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THE HAWAIIAN MONK SEAL IN THE NORTHWESTERN HAWAIIAN ISLANDS, 1999

Thea C. Johanos and Jason D. Baker

NOAA-TM-NMFS-SWFSC-310

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

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NOAA Technical Memorandum NMFS

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EXECUTIVE SUMMARY

In 1999, 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. Pooled site-specific data, however, provide useful indices of the status and trends of the species as a whole, including the total number of pups at the 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. 1 a), the largest subpopulation. In 1999, 231 pups were counted at these sites, 92 of which were born at French Frigate Shoals. Record numbers of pups were born at Laysan Island, Lisianski Island, and Midway Atoll. Mean beach counts, excluding pups, from the main reproductive sites (again, excluding Midway Atoll) totaled 375 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 (Fig. 1c) and, in 1999, the composition of the counts remained predominately adults and pups. This composition bodes poorly for reproduction in the near future if older adult females are not replaced by young females reaching reproductive age. High mortality of immature seals appears to have led to the shift in composition, particularly at French Frigate Shoals.

In 1999, three 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 18 entangled seals were disentangled by field biologists. Second, debris was removed from coral reefs at Lisianski Island, Pearl and Hermes Atoll, and Midway Atoll to reduce hazards to the seals and assess the extent of reef debris fouling. Third, a beach monitoring and public education program was conducted at Midway Atoll to quantify and mitigate human impacts on seals.

In this document these and other field studies conducted during 1999 are described. The format followed is intended to provide 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 stop the decline of this species and enhance its recovery.

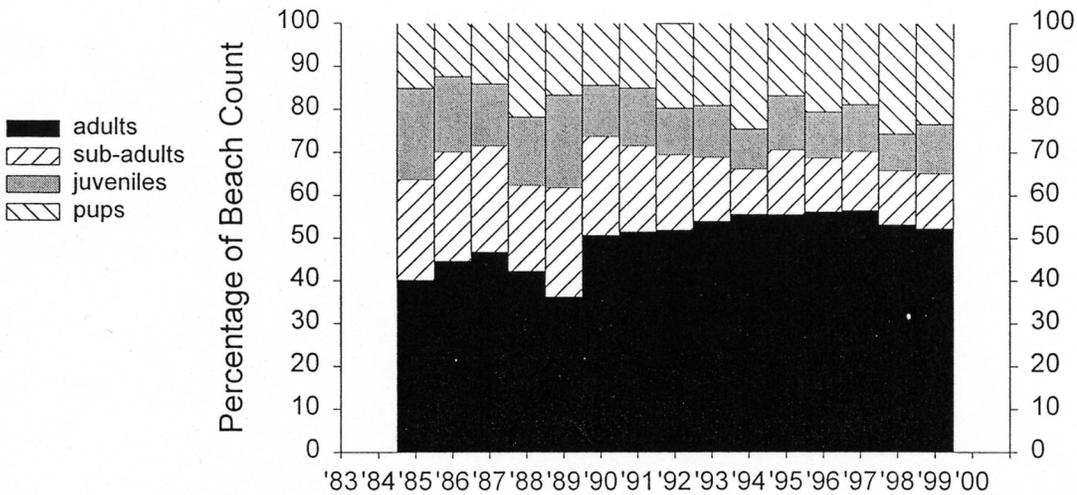
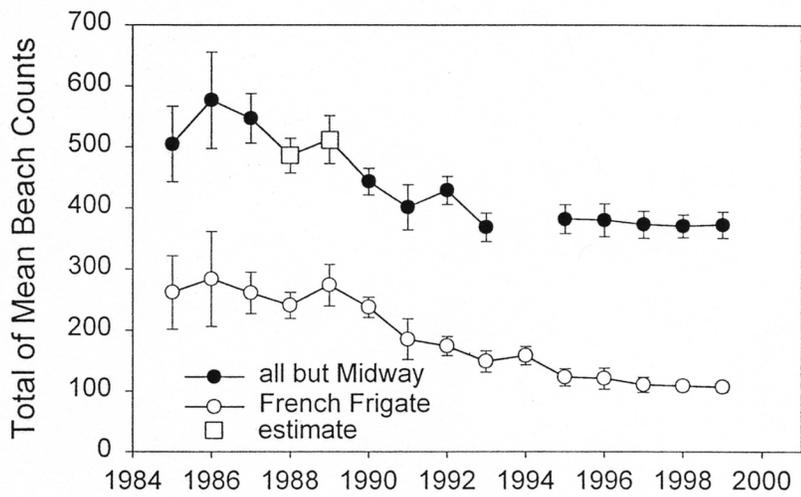
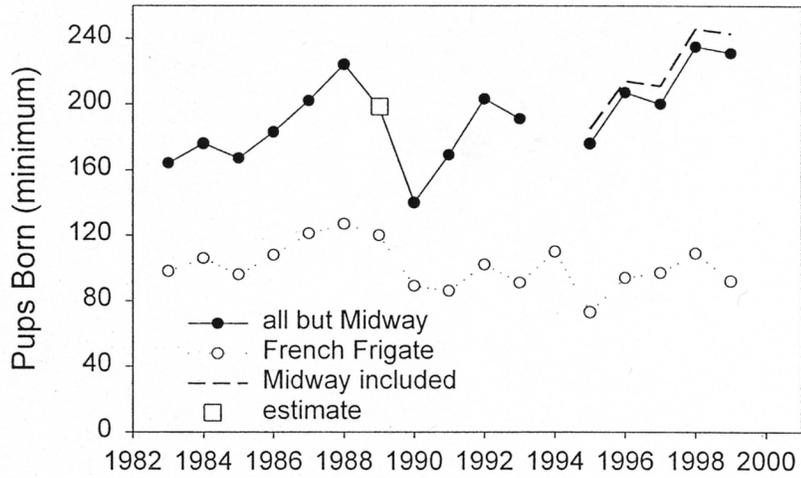


Fig. 1 Demographic trends of the Hawaiian monk seal, based on the main reproductive sites (excluding Midway Atoll). A) Number of pups born (minimum). B) Total of mean beach counts, excluding pups, with 1 standard deviation. C) Percentage of counts comprised of adults, subadults, juveniles, and pups.

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CHAPTER 1. GENERAL INTRODUCTION

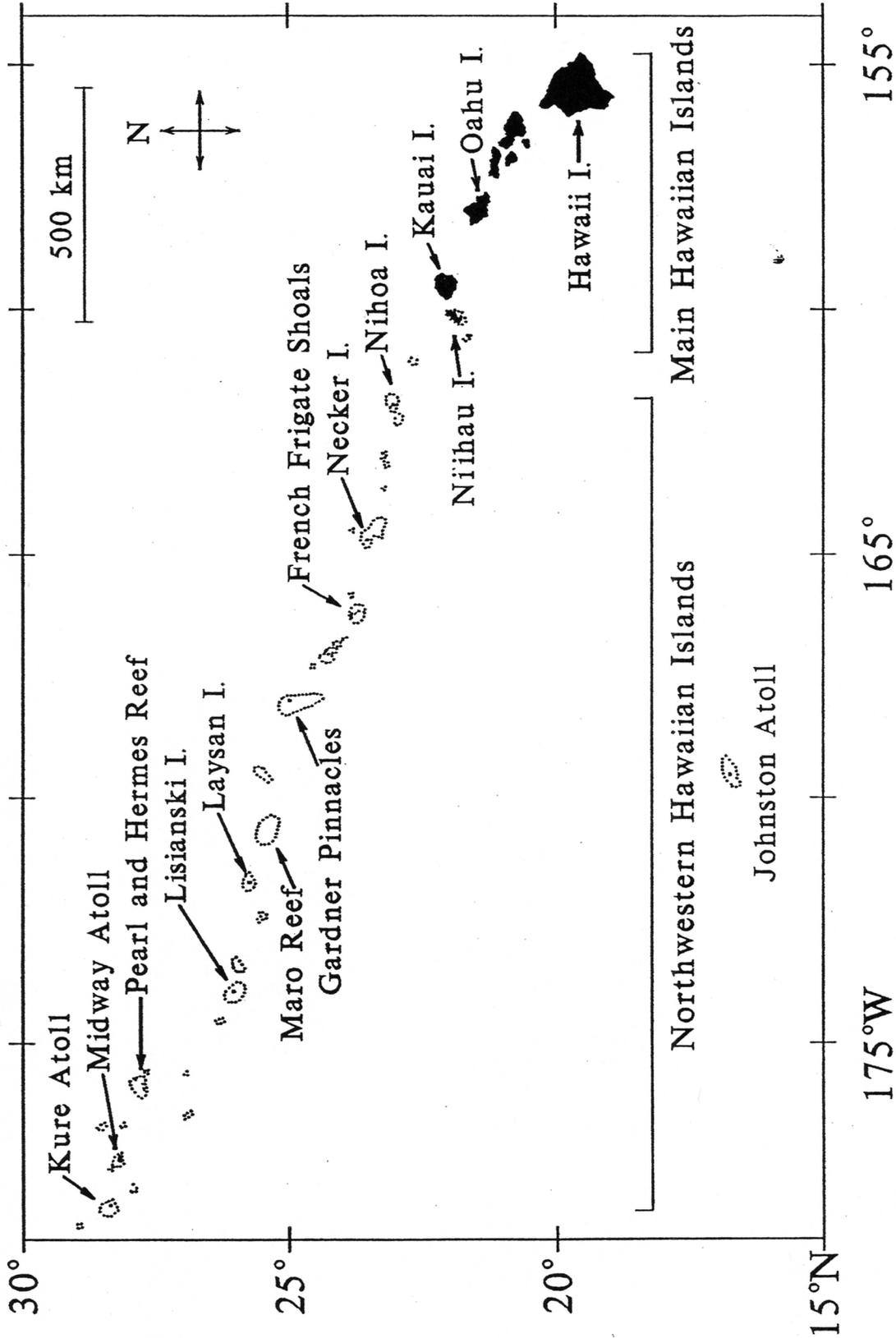


Fig. 1.1 The Hawaiian Archipelago.

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 responsible 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 Atoll), and 1983 (Midway Atoll). Nearly every year thereafter, field camps were established for periods of several days to 9 months to monitor and enhance the recovery of this species. Limited population monitoring has also been conducted at Nihoa and Necker Islands, where subpopulations appear to be limited to a small number of animals by availability of haulout area. Reports summarizing past NMFS research are listed in Appendix A.

In 1999, 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 placental samples for histological and bacteriological examination and hormonal studies, (9) disentangling seals, and (10) inventorying and removing debris capable of entangling seals. Location-specific objectives and summaries of data collected during the 1999 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 HWN-01-99 and HWN-04-99, 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. Although data were collected on all seals, those that were in the water, captive, 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 population size but provided an index of population 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 an animal had molted); 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 Nihoa Island, twice at Necker Island, and every 4 to 8 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 Atoll, Midway Atoll, and Kure Atoll) were completed within a 2-day period. 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. 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 which 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 was recorded. Because parturient females will 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 become separated, and one or both seals then actively seek and obtain another nursing relationship (Boness, 1990).

The average nursing period was calculated for some or all pups at each location. Nursing periods could not be determined for pups weaned or born prior to or after the conclusion of full research effort. The average lactation period of parturient females was also calculated for seals at FFS because higher population 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, then 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 used if the 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 <5 cm in diameter, or one abscess with a diameter ≥ 5 cm; (2) an amputation of a minimum of half a flipper (either foreflipper or hindflipper); (3) a minimum of three punctures or gaping wounds, if largest dimension was <5 cm, or one gaping wound with a maximum diameter-largest dimension ≥ 5 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 impaired seal movement). Major healed injuries that had been 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 for the field season, or (2) the seal was in deteriorating condition (loss of weight, enlargement of abscesses, sloughing of skin) and disappeared a minimum

of 10 surveys or 1 month before the end of data collection for the field season (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 a minimum of one puncture or gaping wound (missing skin or extending into the blubber layer) or ≥ 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 number (Gilmartin et al., 1986). In addition, two passive integrated transponder (PIT) tags were implanted subcutaneously in the posterior 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, since 1982 at Lisianski Island, since 1983 at Laysan Island and Pearl and Hermes Atoll, since 1984 at French Frigate Shoals, and since 1995 at Midway Atoll. Pups at Midway Atoll, Necker and Nihoa Islands, and the main Hawaiian Islands have been tagged opportunistically since 1983. Since 1991, PIT tags have also been implanted subcutaneously in the ankle (1991) or the posterior dorsum (all subsequent years) of most weaned pups.

In 1999, 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.

At five locations (Laysan Island, Lisianski Island, Pearl and Hermes Atoll, Midway Atoll, and Kure Atoll), seals were bleach-marked for individual identification

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

(Stone, 1984), using the solution described in Johanos et al. (1987). Molting seals were re-marked with bleach to maintain their identities over the study interval. At Laysan and Lisianski Islands, nursing pups were also bleach-marked prior to the post-natal molt to facilitate identification during the nursing period.

Tags, scars, other natural markings, and any applied bleach marks were sketched by hand on an individual scar card for each seal, which 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, depending on site.

Subpopulation size and composition were determined at locations where observers no longer encountered unidentified seals, and we assumed all seals were identified. These statistics included all individuals observed alive at the location during the interval 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 Atoll). Therefore, standardized rules for assigning each seal identified to just one subpopulation are applied as follows. If a seal was observed at more than one location during March-August, it was included exclusively in the subpopulation where it was sighted nearest to May 15, unless it pupped or molted at another location. A parturient female was always exclusively included in the subpopulation where she pupped, and a non-parturient seal was exclusively included in the subpopulation where it molted. Pups were always exclusively included in the subpopulation where they were born.

Measurements of Seals

Pups were measured to provide information on condition and to examine the relationship between body size and survival. Measurements were taken as soon after weaning as possible, and measurements taken within 2 weeks after weaning were included in the summaries. Measurements included straight dorsal length (Winchell, 1990) and axillary girth (American Society of Mammalogists, 1967).

Samples Collection

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 recently dead seals. Samples of placentas were also collected from recent birth sites.

