weaning dates were both known or occurred within a range of 4 days or less. All measurements were taken within 2 weeks after weaning.

	Nursing period (days)	Axillary girth (cm)	Straight dorsal length (cm)
Mean	37.2	108.7	125.2
Standard deviation	5.6	9.1	6.3
n	6	40	40

Table 2.5a.–Documented movement of Hawaiian monk seals to French Frigate Shoals from other locations in 2000, summarized by movements between two locations. One seal made more than one trip.

Original location	Number of trips, size, and sex class
Laysan Island	4 adult female 1 subadult male 2 subadult female
Lisianski Island	1 subadult male

Table 2.5b.–Documented movement of Hawaiian monk seals from French Frigate Shoals to other locations in 2000, summarized by movements between two locations. One seal made more than one trip.

Destination	Number of trips, size, and sex class
Necker Island	1 adult female
Laysan Island	1 adult male 4 adult female 1 subadult female

Table 2.6.--Factors affecting Hawaiian monk seal survival at French Frigate Shoals in 2000.

		Outcome			
Size	Sex	Total	Injured	Died	Probably died
		Attack by Large Shark			
Adult	Male	1	1	0	0
	Female	1	1	0	0
Juvenile	Male	2	2	0	0
Weaned pup	Male	3	3	0	0
	Female	1	1	0	0
Nursing pup	Male	1	0	1	0
		Mounting by Males			
Subadult	Female	1	0	0	1
		Entanglement			
		(none observed)			
		Emaciation			
Adult	Female	2	0	1[a]	1
Juvenile	Male	1	0	0	1
	Female	1	0	0	1
		Other/Unknown			
Subadult	Male	1	0	1	0
Juvenile	Female	1	0	1	0
Weaned pup	Male	3	3[b]	0	0
	Female	1	1	0	0
Nursing pup	Male	2	0	0	2
	Female	1	0	0	1
	Unknown	5	0	1	4
Pup	Unknown	1	0	1[c]	0

[a] Seal was observed prior to death in poor condition, with opacities in both eyes. A fresh large shark bite was present on the carcass when the seal was found dead.

[b] Two weaned pups had seal-inflicted dorsal injuries.

[c] Bones found in October, unknown if the pup was nursing or weaned at time of death.

CHAPTER 3. THE HAWAIIAN MONK SEAL ON LAYSAN ISLAND, 2000

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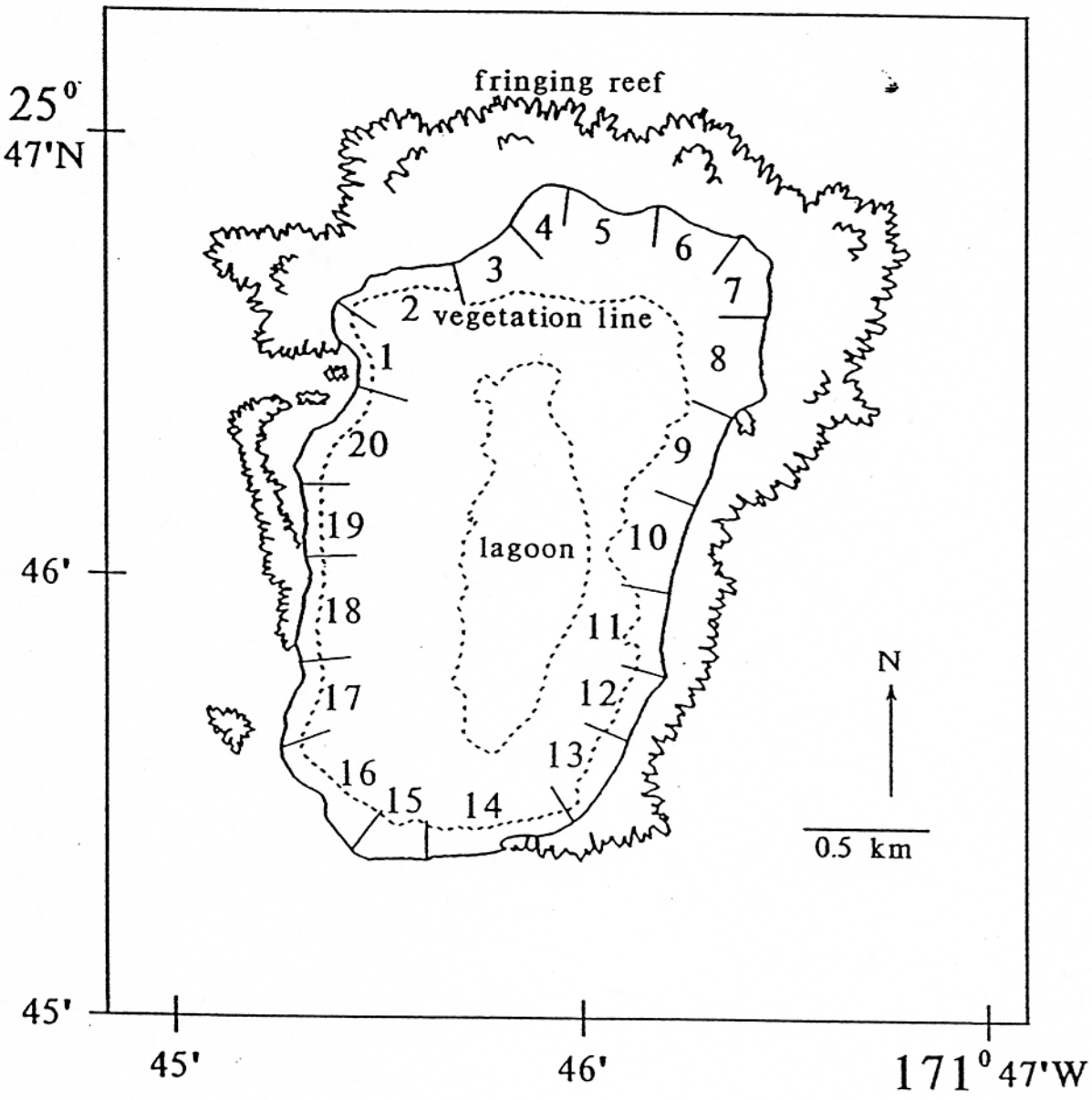

Fig. 3.1 Laysan Island in the Northwestern Hawaiian Islands.

Laysan Island (lat. 25°42'N, long. 171°44'W) is located ca. 1,300 km northwest of Oahu in the Northwestern Hawaiian Islands (Fig. 1.1). This island lies within the Hawaiian Islands National Wildlife Refuge and is one of the six primary haulout and pupping locations of the Hawaiian monk seal.

RESEARCH

The National Marine Fisheries Service (NMFS) began research on Hawaiian monk seals at Laysan Island in 1981. In 2000, research was conducted by NMFS during March 2-July 28, and incidental observations were recorded by U.S. Fish and Wildlife Service (USFWS) personnel during the remainder of the year. The perimeter of the island (ca. 11 km) was divided into 20 sectors using artificial or natural landmarks (Fig. 3.1). Research objectives specific to this subpopulation in 2000 included (1) assessment of maternity and pup exchanges and (2) documentation of male behavioral patterns and aggression, including incidence of mobbing. Due to concerns about premature births that occurred in January and February 2000, additional research objectives included epidemiological sampling for health and disease assessment studies.

Censuses and Patrols

Censuses, patrols, and incidentals were scheduled to ensure that the entire island perimeter was monitored at least once daily during March 4-July 14. Censuses (n = 24) were conducted by two observers every fourth day from April 22 to July 25. Each census began at 1300 Hawaii standard time and continued for 2.3 to 3.2 h.

Standardized behavior patrols were conducted on 21 noncensus days from March 24 to July 14 to assess activity patterns of adults and large subadults, document male aggression, and detect mobbing incidents. During behavior patrols, observer attention was directed out to sea as much as possible, as mobbings have been observed most frequently in the water.

Full-island standardized incidental surveys (n = 77) were conducted on noncensus and nonbehavior patrol days from March 4 to July 13 to record females with pups, weaned pups, injured seals, and molting animals. If observed, major behavioral interactions (i.e., male mobbing/harassment) were also recorded. Additional partial island incidental surveys were conducted as needed.

Individual Identification

A total of 327 individuals (284 excluding pups) were identified by existing or applied tags, bleach marks, scars, or natural markings. Bleach marks were applied to 263

seals, including 37 nursing pups. Most weaned pups (n = 32) were tagged with Temple Tags and a single passive integrated transponder (PIT) tags. The four pups still nursing when the NMFS staff left Laysan, received only post-molt bleaches as applied by USFWS personnel. Two of these pups were tagged in April 2001. An additional 11 adult seals (10 male, 1 female) were retagged with temple tags and/or received pit tags during the epidemiological sampling.

Collection of Samples

One hundred and six scat and eight spew samples were collected. Skin punches were collected from 32 weaned pups during tagging, from 6 adult seals during retagging, and from 3 seals during necropsies. Shed molt samples were collected from 12 seals. Five placentas were also sampled. Three necropsies were performed and tissue samples were collected from each of the seal carcasses. Various additional samples were collected from 17 seals during the epidemiological study. In total, 793 pieces of potentially entangling debris were inventoried and left at a secure site on the island to be removed later.

Special Studies

Health and Disease Study

During January and February 2000, USFWS personnel stationed on Laysan reported the perinatal deaths of the first four pups, all born within a 4-week period. Measurements indicated that these pups were probably premature, and concern over these unexplained deaths led to the early March deployment of a research team for a 26-day field camp to collect epidemiological samples and prepare for on-site response if further mortalities occurred. During this time 16 seals (10 adult males, 2 adult females, 2 juvenile males, and 2 juvenile females) were restrained specifically to collect blood, fecal samples, virological and bacteriological swabs, and blubber biopsies. In addition, vaginal swabs were obtained without restraint from an adult female thought to have been the mother of one of the dead pups. Virological and bacteriological swabs were also collected from five placentas after five live births. Tagging and retagging of sampled seals occurred opportunistically. Although no further perinatal pup deaths occurred during this study, a single subsequent abortion/perinatal death occurred at the end of April.

RESULTS

Subpopulation Abundance and Composition

The mean (±SD) of 24 censuses was 103.3 seals (±10.9) including pups, and 82.0 seals (±9.0) excluding pups (Table 3.1). The total spring-summer subpopulation was 315

individuals, 272 excluding pups (Table 3.2). This number is a subset of the total identified in the calendar year. The sex ratio for older (>17 years of age) and unknown aged adults was 1.0:1 (28 males: 28 females), whereas the ratio for younger adults (≤17 years of age) was ca. 0.8:1 (46 males: 57 females). The numbers of tagged known-age seals born at Laysan Island during the period from 1983 to 1999, and resighted at any location in 2000, are summarized in Table 3.3.

Reproduction

At least 43 pups were born at Laysan Island in 2000: 36 were successfully weaned, 5 died and 2 disappeared prior to weaning (Table 3.4a). Nursing periods and measurements of weaned pups are summarized in Table 3.4b. The birth rate measured as the number of pups divided by the number of adult-sized females in the subpopulation x 100 was 50.6% ((43/85) x 100). At least 15 pup exchanges occurred, involving 17 nursing females.

Interatoll Movement

Interatoll movement was documented for 25 seals that completed a total of 55 movements between Laysan Island and either Molokai, French Frigate Shoals, Lisianski Island, or Midway Atoll (Tables 3.5a and b). An adult female made the first ever documented movement from Laysan Island to Molokai.

Factors Affecting Survival

Attacks by large sharks, mounting attempts by male Hawaiian monk seals, entanglement in marine debris, emaciation, and other/unknown factors led to 25 life-threatening conditions, which resulted in the confirmed deaths of eight animals and the disappearance of two other seals (Table 3.6). Although no incidents of prolonged adult male aggression were observed, one adult female suffered moderate dorsal injuries indicative of male mounting. One seal was entangled and escaped independently without obvious injury. In addition to the incidents presented in Table 3.6, two adult females and two weaned pups suffered minor dorsal scratches.

ACKNOWLEDGMENTS

We acknowledge the support of the U.S. Fish and Wildlife Service, Hawaiian Islands National Wildlife Refuge staff and thank the captain and crew members of the *SS Midway* and the NOAA ship *Townsend Cromwell.* Special thanks are extended to Chris Eggleston, Holly Gellerman, Dr. Marty Haulena, and Brad Ryon for their assistance during the epidemiological sampling. Thanks also to Chris Depkin, Jennifer Hale, Marvin Friel, and Eric Lund for their data collection and seal bleaching assistance.

TABLES
for Laysan Island

Table 3.1.--Summary statistics for censuses (n = 24) of Hawaiian monk seals at Laysan Island from April 22 to July 25, 2000.

Size/Sex	Mean number of individuals	Standard deviation
Adults	48.6	4.5
Male	17.3	4.5
Female	30.0	3.3
Unknown	1.3	1.4
Subadults	18.4	7.8
Male	7.8	3.9
Female	9.8	4.6
Unknown	0.8	0.8
Juveniles	15.0	5.3
Male	5.0	2.3
Female	9.7	4.1
Unknown	0.3	0.5
Pups	21.3	5.7
Male	8.9	2.9
Female	12.3	3.2
Unknown	0.0	0.2
Non-pup total	82.0	9.0
Grand total	103.3	10.9

Table 3.2.--Composition of the Hawaiian monk seal subpopulation at Laysan Island during the spring and summer of 2000. All known parturient females and pups born during the calendar year are included.

	Number of seals				
Size	Male	Female	Unknown	Total	Sex ratio male:female
Adults	74	85	0	159	0.9:1
Subadults	26	30	0	56	0.9:1
Juveniles	20	37	0	57	0.5:1
Pups	18	22	3	43	0.8:1
Non-pup total	120	152	0	272	0.8:1
Grand total	138	174	3	315	0.8:1

Table 3.3.--Summary of tagged known-age seals born at Laysan Island and resighted at any location in 2000.

Cohort year	Age (years)	Sex	Number originally tagged	Number resighted in 2000
1983	17	Male	10	1
		Female	10	6
1984	16	Male	16	3
		Female	13	5
1985	15	Male	16	1
		Female	14	4
1986	14	Male	15	2
		Female	17	2
1987	13	Male	13	3
		Female	15	6
1988	12	Male	23	4
		Female	17	3
1989	11	Male	16	2
		Female	13	2
1990	10	Male	7	2
		Female	9	3
1991	9	Male	18	7
		Female	13	6
1992	8	Male	18	2
		Female	14	4
1993	7	Male	23	4
		Female	14	5
1994	6	Male	18	8
		Female	29	8
1995	5	Male	16	7
		Female	21	9
1996	4	Male	23	11
		Female	21	12
1997	3	Male	19	8
		Female	16	8
1998	2	Male	24	15
		Female	20	15
		Unknown	1	0
1999	1	Male	20	11
		Female	34	30

Table 3.4a.--Summary of Hawaiian monk seals born at Laysan Island in 2000.

Event	Number of pups			
	Male	Female	Unknown	Total
Born	18	22	3	43
Died/probably died prior to weaning	3[a]	1[a]	3[b]	7
Weaned	15	21	0	36[c]
Tagged	14	20	0	34[c]

[a] All cases involve the perinatal death of premature pup(s).
[b] The perinatal death of one premature pup and the disappearance of two pups <12 days after birth.
[c] Includes four pups (one male and three females) weaned after NMFS staff left Laysan. Post-molt bleaches were applied by USFWS personnel. Two of these pups (both female) were tagged in April 2001.

Table 3.4b.--Summary of nursing periods and measurements of weaned pups at Laysan Island in 2000. Nursing periods were calculated where birth and weaning dates were both known or occurred within a range of 4 days or less. All measurements were taken within 2 weeks after weaning.

	Nursing period (days)	Axillary girth (cm)	Straight dorsal length (cm)
Mean	37.4	107.2	126.1
Standard deviation	6.7	11.5	6.2
n	32	32	32

Table 3.5a.–Documented movement of Hawaiian monk seals to Laysan Island from other locations in 2000, summarized by movements between two locations. Six seals made more than one observed trip.

Original location	Number of trips, size, and sex class
French Frigate Shoals	1 adult male 4 adult female 1 subadult female
Lisianski Island	1 adult male 8 adult female, 4 subadult male 4 subadult female 1 juvenile female

Table 3.5b.–Documented movement of Hawaiian monk seals from Laysan Island to other locations in 2000, summarized by movements between two locations. Eight seals made more than one observed trip.

Destination	Number of trips, size, and sex class
Molokai	1 adult female
French Frigate Shoals	4 adult female 1 subadult male 2 subadult female
Lisianski Island	1 adult male 9 adult female 5 subadult male 7 subadult female
Midway Atoll	1 adult female

Table 3.6.--Factors affecting Hawaiian monk seal survival at Laysan Island in 2000.

