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THE HAWAIIAN MONK SEAL IN THE NORTHWESTERN HAWAIIAN ISLANDS, 1998

Thea C. Johanos and Jason D. Baker
(editors)

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

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National Oceanic and Atmospheric Administration
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Honolulu Laboratory
2570 Dole Street
Honolulu, Hawaii 96822-22396

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U.S. DEPARTMENT OF COMMERCE
William M. Daley, Secretary
National Oceanic and Atmospheric Administration
D. James Baker, Under Secretary for Oceans and Atmosphere
National Marine Fisheries Service
Penelope Dalton, Assistant Administrator for Fisheries

EXECUTIVE SUMMARY

In 1998, 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 evaluate (1) the status and trends of monk seal populations, (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 whole species, 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. 1a), the largest subpopulation. In 1998, 235 pups were counted at these sites, 109 of which were born at French Frigate Shoals. This is the highest number of pups counted since standard assessments began. 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).

Since the mid 1980s, adults have comprised a growing portion of the animals counted (Fig. 1c) and, in 1998, the composition of the counts remained largely skewed towards adults. This shift in composition bodes poorly for reproduction in the near future if older adult females are not replaced by young females reaching reproductive age. The overall impact from this shift in composition will be determined by the magnitude of its change and the length of time that the resulting skewed distribution persists, neither of which can be reliably predicted at this time. High mortality of immature seals appears to be a major factor leading to the shift in composition, particularly at French Frigate Shoals and Laysan Island.

In 1998, three management activities were conducted by the Marine Mammal Research Program (Honolulu Laboratory, National Marine Fisheries Service) to enhance recovery of the species. First, debris capable of entangling seals was removed from all study sites and nine entangled seals were disentangled by field biologists. Second, debris was removed from sections of fringing reef at French Frigate Shoals and Pearl and Hermes Reef to reduce hazards to the seals, to assess the extent of reef fouling, and to determine the feasibility of large scale debris removal. Third, two adult male seals known to drown and kill pups were collected and translocated to Johnston Atoll to increase pup survival.

This document describes these and other field studies conducted during 1998. 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.