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. Detailed descriptions of necropsy procedures and sample collection methods are in Winchell (1990).

Scat and spew samples were collected opportunistically for analysis of food habits (Alcorn, 1984). These samples were collected from seals of known size and sex class, 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 via incineration, following the methods in Johanos and Kam (1986). At all other locations, debris was cut into manageable pieces and placed in storage bins or secured piles in centralized locations for subsequent removal via ship.

**CHAPTER 2. THE HAWAIIAN MONK SEAL ON
FRENCH FRIGATE SHOALS, 1999**

Mitchell Craig, Melissa Shaw, and Jane MacKenzie

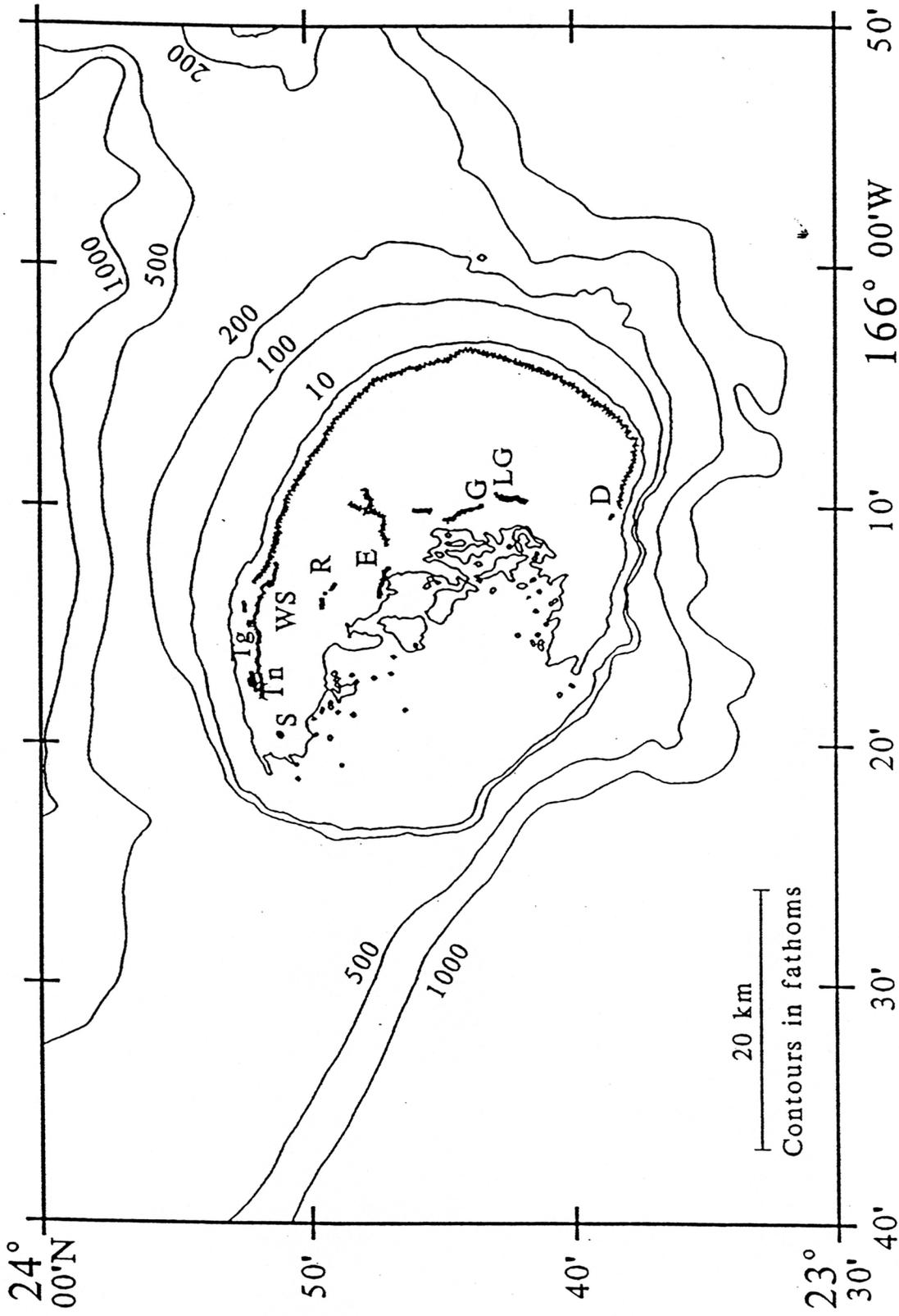


Fig. 2.1. French Frigate Shoals in the Northwestern Hawaiian Islands. Islands are: Disappearing (D), East (E), Gin (G), Little Gin (LG), Round (R), Shark (S), Tern (Tr), Trig (Tr), and Whaleskate (WS).

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 1999, research was conducted by NMFS during January 12-February 4 and May 19-December 31. Incidental observations were recorded by U.S. Fish and Wildlife Service (FWS) personnel during the rest of the year. The perimeters of the six larger islets were divided into sectors using artificial or natural landmarks. Research activities specific to this subpopulation in 1999 included (1) ongoing health, disease, and foraging ecology studies (2) investigation of health, condition, causes of mortality, and habitat use of weaned pups, (3) investigation of adult male seal habitat use patterns using seal-mounted video cameras, (4) assessment of nearshore reef fish abundance, and (5) collection of reef vertebrates and invertebrates for a Hawaiian monk seal prey fatty acid analysis.

Censuses and Patrols

Atoll censuses ($n = 10$) were conducted every 8 d, on average, from May 25 to August 16. Each atoll census began between 1050 and 1220 and ended between 1540 and 1810 Hawaii standard time. Round and Mullet were censused from a boat or on foot, while the remaining islets were censused on foot by one or two persons. Patrols were conducted on noncensus days. Frequency of surveys was higher at islets where more pups were born. Thus Trig, East, Round, and Whaleskate islets were surveyed every 2-4 d and Little Gin and Gin islets were visited every 7-10 d to monitor pupping activity and factors affecting survival. Patrols of Tern Island were conducted every 2-4 d.

Individual Identification

A total of 428 individuals (336 excluding pups) were identified by existing or applied tags, scars, or natural markings. Fifty-six weaned pups were tagged with Temple Tags; 55 of these pups were tagged with passive integrated transponder (PIT) tags. Nine adult seals (seven male, two female) were tagged, and two juveniles (one male, one female), seven subadults (four male, three female), and 10 adult seals (six male, four female) were retagged with Temple Tags.

Samples Collection

Seventy-five scat and spew samples were collected. Skin punches were collected from 71 seals during tagging. Necropsies were performed on three dead seals found at the study site. Tissue and skeletal samples were collected from all necropsied seals. In total, 15 items of potentially entangling debris were inventoried and stored for removal via ship.

Special Studies

Health, Disease and Foraging Ecology Studies

In January and February, biologists collected blood, fecal samples, and blubber biopsies from 47 seals (22 adult and 25 immature seals) restrained specifically for ongoing epidemiological and fatty acid diet studies. Blood, fecal samples, and blubber biopsies were also collected from four seals instrumented with video cameras for a habitat use study and from 27 weaned pups during a study of first year survival. The purpose of this sampling was to obtain baseline information to assess the health, disease status, and foraging ecology of the Hawaiian monk seal population (Aguirre and Reif, 1998).

Weaned Pup Study

From June through September, 53 and 9 weaned pups were instrumented with VHF radio transmitters and time-depth recorders, respectively, as part of a health, condition, habitat use, and mortality study. Mass of 50 weaned pups was measured.

Adult Male Habitat Use Study

In July and August, four molted adult males were instrumented with CRITTERCAMs for 8 to 72 d. The seals were instrumented as part of a habitat use pilot study conducted in collaboration with National Geographic Television.

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, 1995-98 (see DeMartini et al., 1993). In 1998 and 1999 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 and September, the IRI also collected reef vertebrates and invertebrates for analysis of fatty acid in potential monk seal prey.

RESULTS

Subpopulation Abundance and Composition

The mean (\pm SD) of 10 atoll censuses was 145.4 seals (\pm 10.4) including pups, and 106.2 seals (\pm 10.1) excluding pups (Table 2.1). The total spring-summer subpopulation was 405 individuals, 313 excluding pups (Table 2.2). This number is a subset of the total identified in the calendar year. The numbers of tagged known-age seals born at FFS during the period from 1984 to 1998 and resighted at any location in 1999 are summarized in Table 2.3.

Reproduction

A minimum of 92 pups were born at FFS in 1999: 69 were successfully weaned and 23 died or disappeared prior to weaning (Table 2.4a). One fetus was found in December 1999. Nursing periods and measurements of weaned pups are summarized in Table 2.4b. The birth rate, measured as the number of pups born divided by the number of adult-sized females in the subpopulation X 100 was 63.9% ((92/144) X 100). The mean (\pm SD) lactation period for 36 females was 36.6 d (\pm 7.0 d). A minimum of 12 pups were fostered by mothers other than their own.

Interatoll Movement

Interatoll movement was documented for seven seals that completed a total of 11 movements between FFS and either Necker Island, Laysan Island, or Johnston Atoll (Tables 2.5a and b).

Factors Affecting Survival

Attacks by large sharks, mounting attempts by male Hawaiian monk seals, entanglement in marine debris, emaciation, and unknown factors resulted in 85 life-threatening conditions, which led to the confirmed deaths of 11 animals (all nursing or weaned pups except one juvenile) and the probable death of 24 seals (all nursing or weaned pups except one juvenile) (Table 2.6). Three incidents of adult male aggression were observed; each of these involved a single adult male aggressively mounting and biting a weaned pup. One such incident resulted in injury to a female pup and is included in Table 2.6; the other pups (one male, one female) escaped obvious injury. Seven seals were entangled: one escaped independently and six were released by observers. One aborted fetus was found on Tern Island in December 1999. In addition, a weaned female pup was entrapped by the seawall on Tern Island and was guided out to the beach.

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* for logistical assistance.

TABLES
for French Frigate Shoals

Table 2.1.--Summary statistics for atoll censuses ($n = 10$) of Hawaiian monk seals at French Frigate Shoals from May 25 to August 16, 1999.

Size/Sex	Mean number of individuals	Standard deviation
Adults	79.7	5.6
Male	25.1	2.8
Female	52.3	3.5
Unknown	2.3	2.7
Subadults	12.8	4.8
Male	4.9	3.0
Female	7.5	2.4
Unknown	0.4	0.7
Juveniles	13.7	4.9
Male	7.0	3.0
Female	5.5	3.2
Unknown	1.2	0.9
Pups	39.2	5.7
Male	13.3	4.8
Female	11.4	5.2
Unknown	14.5	6.6
Non-pup total	106.2	10.1
Grand total	145.4	10.4

Table 2.2.--Composition of the Hawaiian monk seal subpopulation at French Frigate Shoals during the spring and summer of 1999. Includes all known parturient females and pups born during the calendar year.

Size	Number of seals				Sex ratio male:female
	Male	Female	Unknown	Total	
Adults	92	144	0	236	0.6:1
Subadults	12	19	0	31	0.6:1
Juveniles	23	23	0	46	1.0:1
Pups	39	42	11	92 ^a	0.9:1
Non-pup Total	127	186	0	313	0.7:1
Grand Total	166	228	11	405	0.7:1

^aExcludes one aborted fetus.

Table 2.3.--Summary of tagged known-age seals born at French Frigate Shoals and resighted at any location in 1999.

Cohort year	Age (years)	Sex	Number originally tagged	Number resighted in 1999
1984	15	Male	49	11 ^a
		Female	43	15 ^a
1985	14	Male	48	4 ^a
		Female	38	10 ^a
1986	13	Male	52	11 ^a
		Female	48	18 ^a
1987	12	Male	55	12
		Female	51	12
1988	11	Male	52	5
		Female	62	7
1989	10	Male	51	6
		Female	50	7 ^a
1990	9	Male	38	1
		Female	41	8 ^a
1991	8	Male	24	1
		Female	44	5 ^a
1992	7	Male	36	2
		Female	55	9 ^a
1993	6	Male	40	3
		Female	39	2
1994	5	Male	47	1
		Female	48	6 ^a
1995	4	Male	29	2
		Female	26	13 ^a
1996	3	Male	39	4
		Female	30	4
1997	2	Male	32	1
		Female	19	3
1998	1	Male	49	27
		Female	39	20

^a Cohort survivors include seals removed from French Frigate Shoals for rehabilitation or direct translocation. These seals were either released at Kure or Midway Atoll ($n = 19$) or remain in permanent captivity ($n = 14$).

Table 2.4a.--Summary of Hawaiian monk seals born at French Frigate Shoals in 1999.

Event	Number of pups			
	Male	Female	Unknown	Total
Born	39	42	11	92
Died/probably died prior to weaning	6	6	11	23
Weaned	33	36	0	69 ^a
Tagged	30	30	0	60 ^b

^aThree male and six female weaned pups disappeared before tagging or were severely injured preventing safe restraint for tagging.

^bA weaned female pup, born in 1999, was tagged in February 2000.

Table 2.4b.--Summary of nursing periods and measurements of weaned pups at French Frigate Shoals in 1999. Nursing periods were calculated where both birth and weaning date ranges were ≤ 4 d. All measurements were taken within two weeks after weaning.

	Nursing period (d)	Axillary girth (cm)	Straight dorsal length (cm)	Mass (kg)
Mean	38.7	108.1	129.6	70.9
Standard deviation	8.0	11.7	7.9	18.0
<i>n</i>	5	47	47	41

Table 2.5a.--Documented movement of Hawaiian monk seals to French Frigate Shoals from other locations in 1999, summarized by movements between two locations. No seals made more than one observed trip.

Original location	Number, size, and sex class
Necker Island	1 adult male
Laysan Island	2 adult males 2 adult females

Table 2.5b.--Documented movement of Hawaiian monk seals from French Frigate Shoals to other locations in 1999, summarized by movements between two locations. No seals made more than one observed trip.

Destination	Number, size, and sex class
Necker Island	2 adult males
Laysan Island	1 adult male 2 adult females
Johnston Atoll	1 adult female

Table 2.6.--Factors affecting Hawaiian monk seal survival at French Frigate Shoals in 1999.