			Outcome		
Size	Sex	Total	Injured	Died	Probably died
		Attack by Large Shark			
Adult	Male	3	3[a]	0	0
	Female	3	3	0	0
Juvenile	Female	2	2	0	0
		Mounting by Males			
Adult	Female	1	1	0	0
		Entanglement			
Adult	Female	1[b]	0	0	0
		Emaciation			
Adult	Female	1	0	1[c]	0
		Other/Unknown			
Adult	Female	2	2	0	0
Subadult	Male	1	1	0	0
Juvenile	Male	1	1	0	0
	Female	1	0	1	0
Weaned pup	Male	1	1	0	0
	Female	1	0	1[d]	0
Nursing pup	Male	3	0	3[e]	0
	Female	1	0	1[e]	0
	Unknown	3	0	1[e]	2[f]

[a] One injured seal was also emaciated.
[b] Seal freed itself and had no obvious injury.
[c] Seal was considered emaciated since 1997. Seal was sighted alive February 23 and found dead March 2. A full necropsy was performed.
[d] Carcass had shark bite, but this did not appear to be the cause of death.
[e] Perinatal death of premature pup(s).
[f] Pups disappeared and were never sighted again; 1 ≤ 12 days old, 1 ≤ 7 days old.

CHAPTER 4. THE HAWAIIAN MONK SEAL ON LISIANSKI ISLAND, 2000

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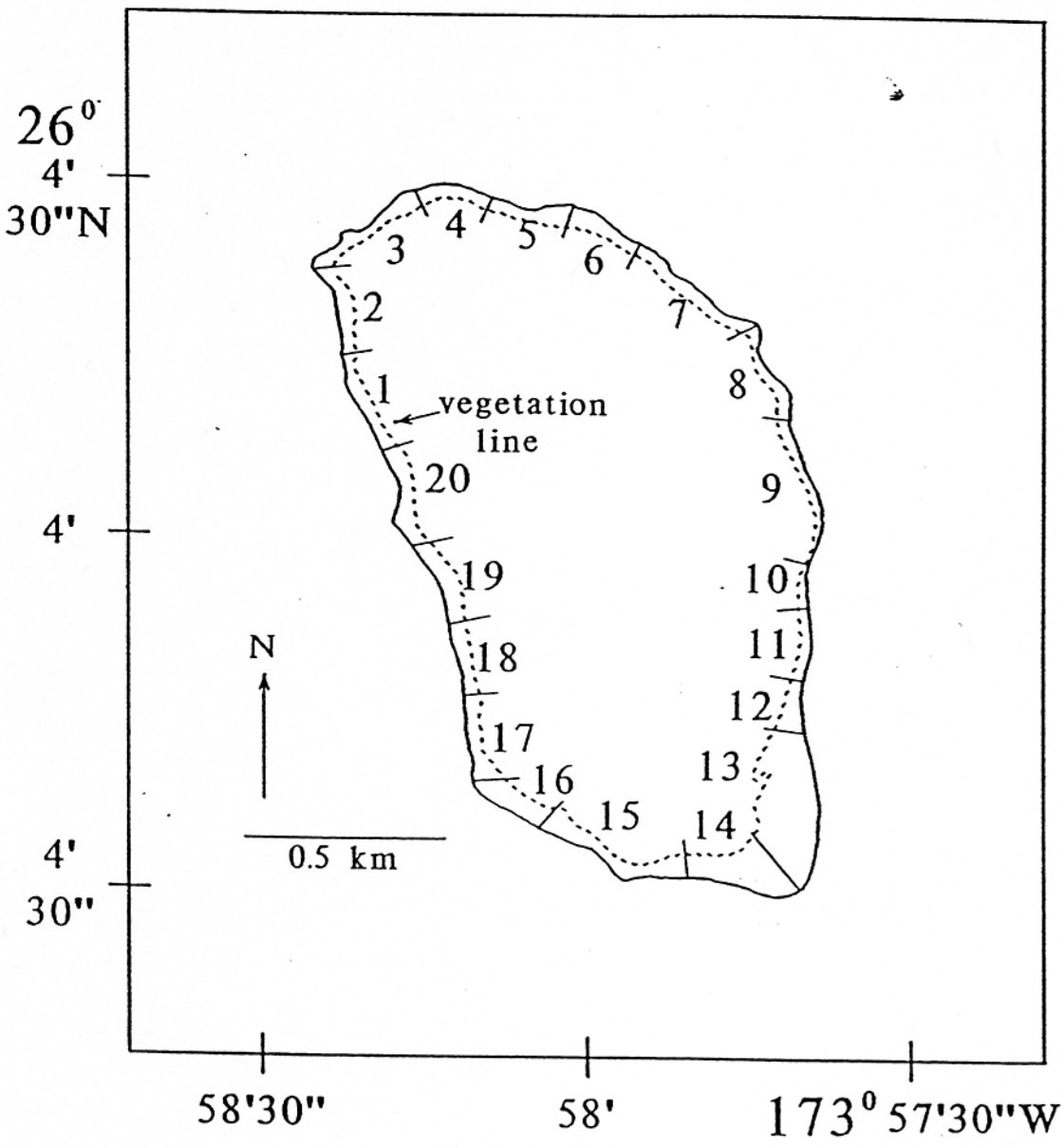

Fig. 4.1 Lisianski Island in the Northwestern Hawaiian Islands.

Lisianski Island (lat. 26°02'N, long. 174°00'W) is one of the primary haulout and pupping locations of the Hawaiian monk seal. The island is located ca. 1,760 km northwest of Oahu (Fig. 1.1), and is part of Neva Shoal, a shallow reef bank within the Hawaiian Islands National Wildlife Refuge.

RESEARCH

The National Marine Fisheries Service (NMFS) began research on Hawaiian monk seals at Lisianski Island in 1981. In 2000, research was conducted by NMFS during March 29-July 27 and October 11-30. The perimeter of the island was divided into 20 sectors using artificial or natural landmarks (Fig. 4.1). Research objectives specific to this subpopulation in 2000 included (1) assessment of maternity and pup exchanges; (2) documentation of adult male behavioral patterns and aggression, including incidence of mobbing; (3) deployment of satellite-linked dive recorders (SLDRs), health and disease assessment and retagging; and (4) large-scale marine debris removal from reefs around the island.

Censuses and Patrols

Censuses and patrols were scheduled to ensure that the entire island was monitored at least once daily during April 5-July 27. Censuses (n = 24) were conducted by two observers every fourth day from April 18 to July 23, beginning at 1300 Hawaii standard time and continuing from 1.6 to 2.7 h.

Standardized behavior patrols were conducted on 21 noncensus days from April 20 to July 17 to assess activity patterns of adults and large subadults, document male aggression, and detect mobbing incidents. During behavior patrols, attention was directed out to sea as much as possible as mobbing has been observed most frequently in the water.

Full-island standardized incidental surveys (n = 73) were conducted on noncensus and nonbehavior patrol days during March 29-July 27 and October 13-25 to record females with pups, weaned pups, injured seals, and molting animals. If observed, major behavioral interactions (i.e., male mobbing/harassments) were also recorded. Additional partial island incidental surveys were conducted as needed.

Individual Identification

A total of 212 individuals (192 excluding pups) were identified by existing or applied tags, bleach marks, scars, or natural markings. All weaned pups (n = 18) were

tagged with Temple Tags and passive integrated transponder (PIT) tags. One weaned pup was retagged to replace a broken tag. During the October camp, 29 seals were retagged with Temple Tags and/or PIT tags, and 8 seals (including an untagged prematurely weaned pup) were newly tagged with Temple Tags and PIT tags.

Collection of Samples

One hundred-eight scat and six spew samples were collected. Skin punches were collected from 18 weaned pups during tagging, 31 adults seals during tagging or retagging, and 2 seals during necropsies. Necropsies were performed and tissue samples were collected from two dead male seals (an adult and a pup) and an aborted fetus. Skeletal samples were collected from both dead seals. Shed molt samples were collected from 14 seals. Various additional samples were collected from 29 seals during the epidemiological study. In total, 638 pieces of potentially entangling debris were collected and removed from Lisianski Island.

Special Studies

Foraging Ecology, Health, and Disease

During October 2000, a field camp was deployed to (1) attach satellite-linked dive recorders (SLDRs) in order to characterize at-sea habitat use, (2) collect epidemiological samples (blood, swabs, blubber, etc.) for health and disease assessment, and (3) retag or newly tag seals to facilitate individual identification in the subpopulation. A total of 52 seals were handled. Twenty-eight seals were fully sampled for the health and disease assessment: 13 received SLDRs and Temple and/or PIT tags, 13 received SLDRs only, 1 received new identification tags only, and 1 seal was not retagged. In addition, 23 seals received Temple and/or PIT tags, and vaginal swabs were obtained without restraint from an adult female located less than 2 feet from (and the possible mother of) an aborted fetus.

Large-Scale Marine Debris Removal from Reefs

A cooperative multiagency coral reef cleanup was conducted at Lisianski Island in October 2000 supported by the NOAA ship *Townsend Cromwell* and the USCG cutter *Kukui*. Personnel from 17 agencies removed debris to reduce entanglement hazards to monk seals and other marine life and document the extent of reef debris fouling. Debris collected and stored on the beaches during 2000 were also removed. In total, 2,035 kg of debris was recovered: 80 kg from the reef and 1,955 kg from the beaches.

RESULTS

Subpopulation Abundance and Composition

The mean (±SD) of 24 censuses was 69.4 seals (±9.3) including pups, and 57.3 seals (±8.2) excluding pups (Table 4.1). The total spring-summer subpopulation was 204 individuals, 184 excluding pups (Table 4.2). This number is a subset of the total identified during the calendar year. The sex ratio for older adults (>18 years of age) was strongly skewed toward males at 2.9:1 (41 males:14 females), whereas the ratio for younger adults (≤18 years of age) was at unity at 1:1 (33 males:33 females). The numbers of tagged known-age seals born at Lisianski Island from 1982 to 1999, and resighted at any location in 2000, are summarized in Table 4.3.

Reproduction

At least 20 pups were born at Lisianski Island in 2000; 18 were successfully weaned, and 2 died or disappeared prior to weaning. No pups were still nursing at the end of this study (Table 4.4a). One fetus was found in October 2000. Nursing periods and measurements of weaned pups are summarized in Table 4.4b. The birth rate measured as the number of pups born divided by the number of adult-sized females in the subpopulation x 100 was 42.6% ((20/47) x 100). At least 10 pup exchanges occurred, involving 8 nursing females.

Interatoll Movement

Interatoll movement was documented for 21 seals that completed a total of 48 movements between Lisianski Island and either French Frigate Shoals, Laysan, Pearl and Hermes Reef, or Midway Atoll (Tables 4.5a and b).

Factors Affecting Survival

Attacks by large sharks, mounting attempts by male Hawaiian monk seals, emaciation, and unknown factors led to 15 life-threatening conditions, which resulted in the confirmed deaths of two animals and the probable death of one other seal (Table 4.6). No entanglements were observed. In addition to incidents summarized in Table 4.6, five yearlings were considered emaciated, five seals were noted with eye opacities, and an aborted fetus was found in October 2000. Male harassment of weaned pups/juveniles was observed on 11 different occasions; no fatalities occurred and only one incident resulted in obvious injury. At least 13 weaned pups were noted with minor dorsal scratches from unobserved intraspecies activity.

ACKNOWLEDGMENTS

We acknowledge the support of the U.S. Fish and Wildlife Service, Hawaiian Islands National Wildlife Refuge staff. We thank the captain, officers, and crew of the NOAA ship *Townsend Cromwell*, and the *SS Midway* for logistical assistance. Special thanks are extended to Brenda Becker for her support in establishing the field camp. We also thank Brent Stewart and Pam Yochem, DVM of Hubbs Sea World Research Institute and Lizabeth Kashinsky and Jason Baker for their efforts during the October foraging ecology, health, and disease studies.

TABLES
for Lisianski Island

Table 4.1.--Summary statistics for censuses (n = 24) of Hawaiian monk seals at Lisianski Island from April 18 to July 23, 2000.

Size/Sex	Mean number of individuals	Standard deviation
Adults	39.4	7.8
Male	20.6	5.8
Female	17.1	3.8
Unknown	1.7	2.6
Subadults	10.0	3.2
Male	5.5	2.6
Female	4.1	1.8
Unknown	0.3	0.8
Juveniles	7.9	3.3
Male	4.4	2.4
Female	3.5	1.6
Unknown	0.0	0.2
Pups	12.1	3.0
Male	6.3	1.3
Female	5.8	2.1
Unknown	0.0	0.0
Non-pup total	57.3	8.2
Grand total	69.4	9.3

Table 4.2.--Composition of the Hawaiian monk seal subpopulation at Lisianski Island during the spring and summer of 2000. All known parturient females and all pups born during the calendar year are included.

	Number of seals				
Size	Male	Female	Unknown	Total	Sex ratio male:female
Adults	74	47	0	121	1.6:1
Subadults	18	12	0	30	1.5:1
Juveniles	18	15	0	33	1.2:1
Pups	10	9	1	20	1.1:1
Non-pup total	110	74	0	184	1.5:1
Grand total	120	83	1	204	1.4:1

Table 4.3.--Summary of tagged known-age seals born at Lisianski Island and resighted at any location in 2000.

Cohort year	Age (years)	Sex	Number originally tagged	Number resighted in 2000
1982	18	Male	7	2
		Female	6	1
1983	17	Male	6	2
		Female	18	7
1984	16	Male	10	4
		Female	5	2
1985	15	Male	5	2
		Female	9	1
1986	14	Male	11	6
		Female	9	3
1987	13	Male	12	1
		Female	6	1
1988	12	Male	10	5
		Female	8	6
1989	11	Male	–	–
		Female	--	--
1990	10	Male	8	4
		Female	9	3
1991	9	Male	9	5
		Female	6	2
1992	8	Male	13	6
		Female	8	4
1993	7	Male	4	1
		Female	9	2
1994	6	Male	4	1
		Female	5	1
1995	5	Male	7	2
		Female	10	2
1996	4	Male	9	3
		Female	13	1
1997	3	Male	10	5
		Female	9	4
1998	2	Male	10	5
		Female	11	6
1999	1	Male	16	12
		Female	11	6

Table 4.4a.--Summary of Hawaiian monk seals born at Lisianski Island in 2000.

Event	Number of pups			
	Male	Female	Unknown	Total
Born	10	9	1	20
Died /probably died prior to weaning	1	0	1	2
Weaned	9	9	0	18
Tagged	9	9[a]	0	18

[a] Includes one pup that was tagged in October 2000.

Table 4.4b.--Summary of nursing periods and measurements of weaned pups at Lisianski Island in 2000. Nursing periods were calculated where birth and weaning weaning dates were both known or occurred within a range of 4 days or less. All measurements were taken within 2 weeks after weaning.

	Nursing period (days)	Axillary girth (cm)	Straight dorsal length (cm)
Mean	35.8	103.5	123.7
Standard deviation	6.2	12.8	6.0
n	13	15	14

Table 4.5a.–Documented movement of Hawaiian monk seals to Lisianski Island from other locations in 2000, summarized by movements between two locations. Seven seals made more than one observed trip.

Original location	Number of trips, size, and sex class
Laysan Island	1 adult male 9 adult female 5 subadult male 7 subadult female
Pearl and Hermes Reef	1 adult male 1 adult female 1 subadult male
Midway Atoll	1 adult female

Table 4.5b.–Documented movement of Hawaiian monk seals from Lisianski Island to other locations in 2000, summarized by movements between two locations. Five seals made more than one observed trip.

Destination	Number of trips, size, and sex class
French Frigate Shoals	1 subadult male
Laysan Island	1 adult male 8 adult female 4 subadult male 4 subadult female 1 juvenile female
Pearl and Hermes Reef	2 adult male 1 subadult female

Table 4.6.--Factors affecting Hawaiian monk seal survival at Lisianski Island in 2000.

			Outcome		
Size	Sex	Total	Injured	Died	Probably died
		Attack by Large Shark			
Adult	Female	2	2	0	0
Subadult	Female	1	1	0	0
Juvenile	Male	1	1	0	0
		Mounting by Males			
Adult	Female	3	3	0	0
Subadult	Female	1	1	0	0
		Entanglement			
		(none observed)			
		Emaciation			
Adult	Male	1	0	1[a]	0
		Unknown			
Adult	Male	2	2	0	0
	Female	1	1	0	0
Weaned pup	Female	1[b]	1	0	0
Nursing pup	Male	1	0	1	0
	Unknown	1	0	0	1

[a] This seal was thin and then bitten by a shark. The injuries healed, but the seal became emaciated and died. Shark injury not considered primary cause of death.