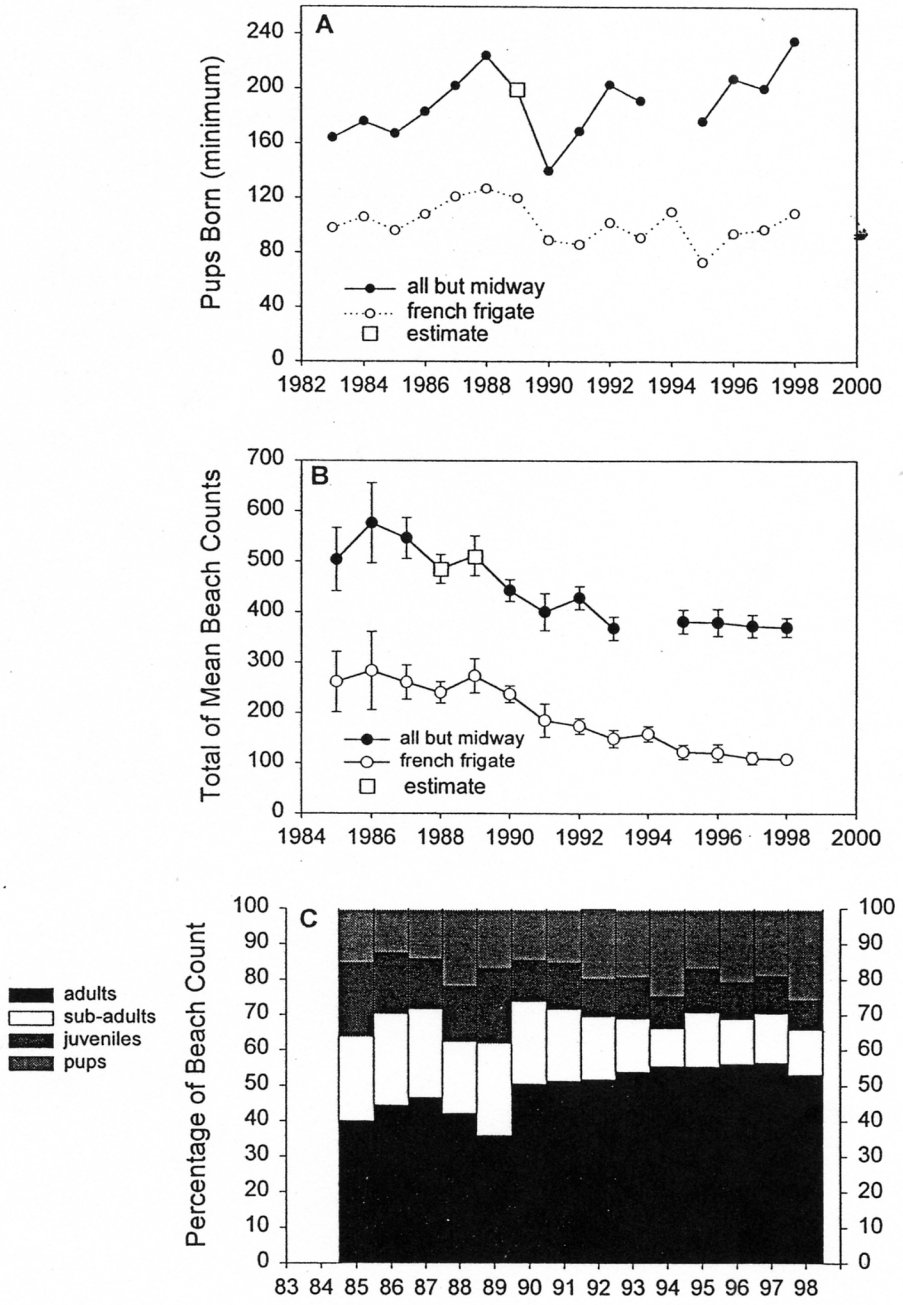

Fig. 1. Demographic trends of the Hawaiian monk seal, based on the main reproductive sites (excluding Midway Atoll). a) number of pups born. b) Total of mean beach counts, excluding pups. c) Portion of the counts comprised of adults, subadults, and juveniles.

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CHAPTER 1. GENERAL INTRODUCTION