Size	Sex	Total	Outcome		
			Injured	Died	Probably died
Attack by Large Shark					
Adult	Male	3	3	0	0
	Female	5	5	0	0
Subadult	Male	1	1	0	0
	Female	2	2		
Juvenile	Male	3	3	0	0
	Female	2	2	0	0
Weaned pup	Male	5	5	0	0
	Female	12	10	1	1
Nursing pup	Male	1	0	1	0
	Female	2	2	0	0
	Unknown	1	0	1 ^a	0
Mounting					
Adult	Female	3	3	0	0
Weaned pup	Male	4	3	1	0
	Female	4 ^b	2	2	0
Entanglement					
Adult	Female	3 ^c	0	0	0
Subadult	Female	1 ^d	0	0	0
Weaned pup	Male	2 ^d	0	0	0
	Female	1 ^d	1	0	0
Emaciated					
Weaned pup	Female	1 ^e	0	1	0
Unknown					
Adult	Female	2	2	0	0
Juvenile	Male	2	0	1	1
Weaned pup	Male	1	0	0	1
	Female	3	0	0	3
Nursing pup	Male	5	0	1	4
	Female	6	0	1	5
	Unknown	10	0	1	9

^aObserved being killed and eaten by a Galapagos shark.

^bOne weaned female pup was mounted, bit, and injured by an aggressive male during an observed incident.

^cTwo released by observers and one freed self.

^dReleased by observers.

^ePrematurely weaned pup.

**CHAPTER 3. THE HAWAIIAN MONK SEAL ON
LAYSAN ISLAND, 1999**

Brenda L. Becker, Petra Bertilsson-Friedman, and Sheila P. Gummeson

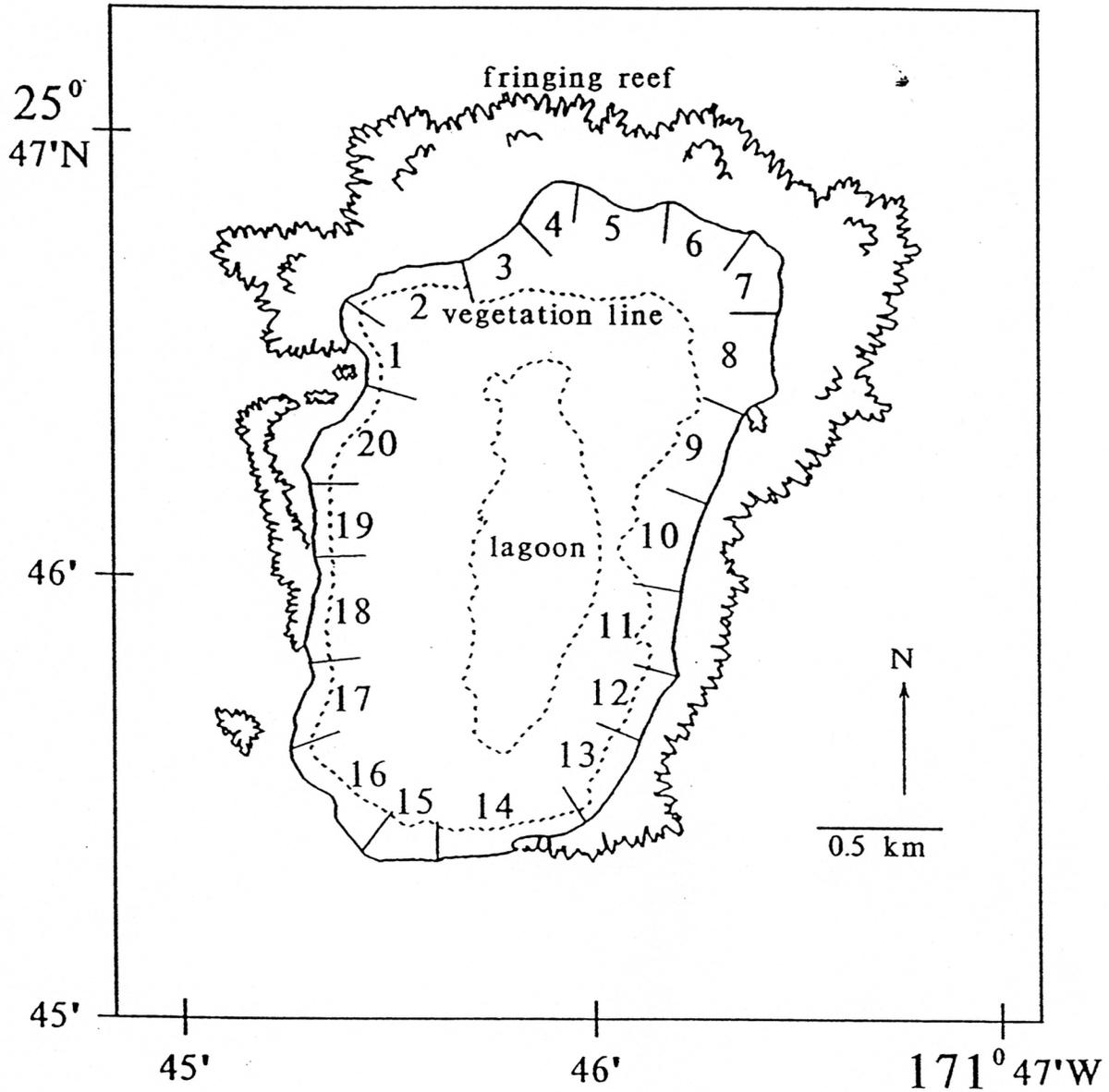


Fig. 3.1 Laysan Island in the Northwestern Hawaiian Islands.

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 (Fig. 3.1).

RESEARCH

The National Marine Fisheries Service (NMFS) began research on Hawaiian monk seals at Laysan Island in 1981. In 1999, research was conducted by NMFS during March 10-July 25, 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 1999 included (1) assessment of maternity and pup exchanges, and (2) documentation of male behavioral patterns and aggression, including incidence of mobbing.

Censuses and Patrols

Censuses and patrols were scheduled to ensure that the entire island perimeter was monitored at least once daily during March 30-July 21. Censuses ($n = 27$) were conducted by two observers every fourth day from April 8 to July 21, beginning at 1300 Hawaii standard time and continuing for 2.6 to 4.0 h.

Standardized behavior patrols were conducted on 57 noncensus days from March 30 to July 8 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. Twenty full-island incidental patrols to record noteworthy events were conducted on noncensus and nonbehavior patrol days.

Individual Identification

A total of 314 individuals (256 excluding pups) were identified by existing or applied tags, bleach marks, scars, or natural markings. Bleach marks were applied to 308 seals, including 52 nursing pups. All weaned pups ($n = 54$) were tagged with Temple Tags and most ($n = 46$) received passive integrated transponder (PIT) tags. In addition, three weaned pups and two two-year-old seals were retagged with temple tags to replace broken or lost tags.

Samples Collection

One hundred-three scat and 30 spew samples were collected. Skin punches were collected from 46 weaned pups. Shed molt samples were collected from 13 individuals.

Necropsies were performed, and tissue samples collected, from six recently dead seals, and skulls from three non-neonate carcasses were also collected. Twenty-five placentas were collected. In total, 727 pieces of potentially entangling debris were inventoried. All debris items were placed in storage bins for removal via ship, with the exception of two pieces removed and collected from entangled animals (one from a seal and one from a seabird), and a third collected for encrustation analysis. Six fishhooks used in commercial fisheries were found on the beach and collected.

RESULTS

Subpopulation Abundance and Composition

The mean (\pm SD) of 27 censuses was 117.2 seals (\pm 19.4) including pups, and 86.5 seals (\pm 13.5) excluding pups (Table 3.1). The total spring-summer subpopulation was 310 individuals, 252 excluding pups (Table 3.2). This number is a subset of the total identified in the calendar year. The sex ratio for older (>16 years of age) and unknown aged adults was at unity at ca. 1.0:1 (30 males: 31 females), whereas the ratio for younger adults (≤ 16 years of age) was ca. 0.8:1 (46 males: 55 females). The numbers of tagged known-age seals born at Laysan Island during the period from 1983 to 1998, and resighted at any location in 1999, are summarized in Table 3.3.

Reproduction

At least 58 pups were born at Laysan Island in 1999: 54 were successfully weaned and 4 died 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 born divided by the number of adult-sized females in the subpopulation $\times 100$ was 67.4% ($(58/86) \times 100$). A minimum of 28 pup exchanges occurred between 25 nursing females; three of these incidents were observed. In addition, two interventions (a human-assisted pup exchange and human-assisted pup fostering) were performed in efforts to improve the survival of pups involved. Three births were observed.

Interatoll Movement

Interatoll movement was documented for 13 seals that completed a total of 22 movements between Laysan Island and either French Frigate Shoals or Lisianski Island (Tables 3.5a and b).

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 24 life-threatening conditions, which resulted in the confirmed deaths of six animals and the disappearance of two other seals (Table 3.6). Although incidents of prolonged adult male aggression were not observed, two seals died from unobserved male mounting incidents; both were injured, and one likely drowned. Three seals were entangled: one escaped

unaided, and two were released by observers. An additional seal, wedged in shallow water rocks, was released by observers. In addition to the incidents presented in Table 3.6, two seals were in poor condition: one adult female has been emaciated for the previous two seasons, and a juvenile since last year. One weaned female pup was temporarily oiled with <5% of its pelage surface area affected.

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 NOAA ship *Townsend Cromwell*. Special thanks are extended to Jason Baker, Matthew Berry, Russell Bradley, Brenden Courtot, Chris Eggleston, Holly Gellerman, Bart McDermott, Laurie Ness, Cindy Rehkemper, Michelle Reynolds, Patty Scifres, Christina Sulzman, Mark Vekasy, and Alex Wegmann for their data collection and seal tagging and disentangling assistance.

TABLES
for Laysan Island

Table 3.1.--Summary statistics for censuses ($n = 27$) of Hawaiian monk seals at Laysan Island from April 8 to July 21, 1999.

Size/Sex	Mean number of individuals	Standard deviation
Adults	54.9	7.1
Male	21.0	3.9
Female	33.6	5.1
Unknown	0.3	0.5
Subadults	17.5	8.7
Male	5.7	2.6
Female	11.8	6.4
Unknown	0.0	0.0
Juveniles	14.1	3.4
Male	8.4	2.6
Female	5.6	1.6
Unknown	0.1	0.4
Pups	30.7	10.6
Male	11.1	4.7
Female	19.4	6.2
Unknown	0.1	0.6
Non-pup total	86.5	13.5
Grand total	117.2	19.4

Table 3.2.--Composition of the Hawaiian monk seal subpopulation at Laysan Island during the spring and summer of 1999. Includes all known parturient females and pups born during the calendar year.

Size	Number of seals			Sex ratio male:female
	Male	Female	Total	
Adults	76	86	162	0.9:1
Subadults	17	30	47	0.6:1
Juveniles	25	18	43	1.4:1
Pups	21	37	58	0.6:1
Non-pup total	118	134	252	0.9:1
Grand total	139	171	310	0.8:1

Table 3.3.--Summary of tagged known-age seals born at Laysan Island and resighted at any location in 1999.

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

Table 3.4a.--Summary of Hawaiian monk seals born at Laysan Island in 1999.

Event	Number of pups		
	Male	Female	Total
Born	21	37	58
Died prior to weaning	1	3	4
Weaned	20	34	54
Tagged	20 ^a	34 ^b	54

^aIncludes two pups weaned and tagged after the NMFS Camp; one of these was also born after the NMFS camp.

^bIncludes five pups weaned and tagged after the NMFS camp; two of these were also born after the NMFS camp.

Table 3.4b.--Summary of nursing periods and measurements of weaned pups at Laysan Island in 1999. Nursing periods were calculated where both birth and weaning date ranges were ≤ 4 d. All measurements were taken within 2 weeks after weaning.

	Nursing period (d)	Axillary girth (cm)	Straight dorsal length (cm)
Mean	38.0 ^a	107.2	127.5
Standard deviation	4.5	8.7	5.6
<i>n</i>	51	54	54

^aIncludes one pup who was initially weaned at 28 days and, with human assisted fostering, weaned a second time at 54 days of age (including an 8-day break between the two nursing periods).

Table 3.5a.—Documented movement of Hawaiian monk seals to Laysan Island from other locations in 1999, summarized by movements between two locations. No seals made more than one observed trip.

Original location	Number, size, and sex class
French Frigate Shoals	1 adult male 2 adult females
Lisianski Island	1 adult male 5 adult females

Table 3.5b.—Documented movement of Hawaiian monk seals from Laysan Island to other locations in 1999, summarized by movements between two locations. One seal made more than one observed trip.

Destination	Number, size, and sex class
French Frigate Shoals	2 adult males 2 adult females
Lisianski Island	5 adult females 2 subadult females 1 juvenile male 1 juvenile female

Table 3.6.--Factors affecting Hawaiian monk seal survival at Laysan Island in 1999.

Size	Sex	Total	Outcome		
			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	2	1	0
Subadult	Male	1	1	0	0
	Female	1	1	0	0
Juvenile	Female	1	1	0	0
Weaned pup	Female	1	0	1 ^a	0
Entanglement					
Adult	Female	1 ^b	0	0	0
Weaned pup	Female	2 ^c	0	0	0
Emaciation					
Adult	Male	1	0	0	1 ^d
Other/Unknown					
Adult	Male	2	1	1	0
	Female	1	1	0	0
Weaned pup	Male	1 ^e	0	0	0
	Female	1	1	0	0
Nursing pup	Male	1	0	1	0
	Female	3	0	2 ^f	1 ^g

^aPup probably drowned during unobserved incident.

^bSeal disentangled itself and sustained no injuries from the entanglement.

^cBoth seals were released by researchers and sustained no injuries from the entanglement.

^dAn older seal in extremely poor and deteriorating condition disappeared.

^eSeal wedged in rocks in shallow water was released by researchers; sustained minor injuries.

^fOne pup's mother was nonresponsive to the pup's nursing attempts and wouldn't present her ventrum; the pup may have starved.