[b] This seal was prematurely weaned after nursing 25 days and suffered a severe eye injury which probably led to loss of one eye.

CHAPTER 5. THE HAWAIIAN MONK SEAL ON PEARL AND HERMES REEF, 2000

Michelle Wainstein and Stephani Holzwarth

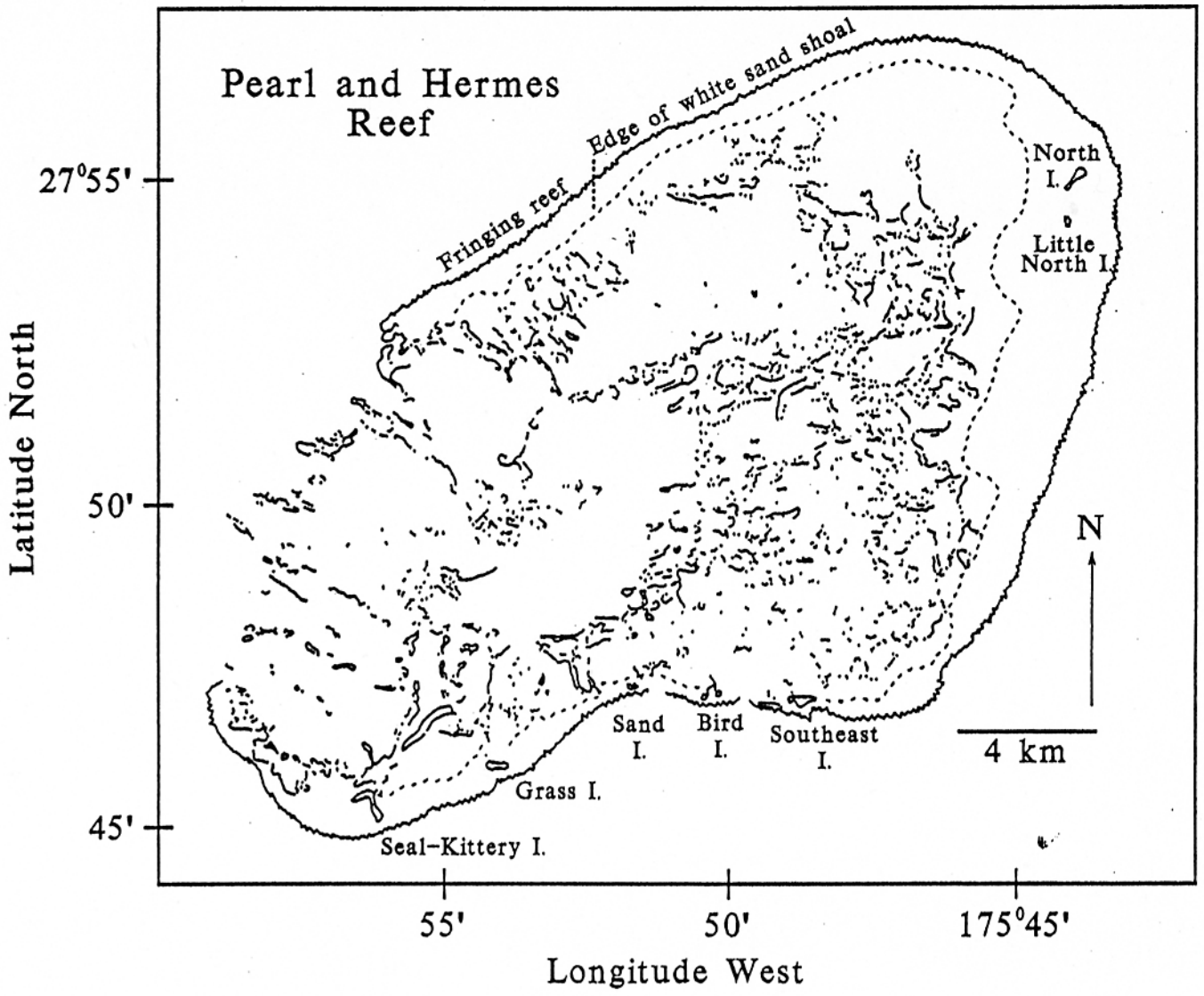

Fig. 5.1 Pearl and Hermes Reef in the Northwestern Hawaiian Islands.

Pearl and Hermes Reef (lat. 27°55'N, long. 175°45'W) is one of the primary haulout and pupping locations of the Hawaiian monk seal. This atoll is located ca. 1,900 km northwest of Oahu in the Northwestern Hawaiian Islands and is part of the Hawaiian Islands National Wildlife Refuge (Fig. 1.1). Pearl and Hermes is composed of four vegetated and three nonvegetated sand islets enclosed in a fringing reef (Fig. 5.1).

RESEARCH

The National Marine Fisheries Service (NMFS) began research on Hawaiian monk seals at Pearl and Hermes Reef in 1982. In 2000, research was conducted by NMFS May 18-July 25. The perimeters of the four larger vegetated islets were divided into sectors using natural landmarks. Research objectives specific to the subpopulation in 2000 included large-scale marine debris removal from the fringing reef.

Censuses and Patrols

Atoll censuses (n = 10) were conducted every sixth day, on average, from May 27 to July 22. Each atoll census began between 0730 and 1730 and ended between 0812 and 1812 Hawaii standard time. All islets were censused on foot by one or two persons. In addition, incidental patrols were conducted opportunistically to resight seals tagged in previous years.

Individual Identification

A total of 247 individuals (216 excluding pups) were identified by existing or applied tags, scars, or natural markings. All weaned pups (n = 22) were tagged with Temple Tags and passive integrated transponder (PIT) tags.

Collection of Samples

One hundred-six scat and four spew samples were collected. Skin punches were collected from 21 seals during tagging. One skeletal sample was collected. In total, 665 items of potentially entangling debris were collected, inventoried, and stored for future removal. In addition, the GPS positions of 13 large, unretrievable debris items were recorded for relocation during future removal efforts.

Special Studies

Large-Scale Marine Debris Removal from Reefs

A cooperative multiagency coral reef cleanup was conducted at Pearl and Hermes Reef in October 2000 supported by the NOAA ship *Townsend Cromwell* and the USCG cutter *Kukui*. Personnel from 17 agencies removed debris from reefs to reduce these entanglement hazards to monk seals and other marine life and document the extent of reef debris fouling. Debris collected and stored on the beaches during the main 2000 field season were also removed. In total, 9,866 kg of debris were recovered: 7,875 kg from the reef and 1,991 kg from the beaches.

Noteworthy Events

Grounding of the *Swordman I*

On the morning of June 6, 2000, the 77-ft longliner *Swordman I* ran aground on the perimeter reef of Pearl and Hermes Reef, approximately 4 miles northeast of Southeast Island. The crew was rescued by the NMFS field personnel. There were 81,200 gallons of fuel on board; 79,000 gallons were recovered and the remainder spilled. A majority of the swordfish carcasses were contained within the fish hold of the vessel. An oil spill response team evaluated the scene 1 week after the incident and determined that the impact to the atoll's wildlife and coral reefs were minimal. The authors found no evidence of oiling or other direct impacts to Hawaiian monk seals. Salvage crews spent approximately 2 weeks cleaning the vessel and preparing it for removal from the reef. On July 27, 2000, the *American Salvor*, a salvage tug, removed the *Swordman I* from the perimeter reef and sank it in 6,000 ft of water en route to Midway Atoll.

RESULTS

Subpopulation Abundance and Composition

The mean (±SD) of 10 atoll censuses was 100.1 seals (±14.6) including pups and 84.9 seals (±12.7) excluding pups (Table 5.1). The total spring-summer subpopulation was 239 individuals, 208 excluding pups (Table 5.2). This number is a subset of the total identified during the calendar year. The numbers of tagged known-age seals born at Pearl and Hermes Reef during the period from 1983 to 1999 and resighted at any location in 2000 are summarized in Table 5.3.

Reproduction

At least 31 pups were born at Pearl and Hermes Reef in 2000: 22 were successfully weaned, 1 died prior to weaning, and 8 were still nursing upon completion of the study period (Table 5.4). The birth rate measured as the number of pups born divided

by the number of adult-sized females in the subpopulation x 100 was 46.3% ((31/67) x 100). Measurements of weaned pups are summarized in Table 5.4.

Interatoll Movement

Interatoll movement was documented for 23 seals that completed a total of 32 movements between Pearl and Hermes Reef and either Lisianski Island, Midway Atoll, or Kure Atoll (Tables 5.5a and b).

Factors Affecting Survival

Attacks by large sharks, entanglement in marine debris, and other/unknown factors resulted in six life-threatening conditions which lead to the confirmed death of one seal (Table 5.6). The partially mummified carcass of a pup was found on North Island. In addition to the incidents presented in Table 5.6, a female weaned pup was observed with fleshy tumors growing from her eye, eyebrow, and lip.

ACKNOWLEDGMENTS

We thank the captain, officers, and crew of the NOAA Ship *Townsend Cromwell* for their logistical support. We also acknowledge the support of the U.S. Fish and Wildlife Service, Hawaiian Islands National Wildlife Refuge staff and thank Brad Ryon for participation in the oil spill response.

TABLES
for Pearl and Hermes Reef

Table 5.1.--Summary statistics for atoll censuses (n = 10) of the Hawaiian monk seal at Pearl and Hermes Reef from May 27 to July 22, 2000.

Size/Sex	Mean number of individuals	Standard deviation
Adults	53.5	7.9
Male	21.2	3.0
Female	26.6	6.0
Unknown	5.7	1.7
Subadults	16.1	6.1
Male	6.6	2.8
Female	7.8	3.7
Unknown	1.7	1.3
Juveniles	15.2	2.5
Male	5.1	1.4
Female	8.9	1.7
Unknown	1.2	0.6
Pups	15.2	3.5
Male	7.9	2.5
Female	6.2	1.7
Unknown	1.1	0.7
Non-pup total	84.9	12.7
Grand total	100.1	14.6

Table 5.2.--Composition of the Hawaiian monk seal subpopulation at Pearl and Hermes Reef during the summer of 2000. All known parturient females and pups born during the calendar year are included.

	Number of seals				
Size	Male	Female	Unknown	Total	Sex ratio male:female
Adults	64	67	0	131	1.0:1
Subadults	18	20	0	38	0.9:1
Juveniles	15	24	0	39	0.6:1
Pups	15	13	3	31	1.2:1
Non-pup total	97	111	0	208	0.9:1
Grand total	112	124	3	239	0.9:1

Table 5.3.--Summary of tagged known-age seals born at Pearl and Hermes Reef and resighted at any location in 2000.

Cohort year	Age (years)	Sex	Number originally tagged	Number resighted in 2000
1983	17	Male	8	2
		Female	2	1
1984	16	Male	5	3
		Female	8	3
1985	15	Male	9	3
		Female	6	4
1986	14	Male	10	2
		Female	7	2
		Unknown	1	0
1987	13	Male	14	6
		Female	7	3
1988	12	Male	12	9
		Female	6	4
1989	11	Male	8	5
		Female	6	3
1990	10	Male	5	3
		Female	1	0
1991	9	Male	10	7
		Female	11	5
1992	8	Male	13	9
		Female	10	8
1993	7	Male	14	5
		Female	7	4
1994	6	Male	--	–
		Female	--	--
1995	5	Male	15	8
		Female	12	6
1996	4	Male	11	2
		Female	12	5
1997	3	Male	16	10
		Female	11	7
1998	2	Male	8	4
		Female	21	16
1999	1	Male	11	8
		Female	15	9

Table 5.4a.--Summary of Hawaiian monk seals born at Pearl and Hermes Reef in 2000.

Event	Number of pups			
	Male	Female	Unknown	Total
Born	15	13	3	31
Died prior to weaning	0	0	1	1
Still nursing	3	3	2	8
Weaned	12	10	0	22
Tagged	12	10	0	22

Table 5.4b.--Summary of nursing periods and measurements of weaned pups at Pearl and Hermes Reef in 2000. All measurements were taken within 2 weeks after weaning.

	Nursing period (days)	Axillary girth (cm)	Straight dorsal length (cm)
Mean	40	103.9	122.8
Standard deviation	-	8.0	7.1
n	1	12	12

Table 5.5a.–Documented movement of Hawaiian monk seals to Pearl and Hermes Reef from other locations in 2000, summarized by movements between two locations. No seals made more than one observed trip.

Original location	Number of trips, size, and sex class
Lisianski Island	2 adult male 1 subadult female
Midway Atoll	5 adult male 3 adult female 2 subadult female
Kure Atoll	1 adult male 1 adult female

Table 5.5b.–Documented movement of Hawaiian monk seals from Pearl and Hermes Reef to other locations in 2000, summarized by movements between two locations. No seals made more than one observed trip.

Destination	Number of trips, size, and sex class
Lisianski Island	1 adult male 1 adult female 1 subadult male
Midway Atoll	2 adult male 7 adult female 2 subadult female
Kure Atoll	2 adult male 1 adult female

Table 5.6.--Factors affecting Hawaiian monk seal survival at Pearl and Hermes Reef in 2000.

Size	Sex	Total	Outcome		
			Injured	Died	Probably died
Attack by Large Shark					
Adult	Male	1	1	0	0
Mounting by Males					
(none observed)					
Entanglement					
Subadult	Female	1[a]	0	0	0
Weaned pup	Female	1[a]	1	0	0
Other/Unknown					
Subadult	Female	1[b]	1	0	0
Weaned pup	Female	1[c]	1	0	0
Nursing pup	Unknown	1[d]	0	1	0

[a]Seal released by observers.
[b]Cookie cutter shark bite.
[c]Approximately 15 cm diameter abscess on back.
[d]Partially mummified carcass found.

CHAPTER 6. THE HAWAIIAN MONK SEAL AT MIDWAY ATOLL, 2000

Suzanne Canja, Bruce Casler, Wayne Sentman, and Cynthia Vanderlip

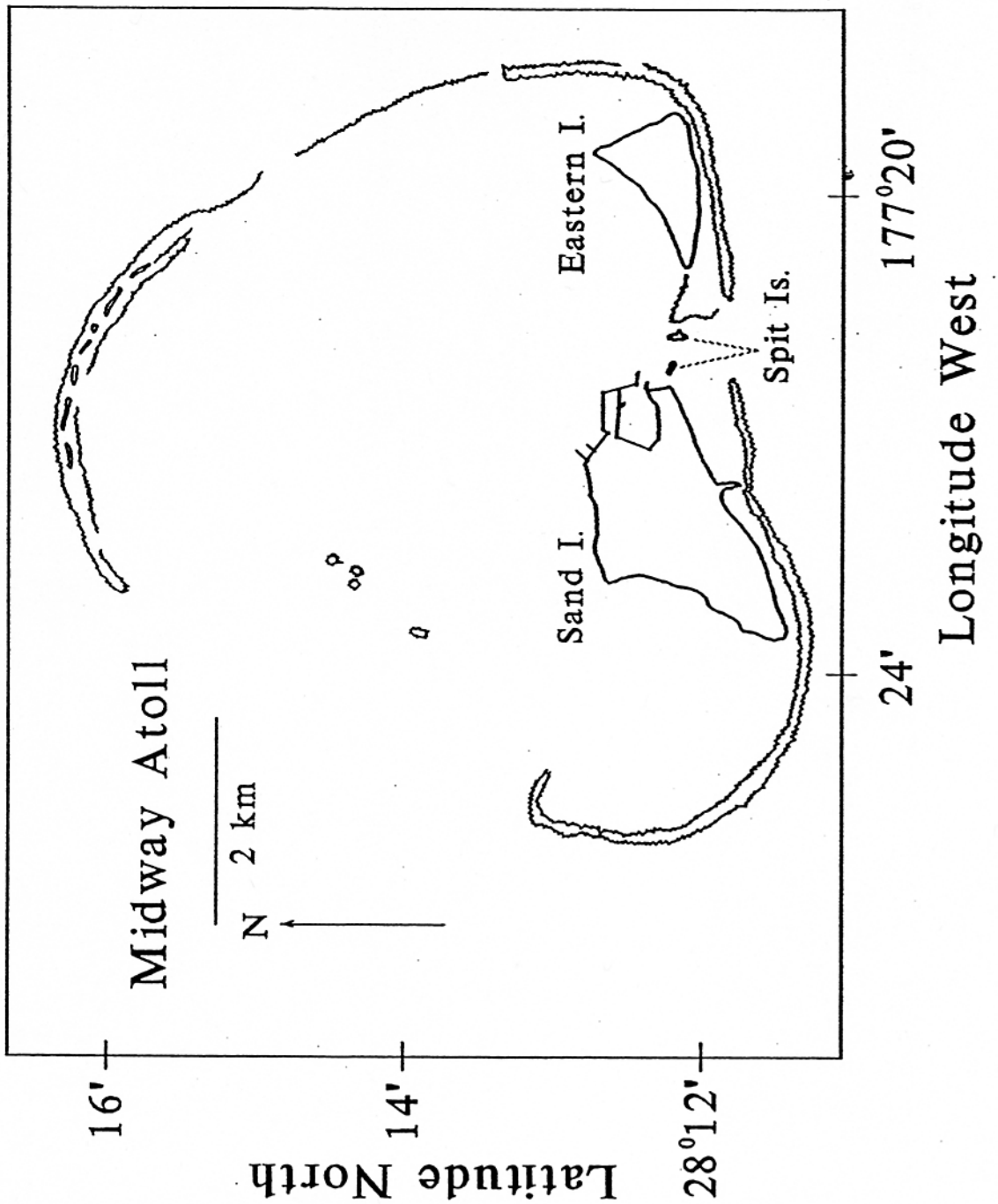

Fig. 6.1 Midway Atoll in the Northwestern Hawaiian Islands.