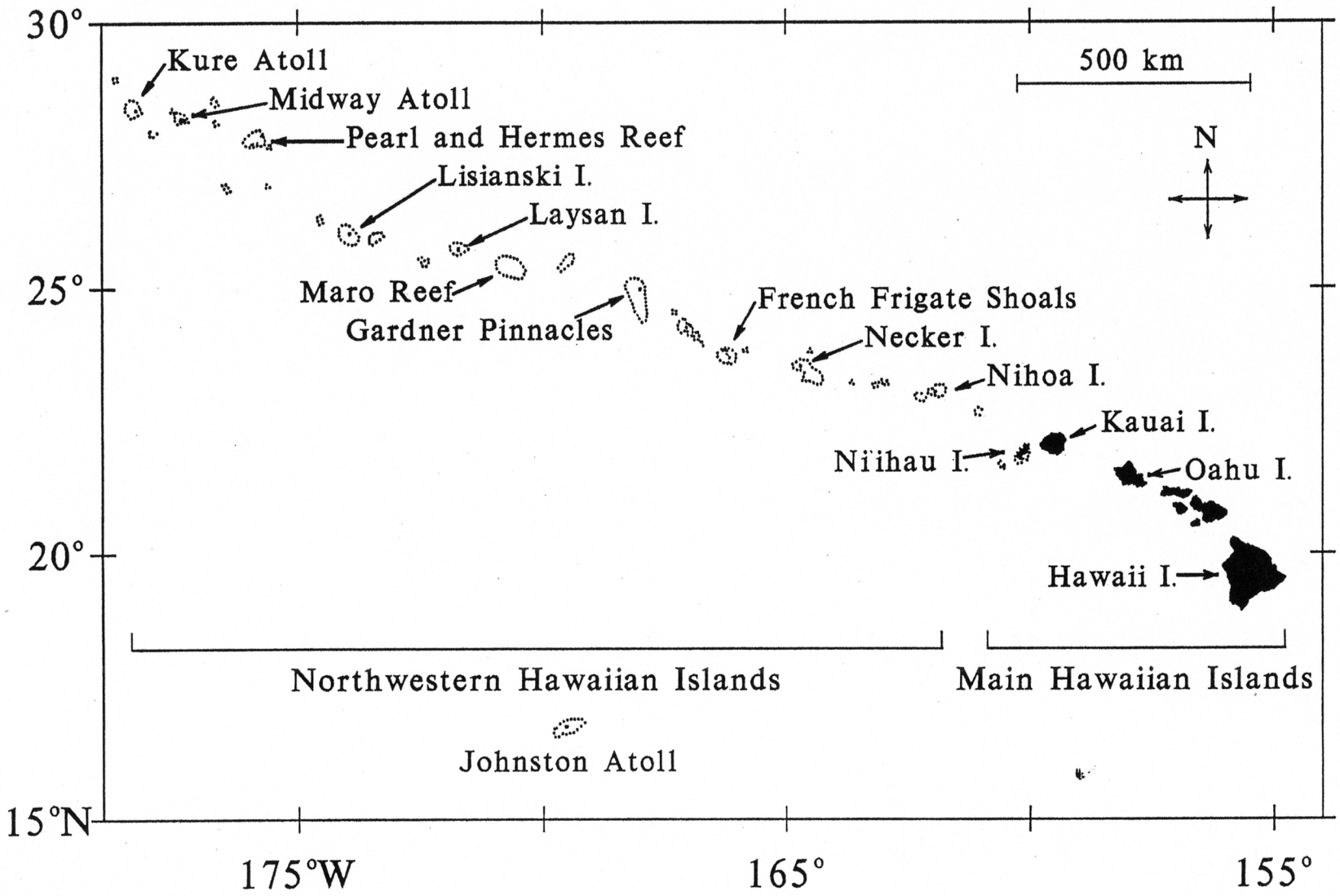

Fig. 1.1 The Hawaiian Archipelago.

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 Southwest Fisheries Science Center, Honolulu Laboratory, NMFS 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 populations, (2) natural history traits such as survival, reproduction, growth, behavior, and feeding habits, and (3) the success of various activities designed to facilitate population growth.

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

In 1998, the Hawaiian monk seal research activities were to (1) conduct beach counts (censuses), (2) tag weaned pups and immature seals for permanent identification, (3) identify other seals by previously applied tags and by natural or applied markings, (4) monitor reproduction, survival, injuries, entanglements, interatoll movements, disappearances, and deaths, (5) perform necropsies, (6) collect scat and spew samples for food habits analysis, (7) collect flipper plugs and molt samples for DNA analysis of paternity patterns and genetic variation within and among populations, (8) collect placental samples for genetic and hormonal studies, (9) disentangle seals, and (10) inventory, sample, and destroy debris capable of entangling seals. Location-specific objectives and summaries of data collected during the 1998 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.

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 to 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 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, behavior data (seal associations and interactions) were collected on Laysan and Lisianski Islands. A sample census form and guidelines for its completion are included in Appendix B. Censuses were conducted once at Necker Island, or every 4 to 7 d (at all other locations), starting at 1300 Hawaii standard time when possible, using census methods and criteria outlined in Johanos et al. (1987). Atoll-wide counts for locations with more than a single island (French Frigate Shoals, Pearl and Hermes Reef, Midway Atoll, and Kure Atoll) were completed within 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, special efforts were directed toward documentation of (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, and birth and weaning information were 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 ended up with multiple pups. Most frequently, such exchanges occurred during an aggressive interaction between the two females. On other occasions, a mother and pup became separated, and one or both seals then actively sought and obtained another nursing relationship.

The average nursing period was calculated for the pups at each location. 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 in nursing relationships 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

A wide range of injuries was observed. The origins of these 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 more than half a flipper (either foreflipper or hindflipper); (3) at least 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). Injuries that were healed when first observed were not included.

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

Mobbing and other mating-related male aggressions were observed and recorded. By definition, mobbing occurred when multiple males attempted to mate with a single seal, usually an adult female or immature seal of either sex, causing injury or death of that seal (e.g., Alcorn, 1984). Mating-related aggression was defined as any incident where an adult or subadult male repeatedly bit the dorsum, attempted to mount, and tried to prevent the escape of another seal. These incidents were summarized in this report if they simultaneously involved more than one male aggressor or resulted in at least one puncture or gaping wound (missing skin or extending into the blubber layer) or ≥ 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 by 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 population, year of birth, and individual ID (Gilmartin et al., 1986). In addition, two passive integrated transponder (PIT) tags were implanted subcutaneously in the dorsum of most weaned pups (see Lombard et al., 1994, for detailed tagging procedures).