^gThe pup disappeared at 22 days old.

**CHAPTER 4. THE HAWAIIAN MONK SEAL ON
LISIANSKI ISLAND, 1999**

Dorothy M. Dick, Amber D. Pairis, and Lara D. Gibson

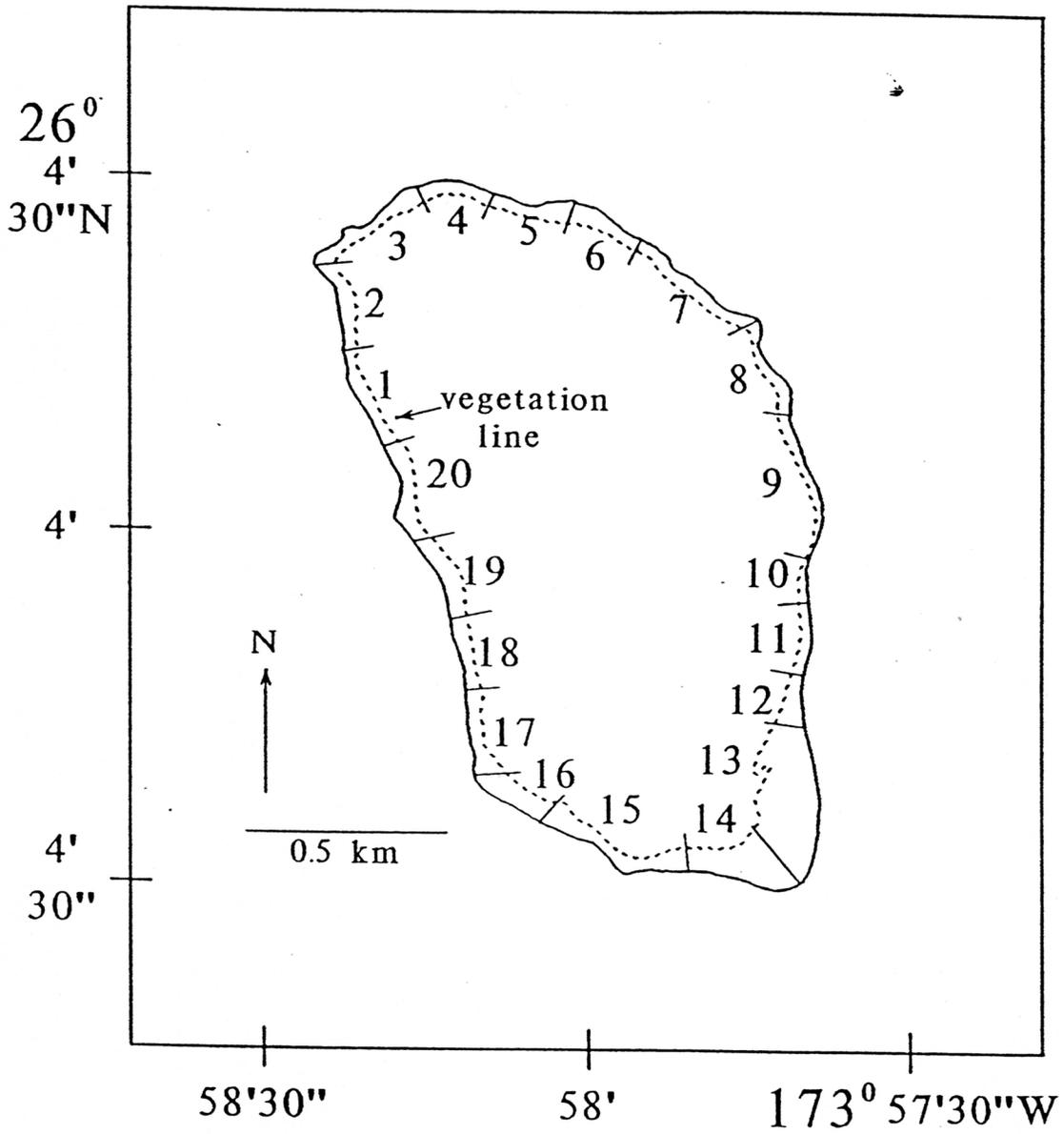


Fig. 4.1 Lisianski Island in the Northwestern Hawaiian Islands.

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 (Fig. 4.1).

RESEARCH

The National Marine Fisheries Service (NMFS) began research on Hawaiian monk seals at Lisianski Island in 1981. In 1999, research was conducted by NMFS during March 15-July 20 and on October 12 and 17. The perimeter of the island was divided into 20 sectors using artificial or natural landmarks (Fig. 4.1). Research activities specific to this subpopulation in 1999 included (1) assessment of maternity and pup exchanges, (2) documentation of adult male behavioral patterns and aggression (including focal observations in areas frequented by weaned pups), and (3) large-scale debris removal from reef around the island.

Censuses and Patrols

Censuses and patrols were scheduled to ensure that the entire island was monitored at least once daily during March 15-July 20. Censuses ($n = 28$) were conducted by two observers every fourth day from March 31 to July 20, beginning at 1300 Hawaii standard time and continuing from 1.8 to 3.0 h.

Standardized behavior patrols were conducted on noncensus days to assess activity patterns of adults and large subadults, to document male aggression, and to detect mobbing incidents. During these patrols ($n = 65$), attention was directed out to sea as much as possible since mobbing has been observed most frequently in the water.

Individual Identification

A total of 207 individuals (174 excluding pups) were identified by existing or applied tags, bleach marks, scars, or natural markings. All weaned pups ($n = 27$) were tagged with Temple tags and passive integrated transponder (PIT) tags. One weaned pup received an additional two temple tags due to a broken original tag. One immature female seal was also Temple tagged.

Samples Collection

One hundred-one scat and 12 spew samples were collected. Skin punches were collected from 28 seals during tagging and from four of the dead pups during necropsies. Necropsies were performed and tissue samples were collected from five dead male pups, all ≤ 7 days old. Skeletal samples were collected from seven dead seals: one lower jawbone and one skull from two seals, respectively, whose year of death is unknown, and five skulls from the necropsied pups. Twenty-three shed molt samples were collected from 20 individuals. Fourteen placenta samples were also collected. In total, 707 items of potentially entangling debris were inventoried; 702 items were stored on Lisianski for removal during a marine debris cruise in October 1999. The remaining 5

items were removed from entangled animals (4 from seals, 1 from an albatross chick), collected, and brought back to Honolulu.

Special Studies

Adult Male Aggression Towards Weaned Pups

In 1999, 2-h focal group and area observations ($n = 25$) were conducted in areas frequented by weaned pups. These observations were designed to document the frequency and intensity of aggressive interactions between adult males and weaned pups and to identify individual male aggressors.

Although aggressive behavior was observed during three focal observations, only one of these incidents involved an adult male; the other two involved subadult males. Interactions between adult or subadult males and weaned pups were also recorded as part of the standard census and behavior patrol procedure as well as opportunistically during other surveys.

Fifteen adult and 6 subadult males were observed interacting with weaned pups on 21 different occasions. Interactions lasted from 30 seconds to 1 h. No incidents resulted in fatalities and only one incident resulted in obvious injury to the pup. All encounters occurred in the water close to shore and involved splashing, rolling, and vocalizing between individuals. Most observations noted the aggressive male attempting to mount or pushing the weaned pup's head underwater and holding it there for up to one minute. During several such events the aggressor's penial aperture was noted to be protruding beyond resting levels, however sexual organs were not visible. Occasional biting of the weaned pups also occurred. Two additional, and similar, encounters occurred between adult males and juvenile seals but did not result in obvious injury.

Large Scale Marine Debris Removal from Reefs

A cooperative multi-agency coral reef cleanup was conducted at Lisianski Island in October 1999 supported by the NOAA ship *Townsend Cromwell* and the USCG cutter *Walnut*. Personnel from 11 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 the main 1999 field season was also removed. In total, 5,437 kg of debris were recovered at Lisianski Island: 910 kg from the reef and 4,527 kg from the beaches.

Noteworthy Events

Observed Adult Male Aggression Towards Adult Females

One mobbing was observed during 1999. The event was already in progress offshore when first noticed, and the participants moved onshore as it concluded some 3.5 h later. Four males were initially observed interacting with one female. Intense splashing and several glimpses of male sexual organs were noted. Two additional males joined onshore events. Beach observations included various males actively defending the female with numerous male-male contests and frequent reversal from challenging to defending roles. Also noted were individual males moving away from the mobbing group for several minutes before actively rejoining the fray. Although the incident was not fatal to the female, a large open wound developed in her dorsal area, and 23 days

later she gave birth to a pup that died perinatally. Later in the season her dorsal injury was reopened in an unobserved incident and it was still healing when researchers left Lisianski.

In separate incidents, two prolonged harassment episodes were witnessed. In both cases, behaviors observed were indicative of interactions that could lead to mobbing (several males actively defending a female with numerous male-male contests and frequent reversal from challenging to defending roles by males) but did not escalate further. The two events both lasted roughly 1 h and involved a different adult female and six and seven adult males. During the incident involving six adult males, the female was noted to have minor injuries (approximately six scratches along with several possible bite marks). In the incident involving seven adult males, no obvious injuries to the female were noted at the time; however, 18 days later she was observed with severe dorsal scratches and two abscesses. Whether these injuries resulted from the observed incident is unknown.

Adult Male Interactions with Mother-Pup Pairs

On two separate occasions adult males were observed to separate mothers from their pups and engage in successive mounting attempts with the former. During both incidents intense splashing, rolling, and vocalizing were noted. Although pups remained nearby, each mother-pup pair was separated from three to six minutes before the mother was able to repel the male and reunite with her pup.

RESULTS

Subpopulation Abundance and Composition

The mean (\pm SD) of 28 censuses was 77.2 seals (\pm 8.0) including pups, and 59.8 seals (\pm 7.2) excluding pups (Table 4.1). The total spring-summer subpopulation was 203 individuals, 170 excluding pups (Table 4.2). This number is a subset of the total identified during the calendar year. The sex ratio for older (>17 years of age) and unknown aged adults was strongly skewed toward males at ca. 3.2:1 (41 males: 13 females), whereas the ratio for younger adults (≤ 17 years of age) was at unity at 1.0:1 (33 males: 33 females). The numbers of tagged known-age seals born at Lisianski Island during the period from 1982 to 1998, and resighted at any location in 1999, are summarized in Table 4.3.

Reproduction

A minimum of 33 pups were born at Lisianski Island in 1999: 27 were successfully weaned, five died prior to weaning, and one disappeared and probably died (Table 4.4a). 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 $\times 100$ was 71.7% ($(33/46) \times 100$). Two births were observed by researchers. A minimum of 14 pup exchanges occurred among 16 nursing females; researchers observed 2 of these incidents. One weaning incident was also observed.

Interatoll Movement

Interatoll movement was documented for 13 seals that completed a total of 20 movements between Lisianski Island and either Laysan Island, Pearl and Hermes Atoll, or Midway Atoll (Tables 4.5a and b).

Factors Affecting Survival

Attacks by large sharks, mounting attempts by male Hawaiian monk seals, entanglement in marine debris, and other/unknown factors led to 34 life-threatening conditions, which resulted in the confirmed deaths of six animals and the probable death of two seals (Table 4.6). One mobbing incident was observed. No seals were known to have directly died following male mounting incidents. However, three pups born to adult females recently injured by male mounting, as evidenced by dorsal injuries, died. Two of these pups died within 7 days of birth, and one perinatally. Seven seals were entangled: three escaped unaided and four were released by observers.

In addition to the cases summarized in Table 4.6, several other cases are noteworthy. Two prolonged adult male harassments of adult females were observed (described above). Male harassment of weaned pups/juveniles was also observed 23 times; no fatalities occurred and 1 incident resulted in obvious, though minor, injury to the seal. A minimum of 13 other weaned pups sustained minor dorsal scratches probably inflicted by other seals during unobserved incidents. One yearling had recent entanglement scars indicating self-release from marine debris sometime after July 1998. Two additional seals displayed healed large shark bite scars that were not present on these animals in 1998; one scar was on a 2-year-old female's right face and muzzle area, the other scar was on an adult female with extensive scarring on the ventrum and posterior laterals and partial amputation of the left hind flipper. One adult male visibly lost body mass throughout the season and was deemed emaciated during the final month of study. A dead unknown adult seal was found in October 1999; however, its identity could not be determined due to advanced decomposition.

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* for logistical assistance.

TABLES
for Lisianski Island

Table 4.1.--Summary statistics for censuses ($n = 28$) of Hawaiian monk seals at Lisianski Island from March 31 to July 20, 1999.

Size/Sex	Mean number of individuals	Standard deviation
Adults	45.4	7.8
Male	26.1	5.2
Female	18.8	3.7
Unknown	0.6	0.9
Subadults	9.0	3.3
Male	4.6	2.2
Female	4.2	2.0
Unknown	0.1	0.3
Juveniles	5.5	2.4
Male	2.6	1.3
Female	2.8	1.6
Unknown	0.0	0.0
Pups	17.4	4.2
Male	10.4	2.6
Female	7.0	1.9
Unknown	0.0	0.2
Non-pup total	59.8	7.2
Grand total	77.2	8.0

Table 4.2.--Composition of the Hawaiian monk seal subpopulation at Lisianski Island during the spring and summer of 1999. Includes all known parturient females and all pups born during the calendar year.

Size	Number of seals				Sex ratio male:female
	Male	Female	Unknown	Total	
Adults	74	46	0	120	1.6:1
Subadults	13	12	0	25	1.1:1
Juveniles	12	13	0	25	0.9:1
Pups	21	11	1	33	1.9:1
Non-pup total	99	71	0	170	1.4:1
Grand total	120	82	1	203	1.5:1

Table 4.3.--Summary of tagged known-age seals born at Lisianski Island and resighted at any location in 1999.

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

Table 4.4a.--Summary of Hawaiian monk seals born at Lisianski Island in 1999.