Midway Atoll (lat. 28°14'N, long. 177°22'W) is one of the primary haulout and pupping locations of the endangered Hawaiian monk seal. This atoll is located 2,100 km northwest of Oahu in the Northwestern Hawaiian Islands (Fig. 1.1) and comprises a circular atoll reef approximately 9 km in diameter, enclosing a lagoon and three permanent islets inside the southern part of the reef (Fig. 6.1). Eastern and Spit are uninhabited. Sand Island was the site of a U.S. Naval Air base from ca. 1939 until 1993. The U.S. Fish and Wildlife Service (USFWS) had maintained an overlay refuge (Midway Atoll National Wildlife Refuge) at the site since 1988 until full authority was transferred to the USFWS in October 1996. In 1996 USFWS joined Midway Phoenix Corporation (MPC) in a cooperative agreement. Through this agreement MPC maintains the infrastructure and operates the airport and harbor. Additionally, this agreement enables MPC to operate ecotourism and recreational ventures.

Beach counts of the Hawaiian monk seal at Midway Atoll averaged 56 animals in the late 1950s (Kenyon, 1972) but declined severely by the late 1960s; a single seal was observed during an aerial survey in 1968 (Kenyon, 1972). Currently, recovery is underway because of immigration from nearby Kure Atoll and Pearl and Hermes Reef and an increasing number of seals born on Midway Atoll. Recovery of this subpopulation remains an important management goal (Gilmartin and Antonelis, 1998).

RESEARCH

The National Marine Fisheries Service (NMFS) began limited monitoring of Hawaiian monk seals at Midway Atoll in 1983. This effort was increased to year-round monitoring in 1997 in collaboration with researchers from Oceanic Society (OS) and Hawaii Wildlife Fund (HWF). HWF concluded its monitoring program January 31, 2000, and research was conducted through an agreement between the USFWS and NMFS during February 20-September 30 and on December 31. Incidental observations were recorded by USFWS and OS personnel during the rest of the year. The perimeters of the three permanent islands were divided into sectors using artificial or natural landmarks. In 2000, research activities specific to Midway Atoll included (1) emergent reef surveys to determine haulout patterns on these areas; (2) deployment of satellite-linked dive recorders (SLDRs), health and disease assessment, and retagging; (3) assessment of nearshore reef fish abundance; (4) survey for and removal of marine debris from emergent reef areas; and (5) monitoring human impacts on seals to quantify occurrence and potential effects on monk seal habitat usage.

Censuses and Patrols

Atoll censuses (n = 27) were conducted every 7 days, on average, from January 5 to September 19. Each atoll census began between 0833 and 1640, and ended between 0922 and 1942 Hawaii standard time. All islands were censused on foot by one or two persons. Patrols of Sand Island (n = 55), Eastern Island (n = 56), or Spit Island (n = 50) were conducted on nonatoll census days during January 2-December 30 to identify and resight seals.

Individual Identification

A total of 89 individuals (75 excluding pups) were identified by existing or applied tags, bleach marks, scars, or natural markings. All weaned pups (n = 14) born at Midway were tagged with Temple tags, and 13 of these were also tagged with passive integrated transponder (PIT) tags. One prematurely weaned pup was not PIT tagged.

Collection of Samples

Eight scats and one placenta were collected. Tissue punches were collected from 14 weaned pups during tagging, and shed molt samples were collected from 13 seals. A total of 597 items of potentially entangling marine debris totaling approximately 3,005 kg were also collected, inventoried, and either destroyed or placed at Midway's inner harbor area to await transport to Honolulu.

Special Studies

Emergent Reef Surveys

Patrols were conducted once per week on average, when weather allowed, along the emergent reef areas of the North Reef (n = 25), the East Reef (n = 25) from January 16 to September 9, and only occasionally along the Southwest Reef (n = 4) from June 30 to July 21. Two people using kayaks and a motorboat surveyed the reefs for seals and turtles. On 16 occasions, the North and East reef areas were surveyed within 1 day of atoll counts to provide an estimate of atoll-wide beach/emergent reef counts.

Foraging Ecology, Health, and Disease

During December 31, 2000 to January 6, 2001, a field camp was deployed to (1) attach satellite-linked dive recorders (SLDRs) to characterize at sea habitat use, (2) collect epidemiological samples (blood, swabs, blubber, etc.) for health and disease assessment, and (3) retag or newly tag seals to facilitate individual identification in the subpopulation. A total of 16 seals were handled (3 during the 2000 calendar year). All three seals handled on December 31 were fully sampled for the health and disease assessment and received SLDRs.

Prey Availability

In August, the Honolulu Laboratory, NMFS, conducted diving transects around Midway Atoll to estimate densities of reef fishes. These surveys replicated those surveys conducted at Midway Atoll during 1980-83, 1992, 1995-99 (see DeMartini et al., 1993). From 1998 through 2000 this study was expanded to assess fish abundance at deeper sites (50-60 m). The results of this ongoing research will be reported elsewhere.

Large-Scale Marine Debris Removal from Reefs

From May to September, a total of 6,455 kg of marine debris were removed from the emergent reef, primarily by USFWS with the collaboration of NMFS. A cooperative multiagency coral reef cleanup effort in October 2000, supported by the NOAA ship *Townsend Cromwell* and the USCG cutter *Kukui*, removed this debris as well as 7,457 kg of other debris previously recovered by USFWS and NMFS personnel from reefs and beaches and debris stored on Sand Island, Midway Atoll.

Noteworthy Events

Beach Monitoring and Public Education

During 2000, Sand Island beaches and trails were monitored for potential monk seal disturbance and refuge violations. Most of the disturbance monitoring took place in public use areas, but information about potential disturbance was also collected during standard monk seal surveys of Sand Island's closed beaches. Incidental surveys usually took place 1-3 times each day, depending on the presence and location of a seal in public areas. In all, from March 1 through September 30, 413 incidental surveys and 69 standard monk seal censuses of Sand Island were conducted.

Other actions taken to help mitigate disturbance to seals at Midway in cooperation with USFWS included creating a "red seal" sign system to alert residents and guests of a seal's presence in public-use areas on Sand Island, setting up a "no stopping zone" along a stretch of shoreline where seals often haul up in vegetation within 3 m of a road and creating a data sheet for use by USFWS on the MPC's snorkel boat at the East emergent reef mooring site to help assess whether this activity impacts seals in that area.

RESULTS

Subpopulation Abundance and Composition

The mean ($\pm$SD) of 27 atoll censuses was 27.4 seals ($\pm$6.7) including pups and 21.9 seals ($\pm$6.5) excluding pups (Table 6.1). The total spring-summer subpopulation was 71 seals, 57 excluding pups (Table 6.2). This number is a subset of the total identified in the calendar year. The numbers of tagged known-age seals born at Midway

Islands during the period from 1988 to 1999 and resighted at any location in 2000 are summarized in Table 6.3.

Reproduction

A minimum of 14 pups were born at Midway Atoll in 2000, a record number for Midway, and all successfully weaned (Table 6.4a). The birth rate, measured as the number of pups born divided by the number of adult females in the subpopulation x 100 was 58.3% ((14/24) x 100). At least three pup exchanges occurred between nursing females. Nursing periods and measurements of weaned pups are summarized in Table 6.4b.

Interatoll Movement

Interatoll movement was documented for 40 seals that completed a total of 68 movements between Midway Atoll and either Pearl and Hermes Reef or Kure Atoll (Tables 6.5a and b).

Factors Affecting Survival

Attacks by large sharks, entanglement in marine debris, and emaciation led to nine life-threatening conditions, which resulted in the probable death of one prematurely weaned pup who disappeared after becoming emaciated (Table 6.6). Two seals were entangled; one seal was released, the other seal was observed with a fresh entanglement wound after apparently freeing itself.

ACKNOWLEDGMENTS

We acknowledge the support of the U.S. Fish and Wildlife Service, Oceanic Society, and Midway Phoenix Corporation. Special thanks are extended to Robert Shallenberger, Refuge Manager; Ron Anglin, Refuge Manager; Nancy Hoffman, Refuge Biologist; and Jennifer Schramm and Steve Dryden, Refuge Rangers. We also thank the officers and crew of the NOAA ship *Townsend Cromwell* for logistical assistance.

TABLES
for Midway Atoll

Table 6.1.--Summary statistics for atoll censuses (n = 27) of Hawaiian monk seals at Midway Atoll from January 5 to September 19, 2000.

Size/Sex	Mean number of individuals	Standard deviation
Adults	10.4	3.8
Male	2.9	1.6
Female	7.3	3.0
Unknown	0.3	0.5
Subadults	4.6	2.2
Male	1.4	1.0
Female	3.0	1.5
Unknown	0.1	0.4
Juveniles	7.0	2.4
Male	4.0	1.3
Female	2.9	1.6
Unknown	0.1	0.3
Pups	5.4	3.8
Male	2.0	1.7
Female	3.3	2.5
Unknown	0.2	0.6
Non-pup total	21.9	6.5
Grand total	27.4	6.7

Table 6.2.--Composition of the Hawaiian monk seal subpopulation at Midway Atoll during the spring and summer of 2000. All known parturient females and pups born during the calendar year are included.

	Number of seals			
Size	Male	Female	Total	Sex ratio male:female
Adults	10	24	34	0.4:1
Subadults	3	7	10	0.4:1
Juveniles	6	7	13	0.9:1
Pups	5	9	14	0.6:1
Non-pup total	19	38	57	0.5:1
Grand total	24	47	71	0.5:1

Table 6.3.--Summary of tagged known-age seals born at Midway Atoll and resighted at any location in 2000.

Cohort year	Age (years)	Sex	Number originally tagged	Number resighted in 2000
1988	12	Male	0	NA
		Female	1	1
1989	11	Male	0	NA
		Female	0	NA
1990	10	Male	0	NA
		Female	0	NA
1991	9	Male	1	1
		Female	1	1
1992	8	Male	0	NA
		Female	1	1
1993	7	Male	1	0
		Female	0	NA
1994	6	Male	0	NA
		Female	0	NA
1995	5	Male	1	0
		Female	6	1
		Unknown	1	0
1996	4	Male	1	0
		Female	4	1
1997	3	Male	3	2
		Female	6	5
1998	2	Male	8	3
		Female	2	2
1999	1	Male	7	4
		Female	4	4

Table 6.4a.--Summary of Hawaiian monk seals born at Midway Atoll in 2000.

Event	Number of pups		
	Male	Female	Total
Born	5	9	14
Died prior to weaning	0	0	0
Weaned	5	9	14
Tagged	5	9	14

Table 6.4b.--Summary of nursing periods and measurements of weaned pups at Midway Atoll in 2000. Nursing periods were calculated where birth and weaning dates were both known or occurred within a range of 4 days or less. All measurements were taken within 2 weeks after weaning.

	Nursing period (days)	Axillary girth (cm)	Straight dorsal length (cm)
Mean	37.3	107.2	125.3
Standard deviation	5.3	13.0	7.8
n	13	12	12

Table 6.5a.–Documented movement of Hawaiian monk seals to Midway Atoll from other locations in 2000, summarized by movements between two locations. Three seals made more than one observed trip.

Destination	Number of trips, size, and sex class
Laysan Island	1 adult female
Pearl and Hermes Reef	2 adult male 7 adult female 2 subadult female
Kure Atoll	9 adult male 7 adult female 1 subadult male 1 subadult female 1 juvenile male

Table 6.5b.–Documented movement of Hawaiian monk seals from Midway Atoll to other locations in 2000, summarized by movements between two locations. Two seals made more than one observed trip.

Destination	Number of trips, size, and sex class
Lisianski Island	1 adult female
Pearl and Hermes Reef	5 adult male 3 adult female 2 subadult female
Kure Atoll	10 adult male 10 adult female 4 subadult male 1 juvenile female 1 juvenile male

Table 6.6.--Factors affecting Hawaiian monk seal survival at Midway Atoll in 2000.

			Outcome		
Size	Sex	Total	Injured	Died	Probably died
Attack by Large Shark					
Adult	Female	5	5	0	0
Subadult	Male	1	1	0	0
Mounting by Males					
(none observed)					
Entanglement					
Juvenile	Male	1[a]	0	0	0
Weaned pup	Female	1[b]	1	0	0
Emaciation					
Weaned pup	Female	1[c]	0	0	1

[a] Seal was released by observers.
[b] Seal was sighted with a new entanglement wound around its neck after apparently freeing itself.
[c] Prematurely weaned pup disappeared after becoming emaciated.

CHAPTER 7. THE HAWAIIAN MONK SEAL AT KURE ATOLL, 2000

Irene T. Kinan and Lizabeth S. Kashinsky

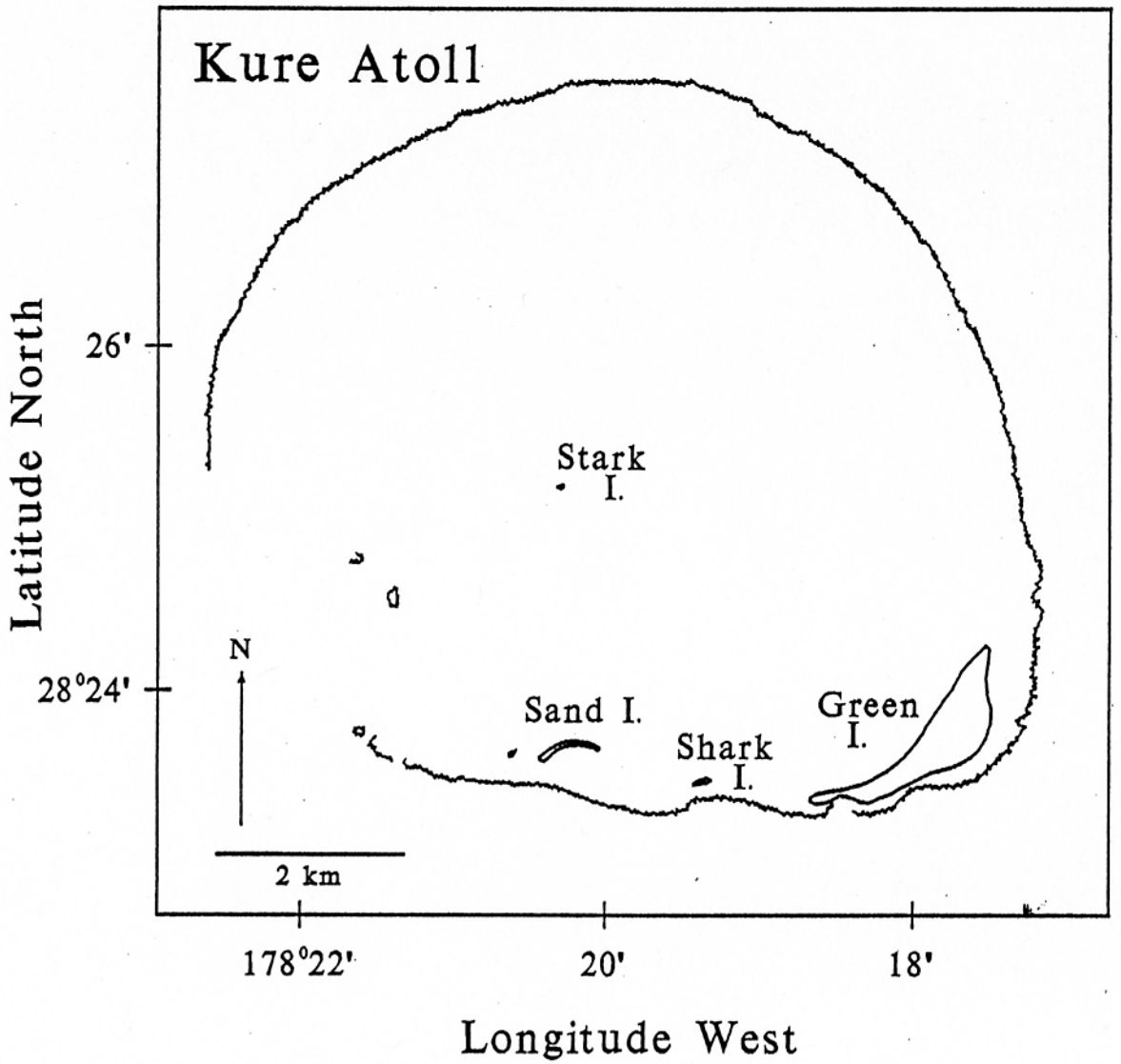

Fig. 7.1 Kure Atoll in the Northwestern Hawaiian Islands.