Colored plastic Temple Tags have been applied to nearly all weaned pups since 1981 at Kure Atoll, 1982 at Lisianski Island, 1983 at Laysan Island and Pearl and Hermes Reef, 1984 at French Frigate Shoals, and 1995 at Midway Atoll. Pups at Midway Atoll, Necker and Nihoa Islands, and the main Hawaiian Islands have been tagged opportunistically since 1983. Since 1991, PIT tags have also been implanted subcutaneously in the ankle (1991) or the dorsum (all subsequent years) of most weaned pups.

In 1998, untagged immature seals were tagged with Temple Tags uniquely coded to indicate that their ages and birth locations were unknown and also received PIT tags. Immature seals with lost or broken tags were retagged to maintain their identities.

At five locations (Laysan Island, Lisianski Island, Pearl and Hermes Reef, Midway Island, and Kure Atoll), seals were bleach-marked for individual identification (Stone, 1984), using the solution described in Johanos et al. (1987). Molting seals were re-marked to maintain their identities. At Laysan and Lisianski Islands, nursing pups were also bleached prior to molt.

Tags, scars, natural markings, and any applied bleach marks were sketched on an individual scar card, 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.

Population size and composition were determined at locations where all seals were identified (i.e., observers no longer encounter unidentified seals). These statistics included all individuals seen alive at the location during the interval from March through August, and all known parturient females and pups born during the year. If a seal was seen at more than one location during March-August, it was included in the population where it was sighted closest to May 15 unless it pupped or molted at another location. A parturient female was always included in the population where it pupped, and a non-parturient seal was included in the population where it molted. Pups were always included in the population where they were born.

The movement of seals between island or atoll populations confounds the estimation of population size and composition. This is particularly true at Midway Atoll, where a number of

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

the observed seals were tagged at other locations (primarily Kure Atoll and Pearl and Hermes Reef). These seals may be transient visitors, and additional study is needed to distinguish them from seals that reside at Midway Atoll.

Measurements of Seals

Pups were measured to determine their condition, and the relation between size and survival. Measurements were taken as soon after weaning as possible and included straight dorsal length (Winchell, 1990) and axillary girth (American Society of Mammalogists, 1967).

Collection of Samples

Samples were collected for DNA analysis, pathology analysis, investigation of food habits, and documentation of marine debris. Tissue samples for DNA analysis 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. The primary objectives of genetic analyses are to investigate paternity patterns and determine genetic variability within and among populations.

For each dead seal recovered, an external examination was made, photographs were taken, 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 (Alcorn, 1984) for analysis of food habits. Emphasis was placed on collecting these samples from seals of known size and sex class, but samples from seals of unknown size and sex class were also collected.

Nets, lines, ropes, and other debris capable of entangling seals and turtles were inventoried and destroyed, following the methods in Johanos and Kam (1986).