Event	Number of pups			
	Male	Female	Unknown	Total
Born	21	11	1	33
Died/Probably died prior to weaning	5	0	1	6
Still nursing	0	0	0	0
Weaned	16	11	0	27
Tagged	16	11	0	27

Table 4.4b.--Summary of nursing periods and measurements of weaned pups at Lisianski Island in 1999. Nursing periods were calculated where both birth and weaning date ranges were ≤ 4 days. All measurements were taken within 2 weeks after weaning.

	Nursing period (d)	Axillary girth (cm)	Straight dorsal length (cm)
Mean	37.9	105.8	124.2
Standard deviation	5.0	8.2	7.1
<i>n</i>	25	27	27

Table 4.5a.—Documented movement of Hawaiian monk seals to Lisianski Island from other locations in 1999, summarized by movements between two locations. One seal made more than one observed trip.

Original location	Number, size, and sex class
Laysan Island	5 adult females 2 subadult females 1 juvenile male 1 juvenile female
Pearl and Hermes Atoll	1 adult male ^a 1 adult female

^a Seal was seen for one day only on Lisianski and was not seen again during the 1999 season at any of the Northwestern Hawaiian Islands.

Table 4.5b.—Documented movement of Hawaiian monk seals from Lisianski Island to other locations in 1999, summarized by movements between two locations. No seals made more than one observed trip.

Destination	Number, size, and sex class
Laysan Island	1 adult male 5 adult females
Pearl and Hermes Atoll	2 adult females
Midway Atoll	1 subadult male

Table 4.6.--Factors affecting Hawaiian monk seal survival at Lisianski Island in 1999.

Size	Sex	Total	Outcome		
			Injured	Died	Probably died
Attack by Large Shark					
Adult	Male	2	2	0	0
	Female	3	3	0	0
Juvenile	Male	2 ^a	2	0	0
	Female	1	1	0	1 ^b
Mounting by Male					
Adult	Female	7 ^{c,d}	7	0	0
Subadult	Female	1	1	0	0
Weaned pup	Male	2	2	0	0
Entanglement					
Adult	Male	1 ^e	0	0	0
	Female	3 ^f	0	0	0
Subadult	Male	1 ^g	0	0	0
Weaned pup	Male	2 ^h	0	0	0
Other/Unknown					
Adult	Female	1	1	0	0
	Unknown	1	0	1 ⁱ	0
Weaned pup	Male	1	1	0	0
Nursing pup	Male	5	0	5 ^j	0
	Unknown	1	0	0	1 ^k

^aIncludes a seal with an extensive yet almost healed injury. Although not seen after the end of March, it is unclear if this injury caused the seal's disappearance.

^bSeal sustained a major shark bite injury, became thinner, had trouble moving, and was not seen after 5/31/99.

^cAn observed mobbing involving one adult female and six adult males resulted in severe dorsal injuries. This female was re-injured in an unobserved, unrelated event 33 days later.

^dA seal was injured twice within 18 days. The injuries were considered related, and counted once.

^eSeal was released by observers.

^fTwo seals freed themselves, one was released by observers.

^gSeal entangled with eel cone on muzzle, released by observers.

^hOne seal with eel cone on muzzle freed itself, one with a plastic ring on muzzle released by observers.

ⁱDecomposed carcass found during 1 day visit to the island in October.

^jAll died within 7 days of age; three had mothers severely injured during male mounting events.

^kPup of unknown sex disappeared 2 days after birth.

**CHAPTER 5. THE HAWAIIAN MONK SEAL ON
PEARL AND HERMES ATOLL, 1999**

Chad Yoshinaga, Michelle Wainstein, Kate Willis, and Andrew McClung

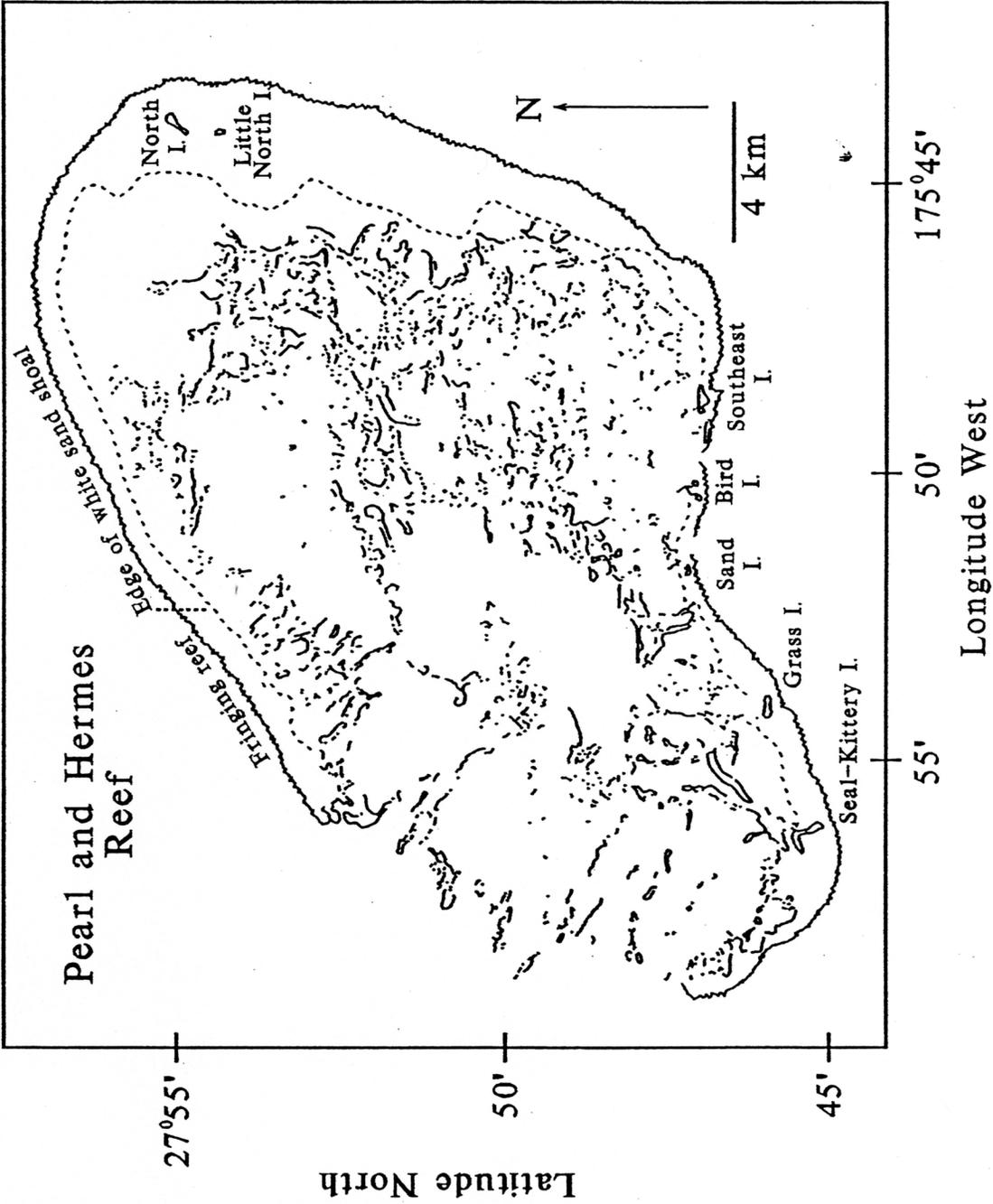


Fig. 5.1 Pearl and Hermes Reef in the Northwestern Hawaiian Islands.

Pearl and Hermes Atoll (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 Atoll in 1982. In 1999, research was conducted by NMFS during May 25 - July 20. The perimeters of the four larger vegetated islets were divided into sectors using natural landmarks. Research activities specific to this subpopulation in 1999 included large scale debris removal from the fringing reef.

Censuses and Patrols

Atoll censuses ($n = 8$) were conducted every fourth day, on average, from June 10 to July 16. Each atoll census began between 0910 and 1047 and ended between 1407 and 1636 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 and to identify and bleach-mark all animals in the subpopulation.

Individual Identification

A total of 241 individuals (213 excluding pups) were identified by existing or applied tags, scars, or natural markings. Twenty-five weaned pups were tagged with Temple Tags and passive integrated transponder (PIT) tags. One weaned pup was tagged exclusively with Temple Tags.

Samples Collection

Forty scat and one spew samples were collected. Skin punches were collected from 26 seals during tagging. One skeletal sample was collected. In total, 449 items of potentially entangling debris were inventoried and left at Pearl and Hermes Atoll for removal during a marine debris cruise in October 1999.

Special Studies

Large Scale Marine Debris Removal from Reefs

A cooperative multi-agency coral reef cleanup was conducted at Pearl and Hermes Atoll in October 1999 supported by the NOAA ship *Townsend Cromwell* and the USCG cutter *Walnut*. Personnel from 11 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 main 1999 field season were also removed. In total, 8,667 kg of debris were recovered at Pearl and Hermes Atoll: 7,527 kg from the reef and 1,140 kg from the beaches.

RESULTS

Subpopulation Abundance and Composition

The mean (\pm SD) of 8 atoll censuses was 98.6 seals (\pm 11.5) including pups and 80.6 seals (\pm 12.7) excluding pups (Table 5.1). The total summer subpopulation was 234 individuals, 206 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 Atoll during the period from 1983 to 1998 and resighted at any location in 1999 are summarized in Table 5.3.

Reproduction

At least 28 pups were born at Pearl and Hermes Atoll in 1999: 26 were successfully weaned and two were still nursing at the end of the research 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 45.2% ((28/62) X 100). Nursing periods and measurements of weaned pups are summarized in Table 5.4.

Interatoll Movement

Interatoll movement was documented for 20 seals that completed a total of 32 movements between Pearl and Hermes Atoll and either Lisianski Island, Midway Atoll, or Kure Atoll (Tables 5.5a and b).

Factors Affecting Survival

Entanglement in marine debris and other factors resulted in three life-threatening conditions (Table 5.6). One adult and one subadult seal were disentangled from debris. A weaned female pup was observed with two open abscesses on her back. In addition to the incidents presented in Table 5.6, a carcass found on Little North islet, appeared to be an adult-sized seal that had died since the previous field season .

ACKNOWLEDGMENTS

We thank the captain, officers, and crew of the NOAA Ship *Townsend Cromwell*. We also acknowledge the support of the U.S. Fish and Wildlife Service, Hawaiian Island National Wildlife Refuge staff.

TABLES
for Pearl and Hermes Reef

Table 5.1.--Summary statistics for atoll censuses ($n = 8$) of the Hawaiian monk seal at Pearl and Hermes Reef from June 10 to July 16, 1999.

Size/Sex	Mean number of individuals	Standard deviation
Adults	48.1	7.0
Male	17.3	5.3
Female	26.3	3.4
Unknown	4.6	2.8
Subadults	20.1	7.6
Male	8.0	4.0
Female	10.0	3.6
Unknown	2.1	2.1
Juveniles	11.5	0.9
Male	4.0	1.8
Female	7.1	1.8
Unknown	0.4	0.5
Pups	18.0	4.1
Male	5.8	2.3
Female	10.6	2.5
Unknown	1.6	0.5
Non-pup total	80.6	12.7
Grand total	98.6	11.5

Table 5.2.--Composition of the Hawaiian monk seal subpopulation at Pearl and Hermes Atoll during the spring and summer of 1999. Includes all known parturient females and pups born during the calendar year.

Size	Number of seals				Sex ratio male:female
	Male	Female	Unknown	Total	
Adults	64	62	0	126	1.0:1
Subadults	19	22	0	41	0.9:1
Juveniles	14	25	0	39	0.6:1
Pups	11	16	1	28	0.7:1
Non-pup total	97	109	0	206	0.9:1
Grand total	108	125	1	234	0.9:1

Table 5.3.--Summary of tagged known-age seals born at Pearl and Hermes Reef and resighted at any location in 1999.

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

Table 5.4a.--Summary of Hawaiian monk seals born at Pearl and Hermes Atoll in 1999.

Event	Number of pups			
	Male	Female	Unknown	Total
Born	11	16	1	28
Died prior to weaning	0	0	0	0
Still nursing	0	1	1	2
Weaned	11	15	0	26
Tagged	11	15	0	26

Table 5.4b.--Summary of nursing periods and measurements of weaned pups at Pearl and Hermes Reef in 1999. All measurements were taken within 2 weeks after weaning.

	Nursing period (d)	Axillary girth (cm)	Straight dorsal length (cm)
Mean	36	105.7	126.1
Standard deviation	--	6.0	4.2
<i>n</i>	1	9	9

Table 5.5a.—Documented movement of Hawaiian monk seals to Pearl and Hermes Atoll from other locations in 1999, summarized by movements between two locations. No seals made more than one observed trip.

Original location	Number, size, and sex class
Lisianski Island	2 adult females
Midway Atoll	2 adult males 7 adult females 1 subadult female 1 juvenile male
Kure Atoll	1 adult female 1 subadult male 1 subadult female

Table 5.5b.—Documented movement of Hawaiian monk seals from Pearl and Hermes Atoll to other locations in 1999, summarized by movements between two locations. One seal made more than one observed trip.

Destination	Number, size, and sex class
Lisianski Island	1 adult male 1 adult female
Midway Atoll	3 adult males 4 adult females 2 subadult females 2 juvenile males
Kure Atoll	1 adult female 1 subadult male 1 subadult female

Table 5.6.--Factors affecting Hawaiian monk seal survival at Pearl and Hermes Atoll in 1999.

Size	Sex	Total	Outcome		
			Injured	Died	Probably died
Attack by Large Shark					
(none observed)					
Mounting by Males					
(none observed)					
Entanglement					
Adult	Male	1 ^a	0	0	0
Subadult	Female	1 ^a	0	0	0
Other					
Weaned pup	Female	1	1	0	0

^aSeal released by observers.