Kure Atoll (lat. 28°25'N, long. 178°10'W) is one of the primary haulout and pupping locations of the Hawaiian monk seal. The atoll is located ca. 2,300 km northwest of Oahu in the Northwestern Hawaiian Islands (Fig. 1.1) and is a seabird sanctuary of the State of Hawaii. The atoll consists of a circular fringing reef approximately 9 km in diameter, an enclosed lagoon, one permanent vegetated islet (Green Island), two sand islets (Sand and Shark Islets), and an ephemerally emergent area known as Stark Reef (Fig. 7.1). From 1960 to 1992, Green Island was the site of a U.S. Coast Guard (USCG) LORAN station, staffed by 20-30 USCG personnel. In July 1992, the station was closed and vacated by the USCG, leaving the atoll uninhabited. In 1993, the USCG completed removal of most infrastructure on Green Island.

The Kure Atoll subpopulation of Hawaiian monk seals has been increasing in recent years due, apparently in part, to a reduction of human disturbance and to two capture and release programs designed to increase recruitment of females. The Head Start Project (1981-91) involved the capture and protection of weaned female pups from Kure Atoll during the transition phase from weaning to independent feeding. The Rehabilitation Project (1984-91, 1993-95) involved the capture of undersized weaned female pups from French Frigate Shoals, their rehabilitation on Oahu, and subsequent transport of these seals to Kure Atoll for release.

RESEARCH

The National Marine Fisheries Service (NMFS) began research on the Hawaiian monk seal at Kure Atoll in 1981. In 2000, research was conducted by NMFS from May 15 to July 26. The perimeter of Green Island was divided into eight sectors, using artificial or natural landmarks. Research objectives specific to this subpopulation in 2000 included (1) evaluating the success of past management efforts, (2) large-scale debris removal from the fringing reef, and (3) assessing entanglement risks and other remaining negative impacts following the *Paradise Queen II* grounding at Kure Atoll which occurred on October 16, 1998.

Censuses and Patrols

Atoll censuses (n = 13) were conducted every fourth day, on average, from May 26 to July 22. Each census began between 12:50 and 13:10 and ended between 14:20 and 14:50 Hawaii standard time. All islands were censused on foot by one or two persons. Shark islet and Stark Reef were not emergent and thus not surveyed during the 2000 field season. Patrols were conducted on nonatoll census days to identify seals and monitor locations used by parturient females.

Individual Identification

A total of 139 individuals (123, excluding pups) were identified by existing or applied tags, bleach marks, scars, or natural markings. Most weaned pups (n = 13) were tagged with Temple Tags and passive integrated transponder (PIT) tags. Two weaned female pups (one large and the other prematurely weaned) were not captured for tagging.

Collection of Samples

Fifty-five scat and four spew samples were collected. Skin punches were collected from 13 weaned pups during tagging. Shed molt samples were collected from 20 seals. A necropsy was performed and tissue samples collected from a recently dead pup. In total, 456 pieces of potentially entangling debris were inventoried. Of this debris, one eel trap ring was removed and collected from a weaned pup's snout, and three large net aggregates (each > 200 kg) remain partially buried on Green Island in sector 4. The remainder of inventoried debris items were either destroyed before the end of the field season or left at a secure site to be removed later.

Special Studies

Large-Scale Marine Debris Removal from Reefs

A cooperative multiagency coral reef cleanup was conducted at Kure Atoll in October 2000 supported by the NOAA ship *Townsend Cromwell* and the USCG cutter *Kukui*. Personnel from 17 agencies removed debris to reduce these entanglement hazards to monk seals and other marine life and document the extent of reef debris fouling. Debris collected and stored on the beaches during the 2000 field season was also removed. In total, 3,069 kg of debris were recovered: 1,664 kg from the reef and 1,405 kg from the beaches.

Noteworthy Events

Impacts of *Paradise Queen II* Grounding

On October 16, 1998 the *Paradise Queen II*, a lobster fishing vessel, ran aground on the eastern edge of Kure Atoll. In 2000, a large portion of the hull remained in the water on the reef, but remnants of the wheel house and one other structural piece had washed ashore on the eastern side of Green Island. The large portion of main deck which originally migrated around the islet (in 1999) to sector 1 (west side) had come to rest in 2000 on the southwest point in sector 6. On occasion, monk seals utilized and hauled out on wreck debris. East beaches of Green Island, which were littered with nonbiodegradable insulating foam (from the interior of the hull) in 1999, were washed clean or debris was washed up into the vegetation by winter storms in 2000.

A cleanup effort was undertaken soon after *Paradise Queen II* ran aground to remove hazardous material and collect lobster traps and other debris from the marine environment. More lobster traps were removed in 1999, and over 200 remaining traps were stacked on Green Island to await removal. Less than 15 traps were found on shore during 2000. These were collected, and virtually all remaining traps (229) were removed from Green Island during the multiagency cleanup effort in October. Some of the lead (used to weigh traps) remains on the islet. It is unknown whether any lobster traps remain in the waters of Kure Atoll. A large line conglomerate (> 500 lbs) left onshore in 1999 was not present in 2000.

RESULTS

Subpopulation Abundance and Composition

The mean (±SD) of 13 atoll censuses was 59.3 seals (±10.0) including pups, and 51.6 seals (±9.3) excluding pups (Table 7.1). The total spring-summer subpopulation was 129 individuals, 113 excluding pups (Table 7.2). This number is a subset of the total identified in the calendar year. Of the 42 adult females identified at Kure Atoll in 2000, 25 (60%) were involved in past management efforts (13 from the Head Start program, 9 rehabilitated from FFS, 2 translocated from FFS, and 1 translocated from Oahu). These seals comprise roughly 20% of the total subpopulation. The numbers of tagged known-age seals born at Kure Atoll during the period from 1981 to 1999 and resighted at any location in 2000 are summarized in Table 7.3.

Reproduction

At least 16 pups were born at Kure Atoll in 2000: 14 weaned successfully, 1 weaned prematurely and subsequently disappeared, and 1 died prior to weaning (Table 7.4a). Nursing periods and measurements of weaned pups are summarized in Table 7.4b. The birth rate, measured as the number of pups born divided by the number of adult-sized females in the subpopulation x 100 was 38.1% ((16/42) x 100). Eight of nine identified parturient females were involved in past management efforts; four had been temporarily maintained as pups in the Kure Atoll Head Start enclosure (one each in 1985 and 1991, and two in 1988), and four were rehabilitated seals from FFS introduced to Kure as yearlings via the Head Start enclosure (two in 1984 and two in 1989).

Interatoll Movement

Interatoll movement was documented for 29 seals that completed a total of 50 movements between Kure Atoll and either Pearl and Hermes Reef or Midway Atoll (Table 7.5a and b).

Factors Affecting Survival

Attacks by large sharks, entanglement in eel trap debris, and other/unknown factors led to five life-threatening conditions, which resulted in the confirmed death of a newborn pup from unknown causes and the probable death of a prematurely weaned female pup (Table 7.6). One female pup (approximately 3 days old) died. A female pup weaned prematurely at approximately 2 weeks old. This pup disappeared 16 June 2000 and is presumed dead.

ACKNOWLEDGMENTS

We acknowledge the support of the State of Hawaii; Department of Land and Natural Resources, Division of Forestry and Wildlife; Ethan Shiinoki; and the captain, officers, and crew of the NOAA ship *Townsend Cromwell* for logistical support and transport to and from Kure Atoll.

TABLES
for Kure Atoll

Table 7.1.--Summary statistics for atoll censuses (n = 13) of Hawaiian monk seals at Kure Atoll from May 26 to July 22, 2000.

Size/Sex	Mean number of individuals	Standard deviation
Adults	31.1	6.9
Male	9.0	3.1
Female	17.2	3.5
Unknown	4.9	4.4
Subadults	11.3	4.0
Male	6.8	2.0
Female	3.0	1.6
Unknown	1.5	1.5
Juveniles	9.2	3.6
Male	5.8	2.2
Female	3.2	1.8
Unknown	0.2	0.6
Pups	7.7	1.8
Male	2.2	1.0
Female	4.6	1.5
Unknown	0.8	1.3
Non-pup total	51.6	9.3
Grand total	59.3	10.0

Table 7.2.--Composition of the Hawaiian monk seal subpopulation at Kure Atoll during the spring and summer of 2000. All known parturient females and pups born during the calendar year are included.

Size	Number of seals			Sex ratio male:female
	Male	Female	Total	
Adults	31	42[a]	73	0.7:1
Subadults	11	5	16	2.2:1
Juveniles	12	12	24	1.0:1
Pups	5	11[b]	16	0.5:1
Non-pup total	54	59	113	0.9:1
Grand total	59	70	129	0.8:1

[a] Number includes 25 individuals involved in management programs (Head Start, Rehabilitation, and Translocation).

[b] Number includes one perinatal pup death and one prematurely weaned pup.

Table 7.3.--Summary of tagged known-age seals born at Kure Atoll and resighted at any location in 2000.

Cohort year	Age (years)	Sex	Number originally tagged	Number resighted in 2000
1981	19	Male	3	2
		Female	5	1
1982	18	Male	1	0
		Female	3	2
1983	17	Male	4	3
		Female	0	NA
1984	16	Male	4	0
		Female	2	2
1985	15	Male	2	1
		Female	3	2
1986	14	Male	1	0
		Female	0	NA
1987	13	Male	1	1
		Female	3	3[a]
1988	12	Male	2	2
		Female	5	2
1989	11	Male	5	1
		Female	4	1
1990	10	Male	3	0
		Female	3	2
1991	9	Male	7	4
		Female	6	3[a]
1992	8	Male	5	3
		Female	8	5
1993	7	Male	9	6
		Female	4	2
1994	6	Male	3	0
		Female	0	NA
1995	5	Male	6	4
		Female	5	3
1996	4	Male	10	4
		Female	6	0
1997	3	Male	9	1
		Female	7	3
1998	2	Male	16	8
		Female	6	4
1999	1	Male	8	4
		Female	13	9

[a] Cohort survivors include seals removed from Kure Atoll for rehabilitation. These seals (n = 2) were released at Kure or Midway Atoll.

Table 7.4a.--Summary of Hawaiian monk seals born at Kure Atoll in 2000.

Event	Number of pups		
	Male	Female	Total
Born	5	11	16
Died prior to weaning	0	1	1
Weaned	5	10[a]	15
Tagged	5	8	13

[a] Number includes one pup that weaned prematurely (at approximately 2 weeks old), and subsequently disappeared and probably died.

Table 7.4b.--Summary of nursing periods and measurements of weaned pups at Kure Atoll in 2000. Nursing periods were calculated where birth and weaning dates were both known or occurred within a range of 4 days or less. All measurements were taken within 2 weeks after weaning.

	Nursing period (days)	Axillary girth (cm)	Straight dorsal length (cm)
Mean	33.5	108.5	133.6
Standard deviation	6.4	10.0	4.5
n	2	7	7

Table 7.5a.–Documented movement of Hawaiian monk seals to Kure Atoll from other locations in 2000, summarized by movements between two locations. Two seals made more than one observed trip.

Original location	Number of trips, size, and sex class
Midway Atoll	10 adult male 10 adult female 4 subadult male 1 juvenile male 1 juvenile female
Pearl and Hermes Reef	2 adult male 1 adult female

Table 7.5b.–Documented movement of Hawaiian monk seals from Kure Atoll to other locations in 2000, summarized by movements between two locations. Three seals made more than one observed trip.

Destination	Number of trips, size, and sex class
Midway Atoll	9 adult male 7 adult female 1 subadult male 1 subadult female 1 juvenile male
Pearl and Hermes Reef	1 adult male 1 adult female

Table 7.6.--Factors affecting Hawaiian monk seal survival at Kure Atoll in 2000.

Size	Sex	Total	Outcome		
			Injured	Died	Probably died
Attack by Large Shark					
Adult	Female	2	2	0	0
Mounting by Males					
(none observed)					
Entanglement					
Weaned pup	Female	1[a]	0	0	0
Other/Unknown					
Weaned pup	Female	1[b]	0	0	1
Nursing pup	Female	1[c]	0	1	0

[a] Seal was released by observers.
[b] Pup weaned prematurely, approximately 2 weeks old.
[c] Pup found dead, approximately 3 days old.

CHAPTER 8. THE HAWAIIAN MONK SEAL ON NIHOA AND NECKER ISLANDS, AND GARDNER PINNACLES, 2000

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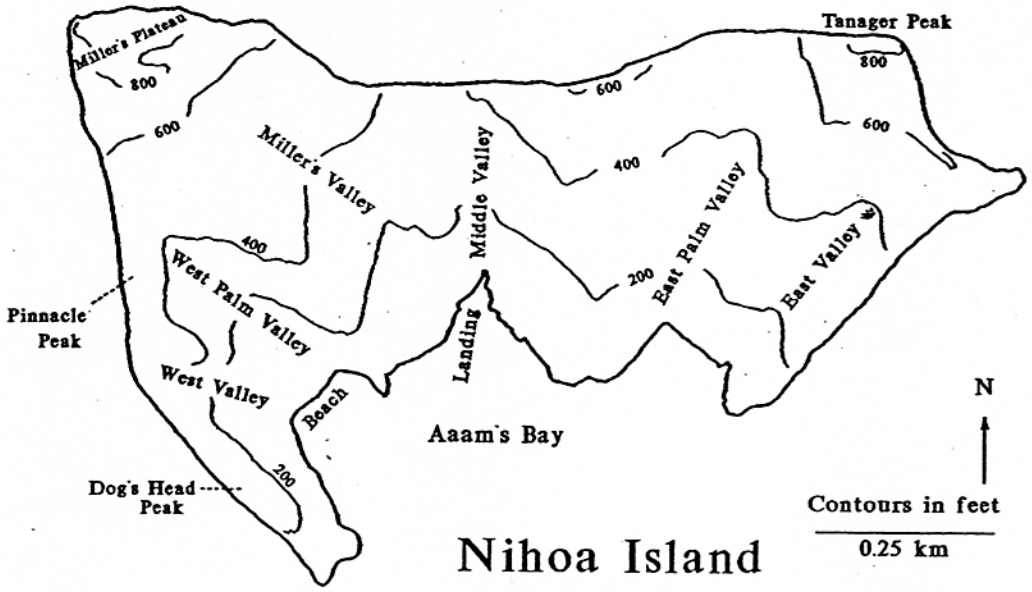

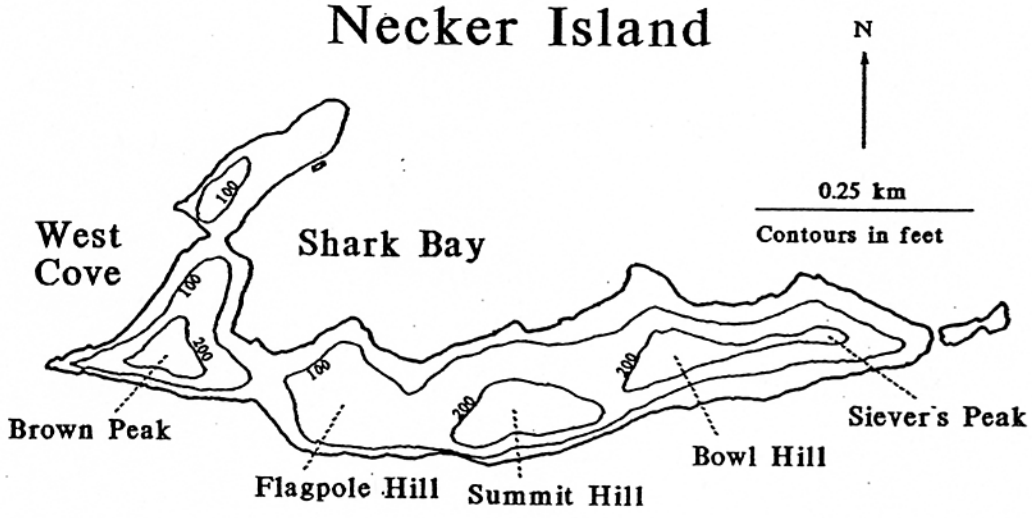

Fig. 8.1 Nihoa and Necker Islands in the Northwestern Hawaiian Islands.

Nihoa Island (lat. 23°04'N, long. 161°55'W), Necker Island (lat. 23°36'N, long. 164°42'W), and Gardner Pinnacles (lat. 25°00N, long. 167°55W) are located ca. 450, 750, and 850 km, respectively, northwest of Oahu in the Northwestern Hawaiian Islands (Fig. 1.1). These islands lie within the Hawaiian Islands National Wildlife Refuge.

RESEARCH

In 2000, the National Marine Fisheries Service collected data at Nihoa Island on July 20, at Necker Island on July 21, and at Gardner Pinnacles on July 31. The perimeters of Nihoa and Necker Islands were divided into 3 and 10 sectors, respectively, using natural landmarks (Fig. 8.1). Gardner Pinnacles was considered 1 sector. In 2000, research objectives specific to the Nihoa Island, Necker Island, and Gardner Pinnacles included assessment of pup production and the extent of migration between main subpopulations and these locations.

Censuses and Patrols

A mixed boat and land survey was conducted on Nihoa Island by two observers on July 20, beginning at 1236 Hawaii standard time and continuing for 1.5 h.

A beach count was conducted on Necker Island by two observers on July 21, beginning at 0854 Hawaii standard time and continuing for 4.0 h.

A boat survey was conducted at Gardner Pinnacles by two observers on July 31, beginning at 1331 Hawaii standard time and continuing for 2.0 h.

Individual Identification

Tagged seals were not observed on Nihoa Island. On Necker Island, one 6-yr-old female was identified by tags applied at French Frigate Shoals. A subadult male was also observed with yellow tags applied at French Frigate Shoals, but was not identified. At Gardner Pinnacles, two adult males were observed with yellow tags applied at French Frigate Shoals, but these seals were also not identified.

Collection of Samples

No samples were collected at Nihoa Island, Necker Island, or Gardner Pinnacles in 2000.

RESULTS

Subpopulation Abundance and Composition

The census total for one count conducted on Nihoa Island was 22 seals (20, excluding pups). The primary haulout beach at Nihoa Island was counted from a small boat as landing was precluded by heavy surf. As such, the total count for the island almost certainly underestimated the total number of seals present. The total for one count conducted on Necker Island was 18 seals (17, excluding pups). The total for one count conducted at Gardner Pinnacles was one adult seal. Additionally, two, seven, and two seals were sighted in the water at Nihoa, Necker, and Gardner Pinnacles but not included in the census total. Because of limited effort, the composition of the spring-summer subpopulation was not determined at any of these locations.

Reproduction

In 2000, at least two nursing pups were born at Nihoa Island (both of unknown sex) and at least one weaned male pup was seen at Necker Island. No pups were observed at Gardner Pinnacles.

Interatoll Movement

Interatoll movement was documented for two seals. An adult male moved from Nihoa Island to Oahu. This seal was translocated from Laysan Island to the Island of Hawaii in July 1994, resighted at Nihoa Island in July 1996, and resighted again on Oahu in January 2000. Additionally, an adult female moved from French Frigate Shoals to Necker Island. This seal was identified at Necker in 2000 and had been previously seen at French Frigate Shoals earlier in 2000. Prior to that, the seal had not been identified since 1994 when it was a weaned pup. Interatoll movement was not documented for seals observed at Gardner Pinnacles.

Factors Affecting Survival

Factors affecting survival were not observed on Nihoa, Necker, or Gardner Pinnacles in 2000.

ACKNOWLEDGMENTS

We acknowledge the support of the U.S. Fish and Wildlife Service, Hawaiian Islands National Wildlife Refuge staff, and the captain, officers, and crew of the NOAA ship *Townsend Cromwell* for logistical assistance.

REFERENCES

Aguirre, A. A. And J.S. Reif.
1998. Hawaiian monk seal epidemiology plan: health assessment and disease status studies. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFC-280.

Alcorn, D. J.
1984. The Hawaiian monk seal on Laysan Island: 1982. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFC-42, 37 p.

American Society of Mammalogists, Committee on Marine Mammals.
1967. Standard Measurements of Seals. J. Mammal. 48:459-462.

Boness, D. J.
1990. Fostering behavior in Hawaiian monk seals: is there a reproductive cost? Behav. Ecol. Sociobiol. 27:113-122.

Boness, D. J., M. P. Craig, L. Honigman, and S. Austin.
1998. Fostering behavior and the effect of female density in Hawaiian monk seals, *Monachus schauinslandi*. J. Mammal. 79(3):1060-1069.

DeMartini, E. E., F. A. Parrish, and J. D. Parrish.
1993. Temporal changes in reef prey populations at French Frigate Shoals, NWHI: Implications for juvenile monk seal (*Monachus schauinslandi*) predators. Honolulu Lab., Southwest Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96822-2396, Southwest Fish. Cent. Admin. Rep. H-93-06, 49 p.

Gilmartin, W. G. and G. A. Antonelis.
1998. Recommended recovery actions for the Hawaiian monk seal population at Midway Island. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFC-253, 14 p.

Gilmartin, W. G. and T. Gerrodette.
1986. Hawaiian monk seal status and recovery potential at Kure Atoll. Honolulu Lab., Southwest Fish. Cent., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96822-2396, Southwest Fish. Cent. Admin. Rep. H-86-16, 26 p.

Hiruki, L. M., Gilmartin, W. G., Becker, B. L., and Stirling, I.
1993. Wounding in Hawaiian monk seals (*Monachus schauinslandi*). Can. J. Zool. 71:458-468.

Johanos, T. C. and Kam, A. K. H.
1986. The Hawaiian monk seal on Lisianski Island: 1983. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFC-58, 37 p.

Johanos, T. C., A. K. H. Kam, and R. G. Forsyth.
1987. The Hawaiian monk seal on Laysan Island: 1984. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFC-70, 38 p.

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

Lombard, K. B., B. L. Becker, M. P. Craig, G. C. Spencer, and K. Hague-Bechard.
1994. The Hawaiian monk seal on Laysan Island, 1990. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFSC-206, 16 p.

Stone, H. S.
1984. Hawaiian monk seal population research, Lisianski Island, 1982. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFC-47, 33 p.

Winchell, J.

1990. Field manual for phocid necropsies (specifically *Monachus schauinslandi*). U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFSC-146, 55 p.

APPENDIXES

Appendix A.–Reports summarizing annual field research on the Hawaiian monk seal by the National Marine Fisheries Service and collaborating scientists.

All islands

Johanos, T. C., and J. D. Baker (Eds.).
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 (Eds.).
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 T. J. Ragen (Eds.).
1999. The Hawaiian monk seal in the Northwestern Hawaiian Islands, 1997. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-262, 131 p.

Johanos, T. C., and T. J. Ragen (Eds.).
1999. The Hawaiian monk seal in the Northwestern Hawaiian Islands, 1996. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-259, 134 p.

Johanos, T. C., and T. J. Ragen (Eds.).
1997. The Hawaiian monk seal in the Northwestern Hawaiian Islands, 1995. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-241, 121 p.

Johanos, T. C., and T. J. Ragen (Eds.).
1996. The Hawaiian monk seal in the Northwestern Hawaiian Islands, 1993. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-227, 141 p.

Johanos, T. C., and T. J. Ragen (Eds.).
1996. The Hawaiian monk seal in the Northwestern Hawaiian Islands, 1994. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-229, 111 p.

Johanos, T. C., L. M. Hiruki, and T. J. Ragen (Eds.).
1995. The Hawaiian monk seal in the Northwestern Hawaiian Islands, 1992. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-216, 128 p.

French Frigate Shoals

Craig, M. P., J. L. Megyesi, C. S. Hall, J. L. Glueck, L. P. Laniawe, E. A. Delaney, S. S. Keefer, M. A. McDermond, M. S. Schulz, G. L. Nakai, B. L. Becker, L. M. Hiruki, and R. J. Morrow.
1994. The Hawaiian monk seal at French Frigate Shoals, 1990-91. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-210, 70 p.

Appendix A.--Continued.

Craig, M. P., D. J. Alcorn, R. G. Forsyth, T. Gerrodette, M. A. Brown, B. K. Choy, L. Dean, L. M. Dennlinger, L. E. Gill, S. S. Keefer, M. M. Lee, J. S. Lennox, C. R. Lorence, G. L. Nakai, and K. R. Niethammer.
1992. The Hawaiian monk seal at French Frigate Shoals, 1988-89. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFSC-178, 83 p.

Eliason, J. J., J. R. Henderson, and M. A. Webber.
1993. Hawaiian monk seal observations at French Frigate Shoals, 1985. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFSC-187, 46 p.

Eliason, J. J., and J. R. Henderson.
1992. Hawaiian monk seal observations at French Frigate Shoals, 1984. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFSC-177, 61 p.

Fairaizl, G. W.
1984. Intra-atoll resighting of the Hawaiian monk seal, *Monachus schauinslandi*, at French Frigate Shoals, 1 January 1983-31 August 1983. Southwest Fish. Cent. Honolulu Lab., Natl. Mar. Fish Serv., NOAA, Honolulu, HI 96822-2396. Southwest Fish. Cent. Admin. Rep. H-84-5C, 27 p.

Johnson, P. A., and B. W. Johnson.
1984. Hawaiian monk seal observations on French Frigate Shoals, 1980. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFC-50, 47 p.

Laysan Island

Alcorn, D.
1984. The Hawaiian monk seal on Laysan Island: 1982. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFC-42, 37 p.

Alcorn, D. J., and E. K. Buelna.
1989. The Hawaiian monk seal on Laysan Island, 1983. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFC-124, 46 p.

Alcorn, D. J., and R. L. Westlake.
1993. The Hawaiian monk seal on Laysan Island, 1986. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFSC-191, 25 p.

Becker, B. L., P. A. Ching, L. M. Hiruki, and S. A. Zur.
1994. The Hawaiian monk seal on Laysan Island, 1987 and 1989. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFSC-213, 20 p.

Becker, B. L., R. J. Morrow, and J. K. Leialoha.
1989. Censuses and interatoll movements of the Hawaiian monk seal on Laysan

Appendix A.--Continued.

Island, 1985. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFC-135,25 p.

Becker, B. L., K. E. O'Brien, K. B. Lombard, and L. P. Laniawe.
1995. The Hawaiian monk seal on Laysan Island, 1991. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFSC-214, 16 p.

Johanos, T. C., and S. L. Austin.
1988. Hawaiian monk seal population structure, reproduction, and survival on Laysan Island, 1985. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFC-118, 38 p.

Johanos, T. C., B. L. Becker, M. A. Brown, B. K. Choy, L. M. Hiruki, R. E. Brainard, and R. L. Westlake
1990. The Hawaiian monk seal on Laysan Island, 1988. U.S.Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFSC-151, 24 p.

Johanos, T. C., A. K. H. Kam, and R. G. Forsyth.
1987. The Hawaiian monk seal on Laysan Island: 1984. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFC-70, 38 p.

Johnson, B. W., and P. A. Johnson.
1984. Observations of the Hawaiian monk seal on Laysan Island from 1977 through 1980. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFC-49, 65 p.

Lombard, K. B., B. L. Becker, M. P. Craig, G. C. Spencer, and K. Hague-Bechard.
1994. The Hawaiian monk seal on Laysan Island, 1990. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFSC-206, 16 p.

Lisianski Island

Alcorn, D. J., R. G. Forsyth, and R. L. Westlake.
1988. Hawaiian monk seal research on Lisianski Island, 1984 and 1985. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFC-120, 22 p.

Johanos, T. C., and J. R. Henderson.
1986. Hawaiian monk seal reproduction and injuries on Lisianski Island, l982. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFC-64, 7 p.

Johanos, T. C., and A. K. H. Kam.
1986. The Hawaiian monk seal on Lisianski Island: 1983. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFC-58, 37 p.

Appendix A.--Continued.

Johanos, T. C., and R. P. Withrow.
1988. Hawaiian monk seal and green turtle research on Lisianski Island, 1987. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFC-121, 18 p.

Lee, M. M., L. K. Timme, R. Van Toorenburg, and B. L. Becker.
1993. The Hawaiian monk seal on Lisianski Island, 1988 and 1990. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFSC-179, 33 p.

Stone, H. S.
1984. Hawaiian monk seal population research, Lisianski Island, 1982. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFSC-47, 33 p.

Westlake, R. L., and P. J. Siepmann.
1988. Hawaiian monk seal and green turtle research on Lisianski Island, 1986. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFC-119, 18 p.

Pearl and Hermes Reef

Choy, B. K., and L. M. Hiruki.
1992. The Hawaiian monk seal and green turtle on Pearl and Hermes Reef, 1988. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFSC-175, 18 p.

Finn, M. A., J. R. Henderson, B. L. Becker, and T. J. Ragen.
1993. The Hawaiian monk seal and green turtle at Pearl and Hermes Reef, 1990 and 1991. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFSC-182, 29 p.

Forsyth, R. G., D. J. Alcorn, T. Gerrodette, and W. G. Gilmartin.
1988. The Hawaiian monk seal and green turtle on Pearl and Hermes Reef, 1986. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFC-107, 24 p.

Kure Atoll

Bowlby, C. E., P. Scoggins, R. Watson, and M. Reddy.
1991. The Hawaiian monk seal, *Monachus schauinslandi*, at Kure Atoll, 1982-83. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFSC-155, 28 p.

Appendix A.--Continued.

Gilmartin, W. G., R. J. Morrow, and A. M. Houtman.
1986. Hawaiian monk seal observations and captive maintenance project at Kure Atoll, l981. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFC-59, 9 p.

Henderson, J. R., and M. R. Finnegan
1990. Population monitoring of the Hawaiian monk seal, *Monachus schauinslandi*, and captive maintenance project at Kure Atoll, 1988. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFSC-150, 24 p.

Reddy, M. L.
1989. Population monitoring of the Hawaiian monk seal, *Monachus schauinslandi*, and captive maintenance project for female pups at Kure Atoll, 1987. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFC-123, 37 p.

Reddy, M. L., and C. A. Griffith.
1988. Hawaiian monk seal population monitoring, pup captive maintenance program, and incidental observations of the green turtle at Kure Atoll, 1985. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFC-101, 35 p.

Van Toorenburg, R. A., W. G. Gilmartin, and J. R. Henderson.
1993. Composition of the Hawaiian monk seal population at Kure Atoll, 1990. Pac. Sci. 47(3):211-214.

Nihoa and Necker Islands

Conant, S.
1985. Observations of Hawaiian monk seals on Necker Island, Northwestern Hawaiian Islands. 'Elepaio. 6(2):11-12.

Finn, M. A. and M. A. Rice.
1994. Hawaiian monk seal observations at Necker Island, 1993. 'Elepaio. 55(9):55-58.

Morrow, R. J., and E. K. Buelna.
1985. The Hawaiian monk seal and green turtle on Necker Island, 1983. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFC-55, 11 p.

Appendix B.--Hawaiian monk seal census form and 2000 census form directions.

(See following pages.)

SEAL CENSUS FORM

ENTERED ☐

DATA TYPE _____ COMPUTER PAGE NO. ☐☐☐☐ PAGE _____ OF _____

ISLAND _____ OBSERVER ☐☐☐ TIME BEGIN ☐☐☐☐ END ☐☐☐☐

DATE _____ NUMBER _____ TEMP. ☐☐ WIND ☐☐☐ CLOUD ☐☐ Prec. ☐

Line No.	Continue	Time	Sector	Size	Sex	Beach Pos	Condition	ID			TAG				MOLT		Disturb	ASSOCIATION			Notes	Notes	EVENT	
								T/P	No.	?	No.	L/R	Col	?	%	?		Line No.	Dist	Behavior			Type	Codes
1																								
2																								
3																								
4																								
5																								
6																								
7																								
8																								
9																								
10																								
11																								
12																								
13																								
14																								

NOTES:

Line No.	Continue	Time	Sector	Size	Sex	Beach Pos	Condition	ID			TAG				MOLT		Disturb	ASSOCIATION			Notes	Notes	EVENT	
								T/P	No.	?	No.	L/R	Col	?	%	?		Line No.	Dist	Behavior			Type	Codes
15																								
16																								
17																								
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NOTES:

2000
CENSUS FORM DIRECTIONS
(Unabridged - Laysan and Lisianski Islands)

This form is used to record all Hawaiian monk seal and green turtle sightings. Turtle sightings are recorded only during census activities (not during patrols), unless noteworthy event occurs (turtle injured, tagged, tumored, mating, etc.). On the census form, all data that can be recorded for seals can also be recorded for turtles (although this data may not be required). **At French Frigate Shoals, do not record a data line for each turtle sighting; instead, write the total for each size/sex class at the bottom of the page.**

All original data should be coded in pencil. Never erase data once you have left the recording site. Instead, cross errors out with a single line. Field editing is editing before running the data entry and checking program. All field editing by the data collector should be in blue, and field editing by others should be in red. As soon as you begin the entry and checking program, the computer will assign the computer page number and display it on the screen. At this point, be sure to fill it in on your census form. All editing after this point should be in orange. After completing the entry and checking program, check off and initial the ENTERED box on the census form.