**CHAPTER 6. THE HAWAIIAN MONK SEAL AT
MIDWAY ATOLL, 1999**

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

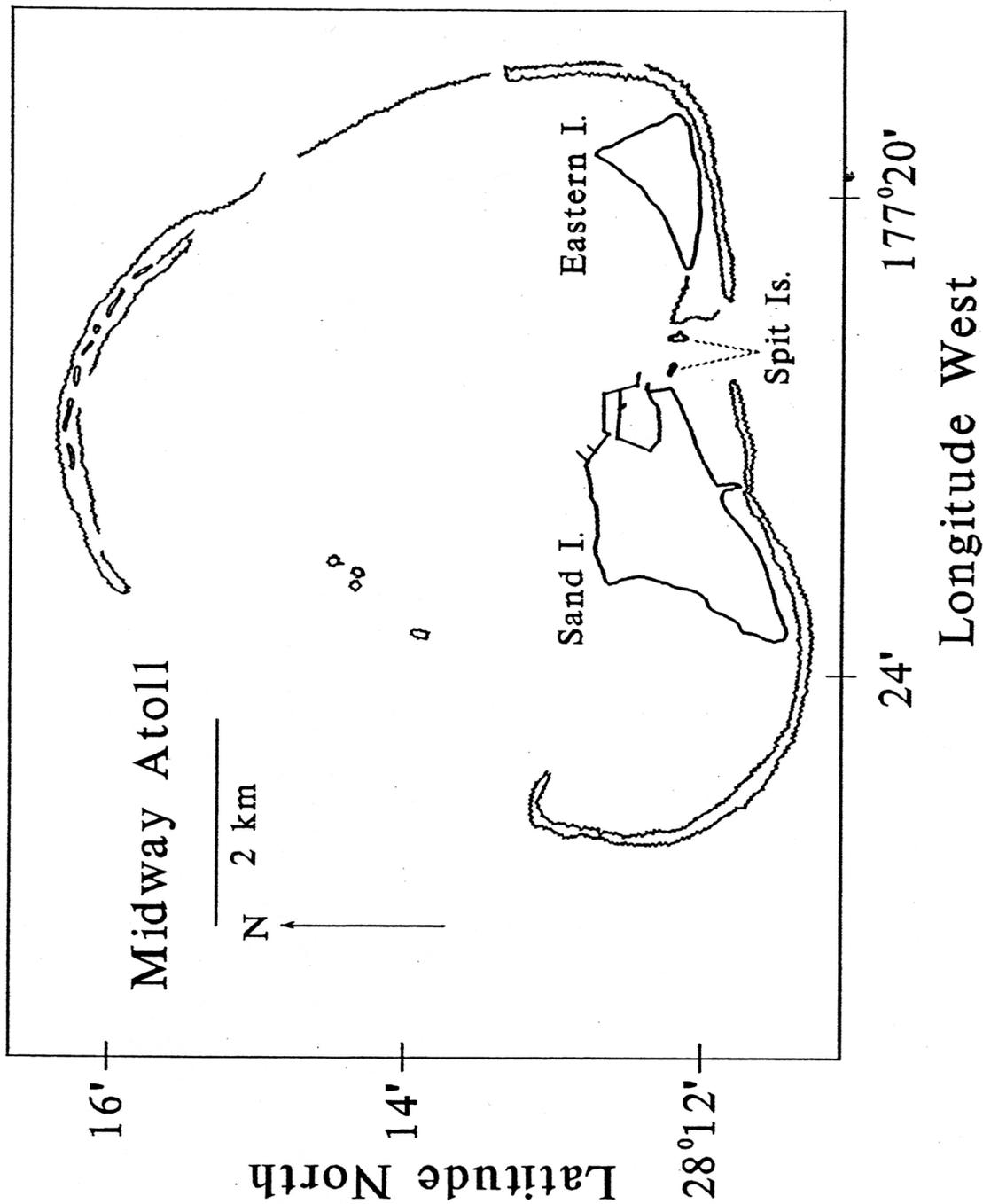


Fig. 6.1 Midway Atoll in the Northwestern Hawaiian Islands.

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, although current population levels and pup production are relatively low. This atoll is located ca. 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) 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 Atoll, 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 by collaborating with researchers from Hawaii Wildlife Fund (HWF). In 1999, year-round monitoring was continued by HWF researchers. In addition, monk seal/human related issues were addressed by a NMFS biologist from May 9 to November 30, 1999, and NMFS conducted a health assessment survey August 28-September 8, 1999. Perimeters of the three permanent islets were divided into sectors using artificial or natural landmarks. Research activities specific to this subpopulation in 1999 included (1) emergent reef surveys to determine haulout patterns on these areas, (2) blood, tissue, and fecal sampling for a disease survey and foraging ecology studies, (3) collection of reef fishes and invertebrates for fatty acid analysis, (4) assessment of nearshore reef fish abundance (5) survey of the northern reef flats for lobster, eel, and octopus abundance, (6) survey for, and removal of marine debris from the north and east reef flats and emergent reef areas, and (7) monitoring human impacts on seals to quantify occurrence and potential effects on monk seal habitat usage.

Censuses and Patrols

Atoll censuses ($n = 50$) were conducted every seventh day, on average, from January 6 to December 30. Each atoll census began between 0705 and 1425, and ended between 1418 and 1935 Hawaii standard time. All islets were censused on foot by one or two persons. Spit was

occasionally surveyed by boat on severe weather days. Patrols of Sand Island ($n = 100$), Eastern ($n = 95$), or Spit ($n = 87$) were conducted on non-atoll census days during January 1-December 27.

Individual Identification

A total of 86 individuals (71 excluding pups) were identified by existing or applied tags, bleach marks, scars, or natural markings. Eleven pups weaned at Midway were tagged with Temple tags and passive integrated transponder (PIT) tags. One prematurely weaned pup was not tagged. In addition, a weaned female pup, born at an unknown location, was tagged with Temple tags and PIT tags. During the health assessment study 8 seals were retagged with both Temple tags and PIT tags (2 adult males, 4 adult females, 1 subadult female, and 1 juvenile male), 3 seals were re-tagged with Temple tags (1 juvenile male, 1 juvenile female, and 1 weaned male pup), and 2 seals were re-tagged with PIT tags (1 adult male and 1 juvenile female).

Samples Collection

Skin punches were collected from 11 weaned pups during tagging. Eight spews, 240 scats, 3 placentas, and 23 shed molt samples were collected. Two necropsies were performed and tissue samples were collected. Blood, fecal, and tissue samples were collected from 20 seals during the health assessment survey. A total of 1,171 items of potentially entangling marine debris were inventoried and either destroyed at Midway or stored on Midway for removal during a marine debris cruise in October 1999.

Special Studies

Health, Disease, and Foraging Ecology Studies

In August and September 1999, NMFS biologists collected blood and fecal samples and blubber biopsies from 20 seals (9 adult and 6 immature seals, and 5 weaned pups) for ongoing epidemiological and fatty acid diet studies. Assistance was provided by HWF. Although all 20 seals appeared healthy prior to capture, one adult male died during sedation. Thorough post-mortem examination indicated that this seal had pulmonary and cardiac conditions which may have predisposed him to mortality during capture. The purpose of this sampling was to obtain baseline information to assess the health, disease status, and foraging ecology of the Hawaiian monk seal population (Aguirre and Reif, 1998).

Emergent Reef Surveys

Patrols were conducted two times per week on average along the emergent reef areas of the North Reef ($n = 94$), and East Reef ($n = 93$), and once per week along the Southwest Reef ($n = 55$) from January 8 to November 21, 1999. Two people using kayaks and a motorboat surveyed the reefs for seals and turtles. On 21 occasions, all three emergent reef areas were surveyed within one day of atoll counts to provide an estimate of atoll-wide beach/emergent reef counts.

Prey Availability

In July, 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, 1995-98 (see DeMartini et al., 1993). In 1998 and 1999 this study was expanded to assess fish abundance at deeper sites (50-60 m). The results of this ongoing research will be reported elsewhere.

From July 30 to November 21, 119 samples of invertebrates and teleost fish were collected in Midway Atoll waters for analysis of fatty acid in potential monk seal prey. Lobster traps were set both inside and outside the lagoon to collect invertebrates and some fish species. Most fish were collected inside the lagoon around shallow reefs by skin divers using Hawaiian slings. The lobster specimens ($n = 37$) were the primary focus in the prey sampling. HWF assisted NMFS personnel with the collection of the specimens and Midway Phoenix Corporation donated the use of their lobster traps for this project.

Reef Surveys for Eels, Lobsters, and Octopus at Midway Atoll

A quantitative diving survey for eels, lobsters, and octopus was conducted on the north and southwest reef flats of Midway's lagoon from June 16 to September 15. This study was a collaborative effort between USFWS and NMFS.

Large Scale Marine Debris Removal from Reefs

From May to November, 9,363 kg of marine debris were removed from the atoll reef and associated reef flats. Diving transect surveys were conducted from the north end of the atoll reef working east, along established monk seal reef patrol sectors. Transect lines, ca. 0.4 km long, were surveyed on reef flats perpendicular to the reef crest (emergent reef). Crews worked 2-3 days a week, weather permitting. In addition, 2,270 kg of debris were collected along the shores of the atoll's three islets. This study was a collaborative effort between USFWS, NMFS, and HWF. The NOAA ship *Townsend Cromwell* and the USCG cutter *Walnut* recovered most of the debris stored at Midway as part of a cooperative multi-agency reef cleanup in October 1999.

Noteworthy Events

Beach Monitoring and Public Education

From May to November 1999, Sand Island beaches and trails were monitored for approximately 10 h/week. Monk seal natural history was shared opportunistically with visitors and residents. On five occasions NMFS observer intervention prevented the probable disturbance of resting monk seals; three involved persons violating refuge rules in the presence of mother/pup pairs. Other actions taken to mitigate disturbance to seals included trail maintenance, planting native vegetation at trail overlooks to create natural blinds, identification of problem areas, and delineating sites (with yellow tape) where seals were resting or molting in areas of public access. Fourteen informational lectures were presented to residents and visitors, covering monk seal natural history, NMFS recovery efforts, and the reasons for refuge rules governing seal viewing

and beach closures. These lectures were eventually incorporated into USFWS's weekly briefing for guests.

RESULTS

Subpopulation Abundance and Composition

The mean (\pm SD) of 50 atoll censuses was 23.5 seals (\pm 7.4) including pups, and 18.7 seals (\pm 7.1) excluding pups (Table 6.1). The total spring-summer subpopulation was 68 seals, 55 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 Atoll during the period from 1988 to 1998, and resighted at any location in 1999, are summarized in Table 6.3.

Reproduction

A minimum of 12 pups were born at Midway Atoll in 1999, and all successfully weaned (Table 6.4a). The birth rate, measured as the number of pups born divided by the number of adult-sized females in the subpopulation X 100 was 60.0% ((12/20) X 100). A minimum of one pup exchange occurred between nursing females, resulting in one prematurely weaned pup. Nursing periods and measurements of weaned pups are summarized in Table 6.4b.

Interatoll Movement

Interatoll movement was documented for 30 seals that completed a total of 49 movements between Midway Atoll and either Lisianski Island, Pearl and Hermes Atoll, Kure Atoll, or an unknown location (Tables 6.5a and b).

Factors Affecting Survival

Attacks by sharks, entanglement in marine debris, and other/unknown causes led to 11 life-threatening conditions, which resulted in the confirmed deaths of two animals and the probable death of an additional seal (Table 6.6). One subadult female was found dead of unknown causes, and an adult male seal died while under restraint during the health assessment survey. One pup disappeared after he was prematurely weaned due to a pup exchange. Three seals were entangled in marine debris: a juvenile male escaped unaided, and two others (an adult female and weaned male pup) were released by observers. In addition, one aborted fetus was found on Eastern islet in November.

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; Nancy Hoffman, Refuge Biologist; Bob Wilson, Midway Harbor Master and the Midway Harbor crew. We also thank the officers and crew of the NOAA ship *Townsend Cromwell* for logistical assistance. We are very grateful to Hays A. McLellan and the Pacific Marine Life Foundation for the funding support given to HWF for monk seal research at Midway. We would

like to honor the memory of Hays A. McLellan and his dedication to the Midway Atoll Hawaiian monk seal recovery effort.

**TABLES
for Midway Atoll**

Table 6.1.--Summary statistics for atoll censuses ($n = 50$) of Hawaiian monk seals at Midway Atoll from January 6 to December 30, 1999.

Size/Sex	Mean number of individuals	Standard deviation
Adults	9.6	3.7
Male	3.7	1.6
Female	5.6	3.0
Unknown	0.3	0.5
Subadults	2.2	1.6
Male	0.6	0.7
Female	1.5	1.1
Unknown	0.1	0.4
Juveniles	7.0	2.8
Male	3.7	1.7
Female	3.1	1.5
Unknown	0.2	0.4
Pups	4.7	2.9
Male	2.9	1.8
Female	1.7	1.5
Unknown	0.1	0.3
Non-pup total	18.7	7.1
Grand total	23.5	7.4

Table 6.2.--Composition of the Hawaiian monk seal subpopulation at Midway Atoll during the spring and summer of 1999. Includes all known parturient females and pups born during the calendar year.

Size	Number of seals			Sex ratio male:female
	Male	Female	Total	
Adults	13	20	33	0.7:1
Subadults	1	5	6	0.2:1
Juveniles	9	7	16	1.3:1
Pups	8	5 ^a	13 ^a	1.6:1
Non-pup total	23	32	55	0.7:1
Grand total	31	37	68	0.8:1

^aIncludes a weaned female pup born at an unknown location that arrived on May 29 and was tagged at Midway Atoll. This pup may have been born at Pearl and Hermes Atoll or Kure Atoll.

Table 6.3.--Summary of tagged known-age seals born at Midway Atoll and resighted at any location in 1999.

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

Table 6.4a.--Summary of Hawaiian monk seals born at Midway Atoll in 1999.

Event	Number of pups		
	Male	Female	Total
Born	8	4	12
Died prior to weaning	0	0	0
Weaned	8	4	12
Tagged	7 ^a	4	11 ^a

^aA prematurely weaned male pup was not tagged. This pup later disappeared.

Table 6.4b.--Summary of nursing periods and measurements of weaned pups at Midway Atoll in 1999. Nursing periods were calculated where both birth and weaning date ranges were ≤ 4 d. All measurements were taken within 2 weeks after weaning.