A separate data sheet should be filled out for each date, observer, data type, and island within an atoll. If no seals are present, you should still fill out the information at the top of the census form and write "No seals" in the data area (only enter the header information). If the island itself is not present, indicate this by using 99 for the sector code, leaving the rest of the (first) line blank. To save paper, you should use a census form with multiple headers if you only have a few seals to record (i.e., at some islands within an atoll, or when recording incidental sightings before or after census or patrol). In essence, on a census form with multiple headers, each header and its associated lines represents a separate data sheet.

If two people conduct the census, they should have the same weather and the same begin and end time (i.e., both begin at the same time and place, and proceed in opposite directions until they meet on the other side of the island or islet) and combine pages into one set. Patrols may be conducted by more than one observer, but page sets are not combined, and header information may differ between page sets. Patrol observers should attempt to start at roughly the same time. The sum of all observers' patrol activity for a day should result in one complete island count.

Always record disturbance. You must be honest about this! Fill out a census form to document disturbance if you disturb a seal when you are not otherwise collecting data. On a census or atoll count, it is also assumed that condition and molt data will be taken.

Do not make up additional codes. If the need for an additional code arises, contact Honolulu.

PAGE HEADER

DATA TYPE

C = Census: A complete, timed count on an island begun around 1300. Census is conducted as quickly as possible (while gathering all information). Data collected on all seals and turtles.

A = Atoll-wide census (must be completed within 2 consecutive days). Data collected on all seals and turtles.

B = Behavior patrol: A complete, untimed count where size, sex, ID and disturbance are recorded. Associations are assumed to be coded for all seals (In 2000, collect only at Laysan and Lisianski Islands, code behaviors for all Adult/S4 seals and their associated seals, otherwise code behavior X (data not taken). Record turtles only if noteworthy observation.

P = Patrol: A complete, untimed count where size, sex, ID and disturbance are recorded. Behavior data is not taken. Record turtles only if noteworthy observation.

I = Incidental observation. In this data type, null fields are interpreted as "data not recorded", so code data explicitly. If numbered, this indicates a full island incidental with year-specific goals. At Laysan and Lisianski Islands in 2000, these surveys will record mother-pup pairs, weaned pups, molters, survival factors, major behavioral events (i.e., severe harassments and mobbings) and other noteworthy observations.

T = Tag status entry for non-active tags (tags not currently on a seal). Record tag status (F or R) in notes columns.

COMPUTER PAGE NO. Leave this blank during data collection. It will be assigned and displayed on the screen when you enter the data. At that time, be sure to fill in the computer page number on your census form, as this number is needed for data retrieval.

PAGE Page number within a census or patrol. For example, if the census (or patrol) requires three pages, then mark the first page as "page 1 of 3" and so on. If more than 1 person conducts the census, then combine page numbers; person A has pages 1 and 2, while person B has pages 3 and 4 of a four-page census day. The maximum number of pages in a set is 9. Header information (time begin/end, date, number, and weather) should be the same for all pages within a set.

ISLAND Name of island and atoll, e.g., East, FFS.

OBSERVER Three initials. If no middle initial, use the first and last block.

TIME BEGIN and **END** On a 24-h clock, e.g., 6 p.m. = 1800, for the group of pages. Midway uses Midway time, all other sites use Hawaii Standard time.

DATE The date that data are collected (in YYMMDD format).

NUMBER Censuses, Atoll counts, Behavior patrols, and Patrols must be numbered. Each data type will have its own 3 digit number series, starting with 001. For data types other than **A**, have a separate number series for each islet within an atoll.

Weather information (except temperature) should be a summary of the entire day up until the end of the census or patrol, not merely an instantaneous observation. Temperatures taken in the morning are not representative for the period of data collection.

TEMP. Temperature in degrees Celsius at beginning of census or patrol.

WIND Speed: 0 = no wind, calm (< 5 knots)
1 = light breeze (5-15 knots)
2 = strong wind (>15 knots)

Direction: NN,NE,EE,SE,SS,SW,WW,NW
Thus, 2 N N = strong wind from north

CLOUD Cloud cover: 00 = no clouds
01-09 = 10 to 90% cover
10 = 100% cover

PREC. Precipitation: 0 = no precipitation or trace
1 = mist/drizzle
2 = rain
3 = intermittent rain

LINES_

CONTINUE If the same seal sighting is recorded on several lines for any reason (e.g., additional tag or association, behavior at a later time, change of beach position), put the original line number you are continuing from here. Lines may be continued only within the same page. Fill in the original line as completely as possible. All fields from TIME through MOLT will be copied from the original line if left blank on the continuation line. Several lines can have the same continuation line number.

Make a new original line (i.e. do not use continuation lines) for a seal each time that you come abreast of it on census or patrol.

TIME The time should be recorded for each seal sighting, on a 24-h clock

SECTOR Location on island (e.g., 1-20 on Laysan)
Special codes as follows:
00 = unknown sector
77 = pen
88 = offshore spit/emergent reef
99 = island not present

SIZE Size is estimated using a classification scheme from Stone (1984), using the following terminology. Note that seals are "sized" by length, girth, appearance, and reproductive status, not by age (except pups):

Pup — Seals born within the calendar year. Newborn pups are black, and weight ca. 11 to 15 kg. Pups molt to a silver-gray pelage near weaning. Weaning weight is ca. 50 to 80 kg.

Juvenile — Short, slight seals from the length of a weaned pup (about 138 cm) to 20-30 cm longer; includes yearlings, and other young seals up to 3 years. Distinguished from pups by thinness and yellowish color.

Subadults — Seals perceptibly longer than juveniles up to breeding size; less robust than adults, generally with lighter pelage. Immature seals ca. 3 to 5 or 6 years old.

Adult — Reproductively active or breeding size seals at least as long as known breeders. Mature or probably mature seals. Adult females often have extensive back scars or wounds; adult males usually dark, including ventrum, and extensively scarred.

Code size as follows:

Pups of the year
P0 = Fetus (aborted, clearly pre-term pup)

P = Nursing pup
- P1 = Nursing pup, wrinkles
- P2 = Nursing pup, no wrinkles
- P3 = Nursing pup, blimp, black
- P4 = Nursing pup, molting
- P5 = Nursing pup, molted

PW = Prematurely weaned/undersized weaned pup (weaned ≤ 2 wks ago and < 90cm girth). Code as PW at time of weaning, and then can code as W for remainder of season.

W = Weaned pup

Immatures

I = Immature
- J = Juvenile
  - J1 = Juvenile I
  - J2 = Juvenile II
- S = Subadult
  - S3 = Subadult III
  - S4 = Subadult IV

Adults

A = Adult

Unknowns

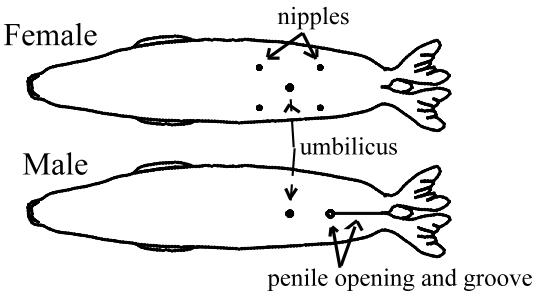
U = Seal of unknown size

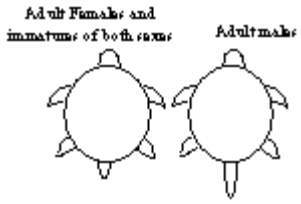
Turtles

T = Turtle (lengths from anterior to posterior tip of carapace)
- T1 = Turtle, juvenile (<65 cm straight carapace length)
- T2 = Turtle, subadult (65 - 80 cm)
- T3 = Turtle, adult (>80 cm)

Only code a seal's sex as known if the ventral is seen, even if you "know" the sex because of the tag, bleach, scars, or behavior. The only exception is that the mother in a mother/pup pair should be recorded as a female. The sex of a turtle can only be distinguished externally if it is adult-sized.

SEX M = Male
F = Female
U = Unknown





BEACH POS. Location of seal or turtle when observer comes abreast of animal (e.g., if seal is seen in the water from a distance and yet is on the beach when the observer come abreast, the seal is recorded as being on the beach). When recording interactions (at Laysan and Lisianski

Islands in 2000), record behaviors as you see them ahead of you (within 30 m). When you come abreast of the seal, record the beach position and time and make this your original line. All previously recorded lines for this sighting will be reverse continuation lines.

0 = animal floating or swimming in water (not included in census tally but may be used for behavioral data or other analysis).
1 = on the beach (or regularly surveyed areas on the fringing reef for **Midway Reef Surveys**)
9 = on an offshore rock/reef with no connections to the island. Separated from shore by a deep channel or substantial distance, and not regularly surveyed (not included in census tally). For **Midway Reef Surveys**, use beach position **9** for the back side of the reef and other areas that are not regularly surveyed.
X = data not taken

CONDITION Condition is recorded for all seals (except nursing pups) on census or atoll count. **Always record** the condition of the mom on her first sighting postpartum, and of the mom and pup on their first sighting post-weaning, regardless of data type. Always note condition when recording a survival factor.

Condition codes:
M = medium
P = probably pregnant
F = fat
T = thin, includes emaciated
X = data not taken
Codes F and T indicate extreme conditions, seals that are medium-fat, or medium-thin should be coded as medium. **Always code condition explicitly**.

A seal is either identified or not during a sighting. If both the ID No. and Tag No. fields are empty, the seal is unidentified. If either the ID No./Tag No. field is filled, the seal may be identified depending on how the ? columns are filled. Questionable codes blank, 0, or 4 indicate the seal is identified with certainty, whereas codes 1 or 5 indicate uncertainty. If a seal's identity is confirmed by any method, coding for the entire sighting (on the original line and all continuation lines) must ultimately show certainty. For example, if the ID columns indicate the seal is identified with certainty but the Tag columns indicate uncertainty, look up the correct tag number during data editing, enter it, and change the Tag? code from uncertain (1 or 5) to certain (4)).

ID DATA These fields can be used to record either a temporary or permanent ID number. Use continuation lines to record both a temporary and permanent number, or two or more temporary numbers. If the seal is identified, it will not be counted twice on census. To link two sightings of an unidentified seal during a survey (i.e. for a cruiser moving ahead of you), assign it a temporary number in a series reserved for unidentified seals, and code a 6 in the temp ? field.

T/P Indicate whether the number in the subsequent field is a temporary or permanent ID number.
T = temporary ID number (or bleach number)
P = permanent ID number

TEMPORARY ID NO. Record the temporary ID number (or bleach number) of seal if known; right justified. This field may be used for any temporary number. Use separate number series for bleach and various types of temporary numbers. If a number is incompletely read, use dashes as place-holders within the number to indicate missing digits (e.g., incompletely read bleach 152 may be coded -52, 1-2, or 15-).

? column:

- 0 = seal is definitely unmarked; can coexist with a temporary number, or with a bleach number if bleach hasn't taken yet or the number has molted off
- 1 = bleach is present but the number is questionable, **and the seal is not identifiable** from other information
- 4 = partially read bleach number completed from other data
- 5 = incompletely read bleach number but partial data are certain, **the seal is not identifiable** from other information
- 6 = temporary number valid for this survey only (for unident. cruisers moving ahead of you on census, etc.)
- blank = number is certain and complete if present

PERMANENT ID NO. Record the 4 digit permanent ID number of seal if known (put both the island-specific prefix and next digit in the first box provided).

? column:

- 1 = ID number is questionable, **and the seal is not identifiable** from other information
- blank= ID number is certain and complete if present. A Permanent ID is not visible, and is always completed from other data. For certain ID numbers, **always use ID? = blank, not ID? =4.**

TAG NO. The complete tag number if known; right justified. If a number is incompletely read, use dashes as place-holders within the number to indicate missing digits. Put the alpha prefix of the temple tag (combined with tag ? column code = 5) if you can determine the hole drilling pattern, but can't decipher the number (e.g. A--RT5 for a right tan tag with a 1983 drill pattern). Explain how you came up with the prefix, and draw the hole drill pattern in Notes.

Record all tag sightings explicitly (i.e., both left and right tag numbers) at least once during your stay. During the first weeks of the field camp, note tag condition each time that a tag is sighted. Once the majority of tags have been resighted, observers can carry a list of tags/individuals that haven't been seen, and only note tag condition if these tags/individuals are resighted. Also carry a list of broken or lost tags, and current tag conditions, so that you will be aware, and can record, if a specific tag breaks or is lost, or a tag condition changes during the field season. When a pup is tagged, record the animal handling event on the census data sheet, and record detailed information (such as all tag numbers, all temporary numbers, and the permanent number) on a Tagging/Handling card. If a seal is identified via a tag, it is not necessary to determine and enter its ID number on the census form. The ID number can be determined by computer later.

L/R: Tag position

L = tag on left flipper
R = tag on right flipper
B = tags on both flippers (enter one tag number). This code can be used if the seal has only 2 Temple tags (one on each flipper).

COL: Color code -see the Tag Sample Kit if unsure of the colors

Temple tags	Other tag types
Y = yellow (FFS)	M = metal, Monel
T = tan/brown (Laysan)	C = clear, PIT tag
G = green (Lisianski)	
B = blue (Pearl & Hermes)	
K = silver/gray (Kure)	
R = red (Midway, Necker, Nihoa, Main Islands)	

? column:

0 = seal is definitely not tagged on **either** flipper. To indicate that a seal has lost a tag, code a known missing tag using tag? code 8. If the tag number is unknowable, write the information in Notes.
1 = seal is tagged but the number is questionable, and **the seal is not identifiable** from other information
4 = partially read tag completed from other data
5 = incompletely read tag, but partial data are certain, **the seal is not identifiable** from other information
8 = a specific tag is lost/unreadable. Fill out tag position (L/R) and the tag condition event with codes L or U. Complete the tag number and color from other data before entry.
blank = tag information is certain if present. Partial data (either complete Tag #, position, or color not filled) are OK and will be completed by computer if the seal is identified by ID, Temporary #, or Tag #. The computer will only fill blank fields, so an incomplete Tag # must be completed by hand (use a "4" in the tag ? column).

MOLT Percentage of old pelage lost, optional for pups. However, for weaned pups, record the % molt at time of tagging. Record molt as 100% for at least 1 month post-molt.

blank = no molting evident

0-9 = 1 to 99% molted. 0 = molting, but less than 10%; 1 = 10-19%; 2 = 20-29%; ... 9 = 90-99%. The first signs of molt usually occur around the eyes, nose, flippers, and scars. **The first record of a ≥ 2 molt is considered the first day of true molt.**

10 = 100% molted, freshly molted, **required for the first month after molt**. Put both digits of the 10 in the single box provided.

? column:

0 = seal is definitely not molting

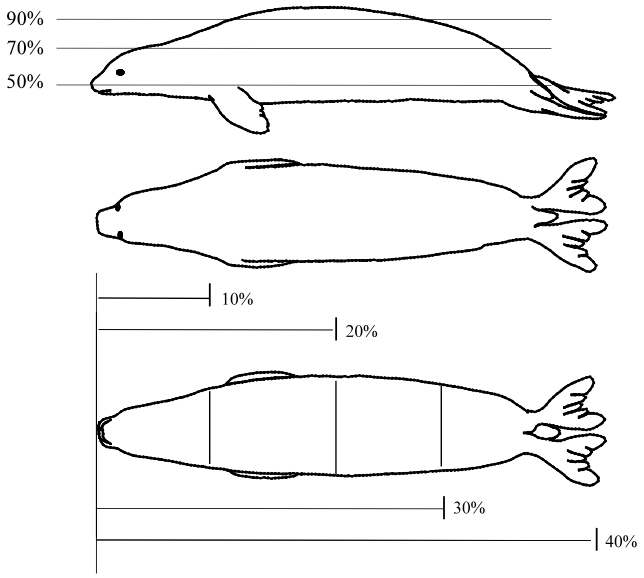
1 = seal is molting, but % molt estimate is questionable. May or may not include an estimate in the molt column

"End of season" editing codes that override molt estimates:

2 = seal in molt

3 = seal pre-molt

4 = seal post-molt



DISTURB The degree to which the seal may have been disturbed by observer. Record disturbance every time a seal is disturbed, regardless of your activity. The only exception is that you do not need to record a disturbance for a seal that you are handling (i.e., tagging, disentangling).