	Nursing period (d)	Axillary girth (cm)	Straight dorsal length (cm)
Mean	36.7	110.0	127.0
Standard deviation	6.4	7.6	7.0
<i>n</i>	12	11	11

Table 6.5a.—Documented movement of Hawaiian monk seals to Midway Atoll from other locations in 1999, summarized by movements between two locations. Three seals made more than one observed trip.

Destination	Number, size, and sex class
Lisianski Island	1 subadult male
Pearl and Hermes Atoll	3 adult males 4 adult females 2 subadult females 2 juvenile males
Kure Atoll	2 adult males 8 adult females 3 subadult males 3 weaned female pups
Unknown location	1 weaned female pup

Table 6.5b.—Documented movement of Hawaiian monk seals from Midway Atoll to other locations in 1999, summarized by movements between two locations. No seals made more than one observed trip.

Destination	Number, size, and sex class
Pearl and Hermes Atoll	2 adult males 7 adult females 1 subadult female 1 juvenile male
Kure Atoll	2 adult males 5 adult females 1 subadult male 1 weaned female pup

Table 6.6.--Factors affecting Hawaiian monk seal survival at Midway Atoll in 1999.

Size	Sex	Total	Outcome		
			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 (none observed)					
Entanglement					
Adult	Female	1 ^a	0	0	0
Juvenile	Male	1 ^b	0	0	0
Weaned pup	Male	1 ^c	0	0	0
Other/Unknown					
Adult	Male	1 ^d	0	1	0
	Female	1	1	0	0
Weaned pup	Male	1 ^e	0	0	1
Subadult	Female	1 ^f	0	1	0

^aSeal released by researchers.

^bSeal freed itself.

^cSeal released by researchers.

^dSeal died during restraint for health assessment study.

^ePup weaned prematurely due to an exchange. Condition deteriorated to thin over a 21-day period postweaning before pup disappeared.

^fSeal was found dead, but the cause was not determined.

**CHAPTER 7. THE HAWAIIAN MONK SEAL AT
KURE ATOLL, 1999**

Irene T. Kinan, David V. Gummesson, and R. Wayne Sentman

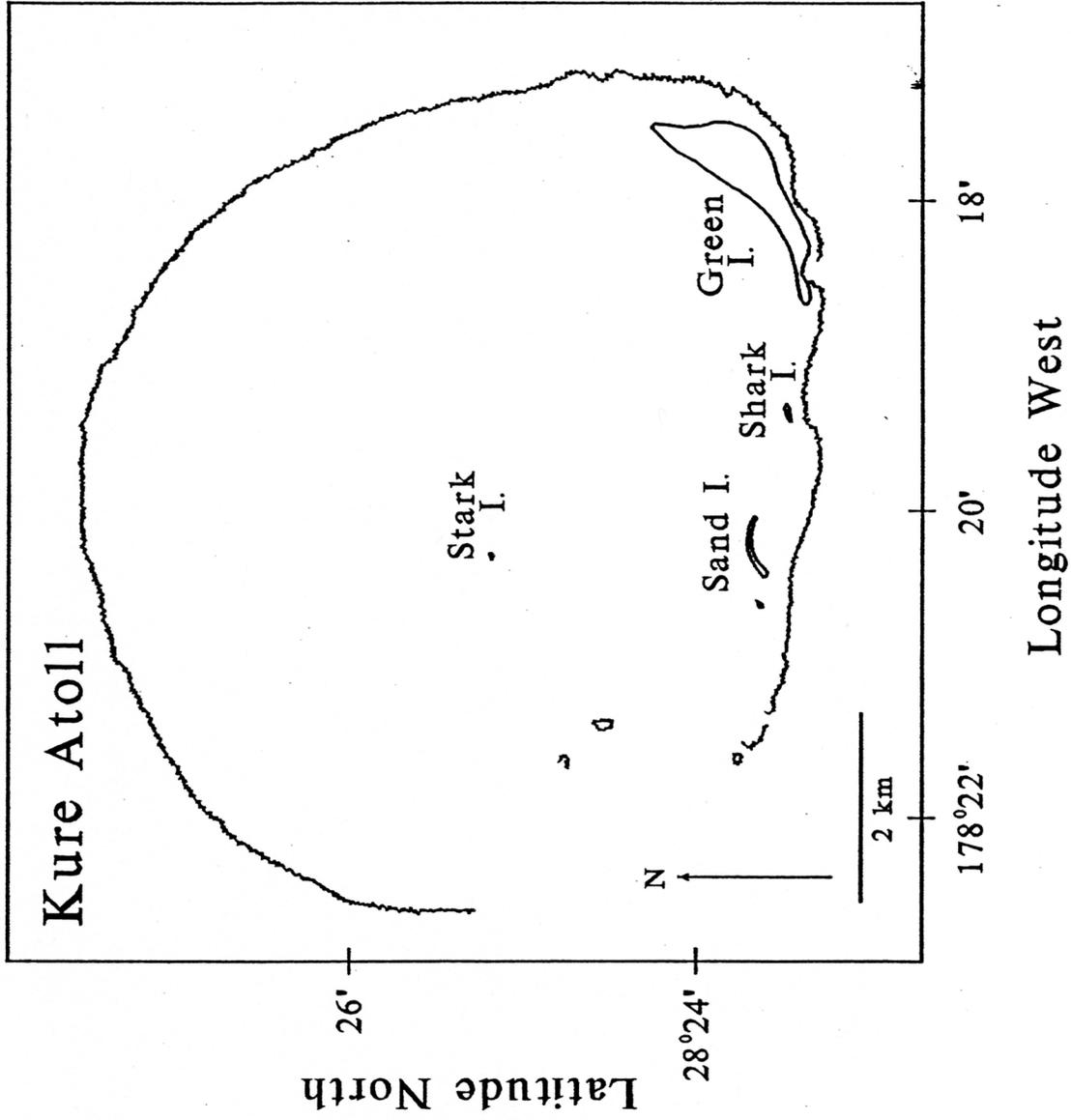


Fig. 7.1 Kure Atoll in the Northwestern Hawaiian Islands.

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, the enclosed lagoon, one permanent vegetated island (Green Island), two sand islets (Sand and Shark), and an ephemerally emergent area known locally 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, this station was closed and vacated by the USCG, leaving the atoll uninhabited. In 1993, the USCG completed the removal of most of the 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 to 1991) 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

National Marine Fisheries Service (NMFS) began research on the Hawaiian monk seal at Kure Atoll in 1981. In 1999, research was conducted by NMFS from May 24 to July 23, and July 27 to August 2. The perimeter of Green Island was divided into eight sectors using artificial or natural landmarks. Research objectives specific to this subpopulation in 1999 included (1) evaluating the success of past management efforts and (2) assessing entanglement risks and other negative impacts following the *Paradise Queen II*'s grounding at Kure Atoll on October 16, 1998.

Censuses and Patrols

Atoll censuses ($n = 10$) were conducted every fifth day on average, from June 4 to July 19. Each census began between 1237 and 1345 and ended between 1435 and 1600 Hawaii standard time. All islets were censused on foot by one or two persons. Stark Reef was not emergent during the 1999 field season.

Patrols were conducted on non-atoll census days to identify seals and monitor locations used by parturient females. In total, 31 patrols of Green Island and 5 patrols of Sand islet were conducted. Patrols were not conducted the day before atoll censuses.

Individual Identification

A total of 127 individuals (106, excluding pups) were identified by existing or applied tags, bleach marks, scars, or natural markings. All weaned pups ($n = 21$) were tagged with Temple Tags, and passive integrated transponder (PIT) tags. One subadult male seal was re-tagged.

Samples Collection

Twenty-seven scat and one spew samples were collected. Skin punches were collected from 21 seals during tagging. Samples from four placentas were also collected. In total, 180 items of potentially entangling marine debris were inventoried; 2 items removed from seals were collected and the remainder was destroyed. Two large (estimated >500 lbs) conglomerates (one net and one line) remain buried on Green Island. Emergent parts of both conglomerates were burned in situ to minimize their entanglement hazard.

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 1999, large portions of the hull and wheel house remained on the reef, smaller structural pieces had washed ashore, and a large portion of the main deck had come to rest on the west side of Green Island in sector 1. Monk seals occasionally haul out on the deck. In addition, the beaches of the east side of Green Island were littered with pieces of foam insulation from the interior hull of the boat. This non-biodegradable insulation is easily blown about by the wind.

During clean-up effort soon after *Paradise Queen II* ran aground, accessible hazardous material and lobster traps were removed from the marine environment. Lead was removed from approximately 350 recovered traps, and the traps were stacked at the northeast end of the runway on Green Island. Since that time, additional lobster traps have continued to wash ashore. During 1999, approximately 100 traps were removed from Green Island beaches. In late July, the crew of the NOAA ship *Townsend Cromwell* removed these newly recovered traps and approximately half of the original lobster traps. An underwater reef survey conducted July 23 by NMFS personnel noted that traps were still in the water.

In addition to the traps above, a very large line conglomerate washed ashore at the southeast point of Green Island at the border of sectors 5 and 6. Based on other line debris recovered with lobster traps from other sectors of the islet, it is evident that this line conglomerate is debris from the *Paradise Queen II*. Although this conglomerate was partially burned in an effort to minimize its entanglement hazard, only a small portion was consumed, and the rest remains onshore.

Photographic Observation and Seal Disentanglement

From July 27 to August 2, a NMFS observer accompanied a British Broadcasting Corporation (BBC) film crew to Kure Atoll. During this trip, an entangled weaned female pup was released from a floating 600-lb conglomerate of marine debris composed of fishing net and line. An additional pup was also observed swimming in this debris. After the entangled pup was freed, the net was removed from the reef. The entire episode was documented on film by the BBC crew.

RESULTS

Subpopulation Abundance and Composition

The mean (\pm SD) of 10 atoll censuses was 53.3 seals (\pm 9.7) including pups, and 42.0 seals (\pm 8.7) excluding pups (Table 7.1). The total spring-summer subpopulation was 124 individuals, 103 excluding pups (Table 7.2). The numbers of tagged known-age seals born at Kure Atoll during the period from 1981 to 1998, and resighted at any location in 1999, are summarized in Table 7.3.

Reproduction

At least 21 pups were born at Kure Atoll in 1999, and all successfully weaned (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 \times 100 was 58.3% ($(21/36) \times 100$). Eight of the 11 identified parturient females (73%) had either been temporarily maintained as pups in the Kure Atoll Head Start Project or rehabilitated from FFS via the Head Start enclosure.

Interatoll Movement

Interatoll movement was documented for 19 seals that completed a total of 31 movements between Kure Atoll and either Pearl and Hermes or Midway Atolls (Table 7.5a and b).

Factors Affecting Survival

Entanglement in marine debris resulted in two life-threatening conditions (Table 7.6). One weaned pup was observed with a plastic ring stuck on its muzzle. This weaned pup was subsequently restrained and the ring removed and collected. A second weaned pup was discovered entangled and then released from a large trawl net caught on the emergent reef northeast of Green Island.

ACKNOWLEDGMENTS

We acknowledge the support of the State of Hawaii, Department of Land and Natural Resources and Division of Forestry and Wildlife. We thank the captain and crew of the NOAA ship *Townsend Cromwell* for logistical support, for transport to and from Kure Atoll, and for their hard work in removing derelict lobster traps.

**TABLES
for Kure Atoll**

Table 7.1.--Summary statistics for atoll censuses ($n = 10$) of Hawaiian monk seals at Kure Atoll from June 4 to July 19, 1999.

Size/Sex	Mean number of individuals	Standard deviation
Adults	25.3	6.5
Male	10.0	2.9
Female	14.6	3.9
Unknown	0.7	1.1
Subadults	10.0	1.9
Male	7.5	1.4
Female	2.3	1.6
Unknown	0.2	0.4
Juveniles	6.7	2.6
Male	4.5	1.8
Female	2.1	1.1
Unknown	0.1	0.3
Pups	11.3	2.3
Male	4.9	1.2
Female	6.3	1.3
Unknown	0.1	0.3
Non-pup total	42.0	8.7
Grand total	53.3	9.7

Table 7.2.--Composition of the Hawaiian monk seal subpopulation at Kure Atoll during the spring and summer of 1999. Includes all known parturient females and pups born during the calendar year.

Size	Number of seals			Sex ratio male:female
	Male	Female	Total	
Adults	28	36	64	0.8:1
Subadults	14	8	22	1.8:1
Juveniles	10	7	17	1.4:1
Pups	8	13	21	0.6:1
Non-pup total	52	51	103	1.0:1
Grand total	60	64	124	0.9:1

Table 7.3.--Summary of tagged known-age seals born at Kure Atoll and resighted at any location in 1999.

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

^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 1999.

Event	Number of pups		
	Male	Female	Total
Born	8	13	21
Died prior to weaning	0	0	0
Weaned	8	13	21
Tagged	8	13	21

Table 7.4b.--Summary of nursing periods and measurements of weaned pups at Kure Atoll in 1999. Nursing periods were calculated where both birth and weaning date ranges were ≤ 4 d. All measurements were taken within 2 weeks after weaning.

	Nursing period (d)	Axillary girth (cm)	Straight dorsal length (cm)
Mean	36.0	110.5	128.4
Standard deviation	3.5	8.0	6.0
<i>n</i>	5	11	11

Table 7.5a.—Documented movement of Hawaiian monk seals to Kure Atoll from other locations in 1999, summarized by movements between two locations. No seals made more than one observed trip.

Original location	Number, size, and sex class
Midway Atoll	2 adult males 5 adult females 1 subadult male 1 weaned female pup
Pearl and Hermes Atoll	1 adult female 1 subadult male 1 subadult female

Table 7.5b.—Documented movement of Hawaiian monk seals from Kure Atoll to other locations in 1999, summarized by movements between two locations. Two seals made more than one observed trip.

Destination	Number, size, and sex class
Pearl and Hermes Atoll	1 adult female 1 subadult male 1 subadult female
Midway Atoll	2 adult males 8 adult females 3 subadult males 3 weaned female pups

Table 7.6.--Factors affecting Hawaiian monk seal survival at Kure Atoll in 1999.