0 = no disturbance, or seal merely raised its head or looked at observer - If column **blank**, 0 is assumed

1 = seal vocalized, gestured, or moved ≤2 body lengths

2 = seal alerted to observer and moved >2 body lengths

3 = seal alerted to observer and fled into water

ASSOCIATION DATA

Behavior data is collected at Laysan and Lisianski Islands because adult male aggression has been more commonly observed at these locations, resulting in injury and death of adult female and immature seals. At Laysan, these data were used to identify 37 males for removal in a successful management action that reduced the adult sex ratio and increased female survival. Data are now used to monitor the long term effects of sex ratio adjustment at Laysan, and assess management options at Lisianski Island.

Record detailed association data at Laysan and Lisianski Islands in 2000. Don't record associations involving turtles. If you wish to indicate that a seal was alone, use the O (this code is alpha, not zero!) behavior code. If you are unable to record association data on a census or behavior patrol at Laysan or Lisianski Island for any reason, indicate this with an X for the behavior code. **Always explicitly record whether the seal is unassociated or association data is not recorded.** Use continuation lines to record more than one association.

An association should either be all blank or have the O, Z, or X behavior only (with no line number or distance), or have a line number, a distance, and some behavior code (other than O or X) all present. Don't code behaviors of an animal after it has been disturbed by the observer (but record the behaviors in Notes).

All associations should be recorded in pairs, i.e., between animals on two different lines. You should fill in the line numbers, distances, and behavior codes for both animals involved in the each association. The association line number should refer directly to the line where the corresponding behavior is coded (i.e. if the corresponding code is on a continuation line, refer to that particular line, not to the original line or a different continuation line).

Active associations

1) interactions are recorded for all seals except behaviors within mother-pup pairs. Only record
   mother-pup interactions during pup exchanges, weanings, or other noteworthy events.
2) must take place within 30 m of observer
3) subjects may be any distance apart

Spatial associations

1) noted as observer comes abreast of the subject
2) individual seals
   - mother-pup pair (N): any distance
   - all others (L): distances ≤10 m away, record two nearest neighbors, can be on opposite sides of a log, etc.

LINE NO. Identity of the other seal in the association. Put its line number here (note line number refers to within same census page only).

DIST. Closest distance during behavior - both associated lines must have the same minimum distance.

0 = body contact
1 = <2 m
2 = 2-5 m
3 = >5 m (>5 m but ≤10 m in the case of L behavior code)

BEHAVIOR Up to four behaviors may be recorded for each association, but L, N, X, and O should not appear together with other behaviors. Behaviors B and M require distance = 0. Behavior J requires distance of 0 or 1. **With the exception of Bites, Chases, Jousts, and Mounts, only record repetitive, sequential behaviors once** (for example, if an animal approaches

three times in a row, code one A). If vocalizations occur, only code V once (whether or not they are sequential). If there is a lot of activity, it is not critical to record all the behaviors. **Focus on the major points**, such as the seals involved, pairings before and after the interaction, the contest winner/loser, and the most intense behaviors (joust, bite, mount, chase, displace). If a behavior is observed that does not have a code, describe it in Notes.

1) individual seal

a) active behavior (directed towards another seal) recorded within 30m of observer

A = approach/investigate/sniff/nudge
B = bite (requires distance 0)
B1 = bite, nip
B2 = bite, draws blood/breaks skin
*C = chase
*C1 = chase, ≤2 body lengths
*C2 = chase, >2 body lengths
*D = seal displaces another (see CONTEST RULES)
F = flee/move away
F1 = flee/move away, ≤2 body lengths
F2 = flee/move away, >2 body lengths move away
*J = joust (requires distance of 0 or 1)
*J1 = joust ≤30 s
*J2 = joust >30 s spar/fight
M = mount/attempted (requires dist. 0) usually A/S4 male
M1 = mount/attempted mount ≤30 s
M2 = mount/attempted mount >30 s
*P = play (typically pup/immature behavior in the water)
R = submissive roll/present ventral
V = vocalize
Z = cruising. A/S4 male only behavior (actual sex may be unknown). Does not require a line number reference to another seal, but may have one)

b) spatial association

N = mother-pup pair (any distance), does not imply actual nursing behavior. This is the only association recorded between mother-pup pairs unless there is an unusual event (i.e., pup switch). If other behaviors are recorded, the N association must be on the original line for each pair member.
L = association by location only (distance ≤10 m apart, for all except mother-pup pairs)

c) additional codes (Laysan and Lisianski 1999)

*L1 = pair assoc. A/S4 male actively defends an adult female or immature of either sex (actual sex may be unknown), or establishes a pair relationship with a female or immature after displacing another male. Code the L1 relationship both before and after the contest if a displacement occurs.
*Q = loser (quitter)
*W = winner
*Y = tie

Note: codes Q, W, and Y are used for A/S4 male-male contests only, although the actual sexes may be unknown (in which case record as though they were known to be males); see the attached **CONTEST RULES**.

* requires a corresponding code on the line of the associated seal

Code	Corresponding code
C, C1, C2	F, F1, or F2
D	F, F1, or F2
J, J1, J2	J, J1, and J2 respectively
P	P
L1	L1
Q	W
W	Q
Y	Y

2) nothing nearby

O = no behavior or association

3) no data

X = no association data recorded on Census or Atoll Count

NOTES--There is room to code 2 different notes. Always use the first column first. Code an H if you have handwritten notes on the observation. Put handwritten notes on the bottom of the census form, labeled by line number. If more than two note codes apply, use continuation lines.

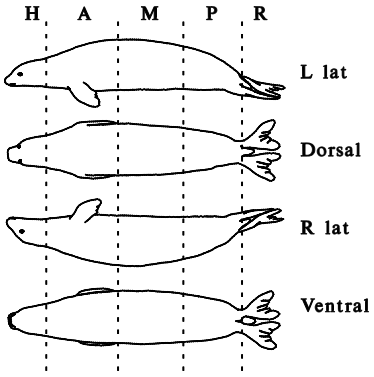
A = artwork (scars drawn) - attach drawing, labeled with date, island, observer, data type, page number, and line number
B = birth, 1st sighting postpartum (mom and pup)
G = seal is green with algae
H = handwritten notes
M = marked, indicate each time a seal is bleached (includes attempts to bleach)
W = weaning, 1st sighting post-weaning (pup)
X = pup exchange, 1st sighting after exchange (mom and pup)
Y = disturbance is to "bystander" seal during non-survey activity such as tagging, bleaching, instrumenting, etc. This includes all "hands on" research, even if the attempt was unsuccessful.

FOR DATA TYPE "T", STATUS OF NON-ACTIVE TAGS:
F = found
R = recovered from seal in hand

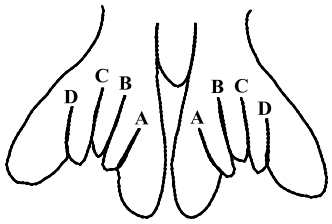
EVENT These columns are used to record a variety of data. The codes used will depend upon the type of event that you wish to record. Left justify your coding:

TYPE	CODES COLUMN	CONTENT
F = survival factor		ONLY RECORD RESIGHT OF A SURVIVAL FACTOR AS AN EVENT IF THERE ARE IMPORTANT CHANGES TO DOCUMENT, SUCH AS A NEW WOUND, HEALING, DEATH, ETC., TRANSCRIBE NOTES TO SURVIVAL FACTOR FORM. FOR TURTLES, USE A DIFFERENT SURVIVAL FACTOR NUMBER SERIES (I.E., BEGIN AT 500), FILL OUT A SURVIVAL FACTOR FORM, BUT DO NOT ENTER THE DATA INTO THE SEAL SURVIVAL FACTOR DATABASE.
	1-3	Survival Factor number
	4	Factor Type. If seal dead, always record factor type "D" on ORIGINAL LINE. For mobbings/ harassments, always code a census entry with factor type "M" for the victim at the beginning and end of the incident. Otherwise, you only need to record the most appropriate factor type if more than one applies. D = death W = wound E = entanglement V = very thin (emaciated) I = illness/abnormal (includes eye disease) M = mobbing/harassment/post-mobbing aggregation O = other
	5	Participant type (for mobbings/ harassments/post-mobbing aggreg. only) V = victim/subject M = male aggressor
H = handling of wild seal		FOR SEAL CAPTURES OR RELEASES, RECORD DETAILS ON EITHER THE CAPTURE OR RELEASE FORM. OTHERWISE, RECORD DETAILS ON THE TAGGING/HANDLING CARD. HANDLING DOES NOT NECESSARILY INVOLVE RESTRAINT OF SEAL.
	1	Handling type T = tagging (w/ restraint) M = measuring (includes weighing) A = all (both tagging and measuring) R = remote tagging D = disentangle (even if not restrained) I = instrument B = bleeding C = take into captivity F = free from captivity O = other (includes instrument removal and the translocation of seals within an atoll)

TYPE	CODES COLUMN	CONTENT
P = photo		SEAL OR TURTLE PHOTOS ARE THE ONLY PHOTOS CODED ON THE CENSUS FORM. OTHER PHOTOS SHOULD BE RECORDED IN NOTES, AND TRANSFERRED TO THE PHOTO COMMENT FORM.
	1	Type of photo S = slide P = print
	2-3	Roll number (pad with zeros)
	4-5	Frame number (pad with zeros)
	6	Side L = left lateral or flipper R = right lateral or flipper D = dorsal side V = ventral side B = both (used for rear flippers only) X = other, describe in hand-written NOTES
	7	Part H = head A = anterior body (neck and shoulders) M = midbody (behind fore-flippers and before posterior) P = posterior body (behind midbody and before rear flippers) F = foreflipper; write whether dorsal/ventral in comments R = rearflipper; write whether dorsal/ventral in comments O = overall view of a particular side X = other, describe in comments
	8	Purpose I = identification F = survival factor (link with survival factor EVENT using continuation lines) X = other, describe in comments



TYPE	CODES COLUMN	CONTENT
T = tag condition		RECORD TAG CONDITION FOR BOTH SIDES OF EACH TAG AT LEAST ONCE DURING THE SEASON. IF TAG CONDITION IS RECORDED FOR AN INCOMPLETELY READ TAG, COMPLETE THE TAG NUMBER (WITH APPROPRIATE TAG? CODE) PRIOR TO COMPUTER ENTRY.
	1	Web



A-D = from inner (medial) to outer web.
E = ankle
P = posterior
U = unknown

2 Side of tag, the dorsal tag side is on the dorsal flipper surface unless the tag is reversed. For Temple Tags, the dorsal side is the bigger side; for Metal (Monel) tags, the dorsal side is the "male" side. For PIT tags, code the side as B (both).

D = dorsal
V = ventral
B = both
U = unknown

3 Condition, code U (unreadable) if cannot use tag to ID seal (i.e. if broken so number gone). Also code U for a PIT tag if you completely scan for it with a reliable reader but get no reading. If reader is unreliable, put attempt in Notes and only code PIT tag as unreadable after 3 separate attempts. Combine the L or U codes with the tag questionable code of 8. You can combine the tag questionable code of 8 with other condition codes to describe why the tag is unreadable (i.e., worn or broken). Unreadable tags can still be used as partial information to help determine a seal's identity. Code more than one condition using continuation lines.

B = broken
F = faded color
G = good
L = tag lost
N = no/partial resin
O = other
P = pulling out
U = unreadable
V = tag side reversed
W = no. worn /abraded

CONTEST RULES

1. **Male-male contest definition** (must conform to at least one condition below):
   a. Distance between adult males = 0
   b. Either adult male vocalizes (**V**) or performs a **C**, **D**, or **J**
   c. If cruiser approaches to beach position ≥1, regardless of other behaviors

2. **The contest outcome depends upon pair type** (what size/sex seal the adult male is paired with)
   a. For contest rules, size S4 seals are considered to be adults (both sexes), seals size S3 or smaller are considered to be immature
   b. Definition of pair type:
      i. Pair type **#1**: adult male with adult female (**L1**)
      ii. Pair type **#2**: adult male with immature seal of either sex (**L1**)
      iii. Pair type **#3**: *single* adult male not pair type **#1** or **#2**

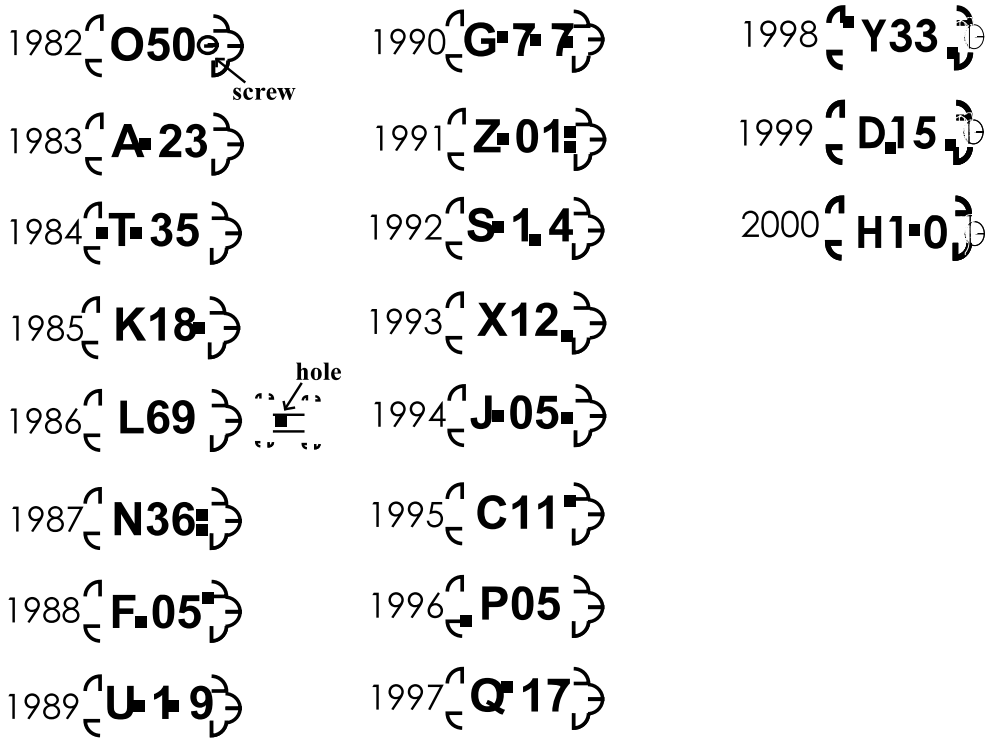
3. **Contest outcomes** (definition of winner or loser adult male):

Case	Winner (**W**)	Loser (**Q**)	Tie (**Y**)
Paired Male *vs*. Single Male: (**#1** or **#2** *vs*. **#3**)	i) Original Single Male if has **D** ii) Original Paired Male otherwise	Has **F**	No Ties No Ties
Male Paired with Adult Female *vs*. Male Paired with Immature Seal: (**#1** *vs*. **#2**)	i) Original Male Paired with Immature Seal if has **D** ii) Original Male Paired with Adult Female otherwise	Has **F**	No Ties No Ties
Paired Male *vs*. Paired Male where both pairs are same type: (**#1** *vs*. **#1** or **#2** *vs*. **#2**)	Has **D**	Has **F**	Tie if no **D**
Single Male *vs*. Single Male: (**#3** *vs*. **#3**)	Has **D** or **C**	Has **F**	Tie if no **D** or **C**

4. **Generalizations:**
   a. **Unequal pair types**
      i. There are no ties
      ii. The male with the **higher pair type (1>2>3) always wins unless he is displaced**
      iii. A seal can win without being aware of the contest. For example, if the "winner" is not aware that the other seal flees, but that seal fled in response to a vocalization, then code the fleeing seal as the loser (Q) and the other seal as the winner (W))

   b. **Equal pair types**
      i. **Males tie unless there is a clear winner/loser**
      ii. To win, a male must chase/displace the other male

HAWAIIAN MONK SEAL TEMPLE TAGS:
NUMBERING SCHEME AND HOLE DRILLING PATTERN FOR TAGS APPLIED TO WEANED PUPS



Be sure to code the original tag color, not the color that a tag has faded to. See the Tag Sample Kit.

Original tag color:	**Faded tag may appear:**
Temple Tags:	
Yellow	White, Lt. Yellow
Light Tan (A,T,K,L series @ Laysan)	Gray, Lt. Yellow, White
Dark Tan/Brown (later series @ Laysan)	Red
Dark Forest Green	Dark Blue, Navy
Kelly Green (C, P, and Y cohorts)	--
Blue (light)	--
Red	Orange
Gray (A,T,K,L,N,F,U,G series @ Kure)	Light Tan
Silver Gray (600-900,0,Z and later @ Kure)	Metal