Size	Sex	Total	Outcome		
			Injured	Died	Probably died
Attack by Large Shark (none observed)					
Mounting by Males (none observed)					
Entanglement					
Weaned pup	Male	1 ^a	0	0	0
	Female	1 ^b	0	0	0

^aSeal had a plastic circular object stuck on his muzzle, released by observers.

^bSeal was discovered entangled in floating net/line conglomerate and released by observers during the BBC film crew visit, after the end of the main field season. Another pup was swimming in the debris but not entangled.

**CHAPTER 8. THE HAWAIIAN MONK SEAL ON
NIHOA AND NECKER ISLANDS, 1999**

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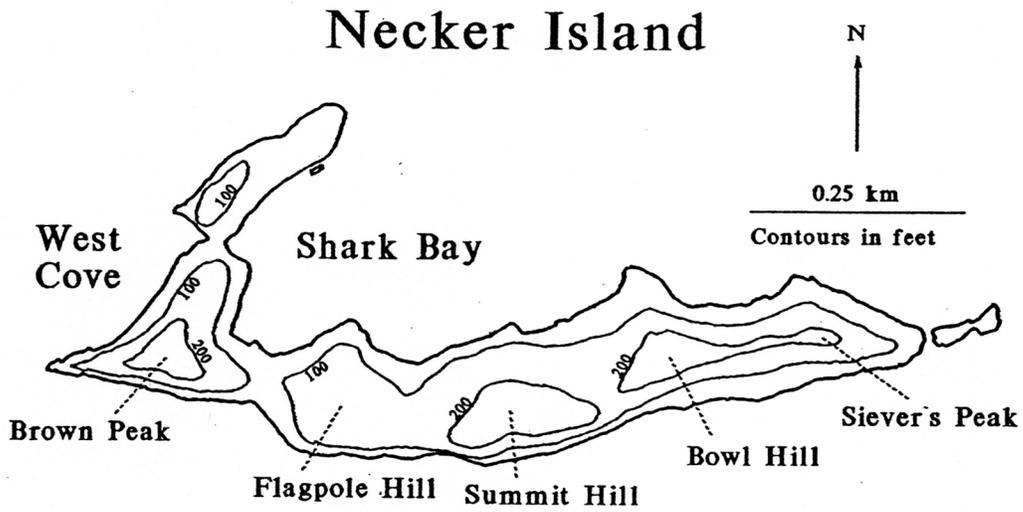
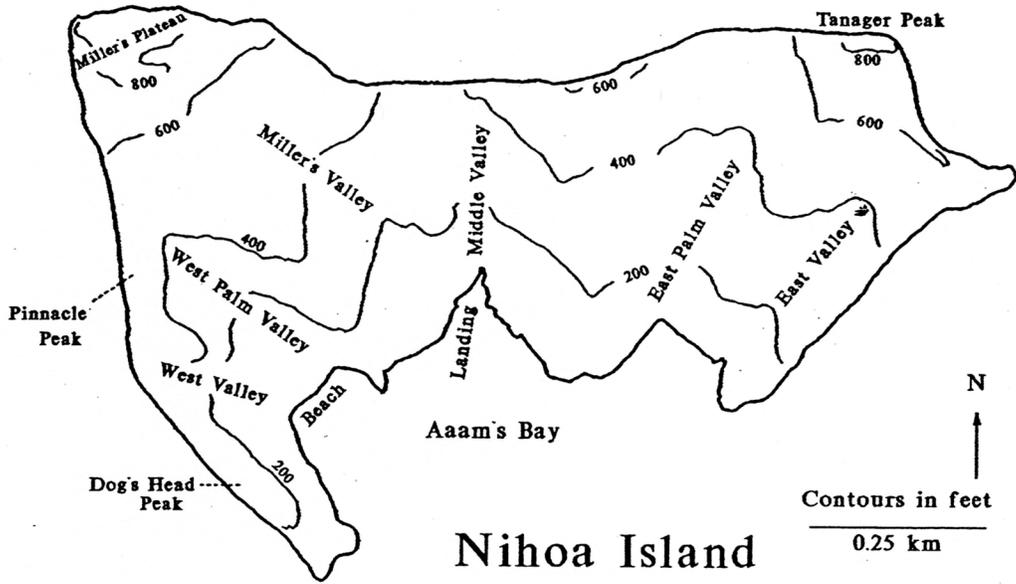


Fig. 8.1 Nihoa and Necker Islands in the Northwestern Hawaiian Islands.

Nihoa Island (lat. 23°04'N, long. 161°55'W) and Necker Island (lat. 23°36'N, long. 164°42'W) are located ca. 450 and 750 km, respectively, northwest of Oahu in the Northwestern Hawaiian Islands (Fig. 1.1). These islands lie within the Hawaiian Islands National Wildlife Refuge. Although endangered Hawaiian monk seals use these islands, their numbers are limited by lack of haulout area.

RESEARCH

In 1999, the National Marine Fisheries Service collected data at Nihoa Island on July 31, and at Necker Island on May 17 and July 30. The perimeters of Nihoa and Necker Islands were divided into 3 and 10 sectors, respectively, using natural landmarks (Fig. 8.1). In 1999, research objectives specific to the Nihoa and Necker Islands included assessment of pup production and the extent of migration between French Frigate Shoals and these locations.

Censuses and Patrols

A beach count was conducted on Nihoa Island by two observers on July 31, beginning at 1402 Hawaii standard time and continuing for approximately 1 h. A simultaneous boat survey of the shoreline was also conducted.

Two beach counts were conducted on Necker Island, on May 17 and July 30, by three and two observers, respectively. Censuses began between 0930 and 1000 Hawaii standard time and continued for 4 or 5 h. A simultaneous boat survey was also conducted on July 30.

Individual Identification

On Nihoa Island, two seals were identified by applied tags; two weaned pups (a male and a female) were tagged with Temple tags and with passive integrated transponder (PIT) tags.

On Necker Island, four seals (three males, one female) were identified by existing tags applied at French Frigate Shoals, including an 8-yr-old female, a 10-yr-old male, a 12-yr-old male, and a 15-yr-old male. Two of these animals, both males, had last been seen at French Frigate Shoals in 1995 and 1997, respectively. The other two seals (a male and a female) were last seen at Necker Island in 1993. Two additional adult seals (a male and a female) were observed with yellow tags applied at French Frigate Shoals, but these seals were not identified.

Samples Collection

On Nihoa Island, skin punches were collected from two weaned pups during tagging. No samples were collected at Necker Island.

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RESULTS

Subpopulation Abundance and Composition

The census total for one count conducted on Nihoa Island was 31 seals (26 excluding pups). Because of limited effort, the composition of the spring-summer subpopulation was not determined.

The census totals for two counts conducted on Necker Island were 9 seals (no pups observed) on 17 May and 30 seals (29 excluding pups) on 30 July. The mean of the two counts is 19.5 (\pm 14.8 SD). Because of limited effort, the composition of the spring-summer subpopulation was not determined.

Reproduction

At least five pups were born at Nihoa Island in 1999; three were successfully weaned (two females and one male), and two were still nursing (one male and one of unknown sex). One weaned male pup was seen at Necker Island in 1999.

Interatoll Movement

Interatoll movement was not documented for seals observed at Nihoa Island. Interatoll movement was documented for two seals that completed a total of three movements between Necker Island and French Frigate Shoals (Tables 8.1a and b).

Factors Affecting Survival

Factors affecting survival were not observed on Nihoa or Necker Islands in 1999.

ACKNOWLEDGMENTS

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

**TABLES
for Necker Island**

Table 8.1a.--Documented movement of Hawaiian monk seals to Necker Island from other locations in 1999, summarized by movements between two locations. No seals made more than one observed trip.

Original location	Number, size, and sex class
French Frigate Shoals	2 adult males

Table 8.1b.--Documented movement of Hawaiian monk seals from Necker Island to other locations in 1999, summarized by movements between two locations. No seals made more than one observed trip.

Destination	Number, size, and sex class
French Frigate Shoals	1 adult male

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APPENDIXES

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

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Appendix B.--Hawaiian monk seal census form and 1999 census form directions.

(See following pages.)

1999
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.). **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 coded for all seals (Laysan and Lisianski Islands only in 1999). 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.
- T = Tag status entry for non-active tags (tags not currently on a seal). Record tag status (F or R) in notes columns. Use this data type to log seal haulout tracks at Midway Atoll.

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. 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.

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: 0 = 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 weigh 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 \leq 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)

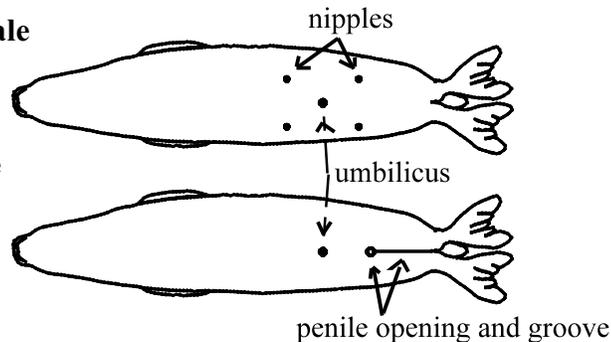
T3 = Turtle, adult ($>$ 80 cm)

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 by tail length, if it is adult-sized.

SEX M = Male
F = Female
U = Unknown

Female

Male



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 comes abreast, the seal is recorded as being on the

beach). When recording male-male interactions (at Laysan and Lisianski Islands in 1999), make a continuation line previous to the original line to indicate behaviors or changes in beach position before you come abreast of the seal.

- 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 on the fringing reef for **Midway Reef Surveys**)
- 9 = on an offshore rock/reef (not included in census tally).
- X = data not taken

CONDITION It is assumed that condition is recorded for all seals (except nursing pups) on census or atoll count. **Always record** the condition of the mother on her first sighting postpartum, and of the mother 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

If the condition code is left **blank** during an atoll or census count, condition is assumed to be medium. Codes F and T indicate extreme conditions, seals that are medium-fat, or medium-thin should be coded as medium.

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
 - 4 = partially read bleach number completed from other data
 - 5 = incompletely read bleach number, but partial data are certain (if seal can't be identified by ID or Tag #)
 - 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
- blank = ID number is certain and complete if present

TAG NO. The complete tag number if known; right justified. If a number is incompletely read, use dashes as placeholders 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 (if seal can't be identified by ID or Temporary #)
 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 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

Record detailed association data at Laysan and Lisianski Islands in 1999. Don't record associations involving turtles. If you wish to indicate that a seal was alone, use the Q (this code is alpha, not zero!) behavior code. On a census or behavior patrol data sheet, no code in any of the association columns means that the seal was alone, whereas on a regular patrol data sheet, no code may simply mean that no data were taken. It is not necessary to put an Q code for each unassociated animal on census or during behavior patrol at these locations because it will be filled in by computer. 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. Use continuation lines to record more than one association.

An association should either be all blank or have the Q, Z, or X behavior only (with no line number or distance), or have a line number, a distance, and some behavior code (other than Q 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 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 a behavior is observed that does not have a code, describe it in Notes.

1) individual seal

a) active behavior (directed towards another seal)

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

<u>Code</u>	<u>Corresponding code</u>
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.	
	1-3	Survival Factor number
	4	Factor Type. If seal is 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)

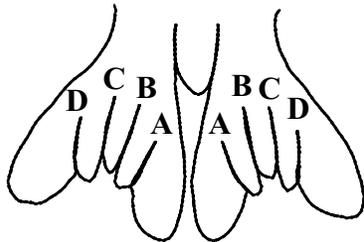
TYPE

**CODES
COLUMN**

CONTENT

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

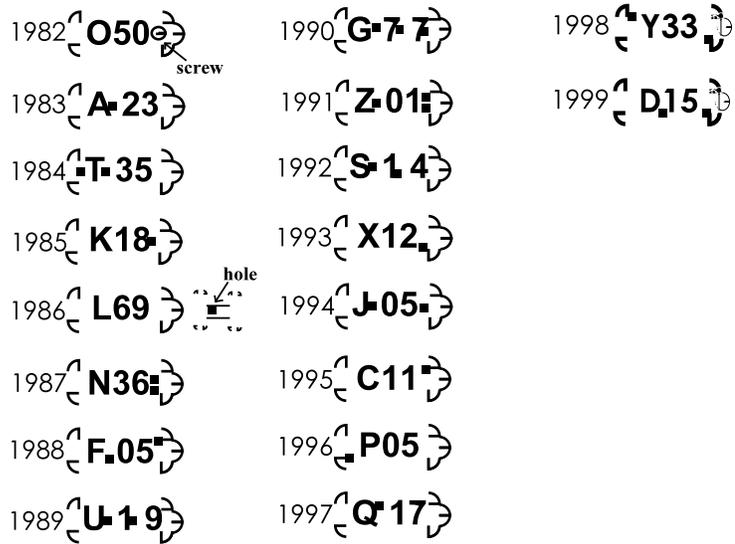
W = no. worn /abraded

CONTEST RULES

1. Size class collapse for contests: all subadults = adults (both sexes)
2. Definition of pair type (depends on associate of adult male):
 - Pair type #1: adult male with adult female (**L1**)
 - Pair type #2: adult male with juvenile or pup of either sex (**L1**)
 - Pair type #3: *single* adult male not pair type #1 or #2
3. Definition of a male-male contest (must conform to at least one condition below):
 - Distance between males = 0
 - Either adult male vocalizes (**V**) or performs a **C**, **D**, or **J**
 - If cruiser approaches to beach position ≥ 1 , regardless of other behaviors
4. Definition of winner or loser adult male (Even if the "winner" is not aware that the other seal flees, if 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)):

Case	Winner (W)	Loser (Q)	Tie (Y)
Paired Male vs. Single Male: (#1 or #2 vs. #3)	i) Original Single Male if has D	Has F	No Ties
	ii) Original Paired Male otherwise		No Ties
Male Paired with Adult Female vs. Male Paired with Juvenile Seal: (#1 vs. #2)	i) Original Male Paired with Juvenile if has D	Has F	No Ties
	ii) Original Male Paired with Adult Female otherwise		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

**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

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