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CHAPTER 2. THE HAWAIIAN MONK SEAL ON FRENCH FRIGATE SHOALS, 1998

Mitchell Craig, Melissa Shaw, Guilia Mo,
and Matthew Rutishauser

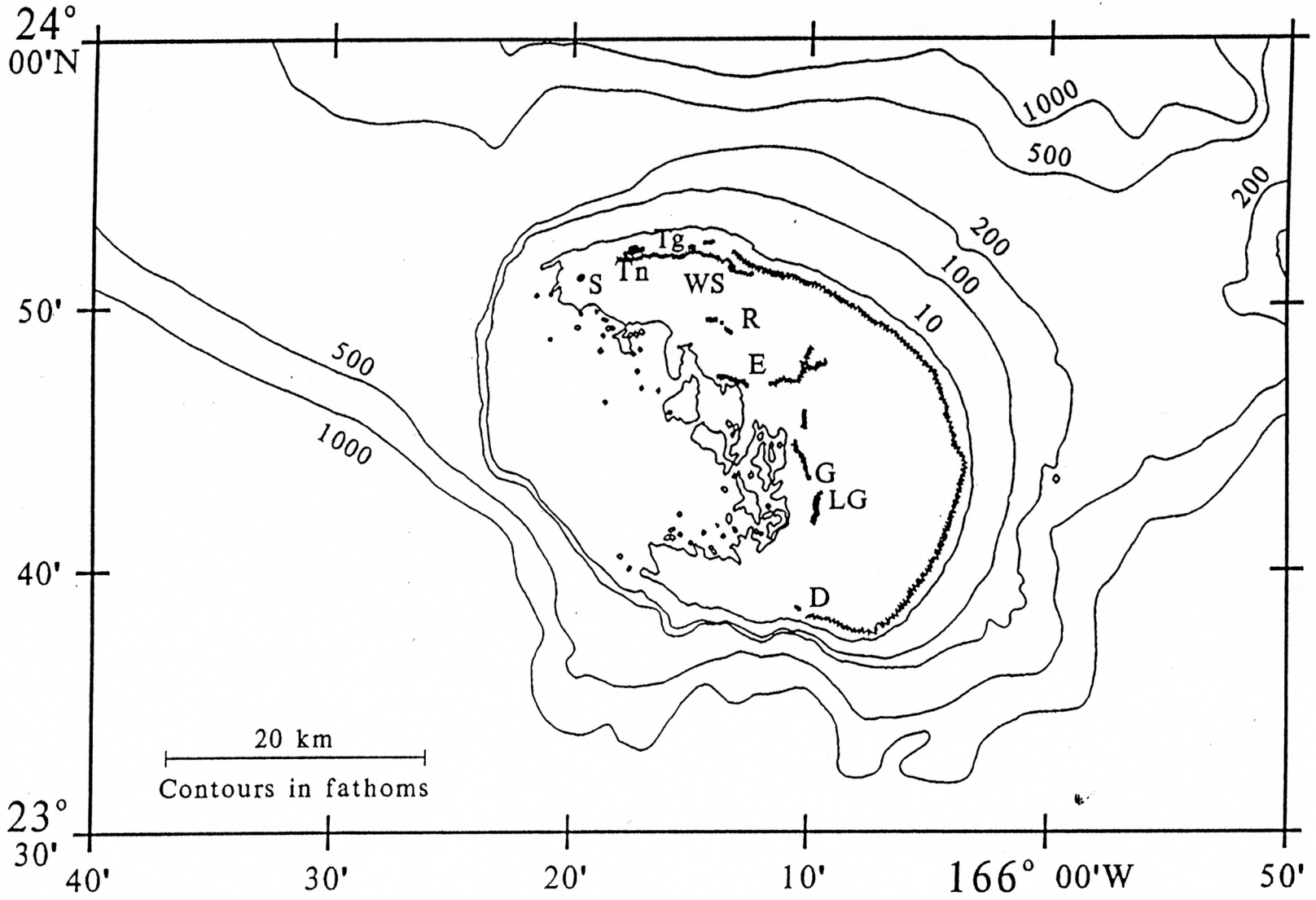

Fig. 2.1. French Frigate Shoals in the Northwestern Hawaiian Islands. Islands are: Disappearing (D), East (E), Gin (G), Little Gin (LG), Round (R), Shark (S), Tern (Tn), Trig (Tr), and Whaleskate (WS).

The largest island population 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 10 islands and 7 sand spits (Fig. 2.1).

RESEARCH

The National Marine Fisheries Service (NMFS) began research on Hawaiian monk seals at FFS in 1982. In 1998, research was conducted by NMFS during May 2-September 5. Incidental observations were recorded by U.S. Fish and Wildlife Service (USFWS) personnel during the rest of the year. The perimeters of the six larger islands were divided into sectors using artificial or natural landmarks. Research activities specific to this population in 1998 included (1) epidemiological assessment of all age and sex classes, (2) investigation of habitat use patterns using seal-mounted video cameras, (3) assessment of nearshore prey availability, (4) removal of adult male seals known to drown weaned pups, (5) assessment of number and behavior of Galapagos sharks in the nearshore area at Trig and Whaleskate Islands, and (6) large-scale debris removal from the fringing reef.

Censuses and Patrols

Atoll censuses (n = 10) were conducted every 5 d, on average, from June 9 to July 30. Each atoll census began between 1045 and 1310 Hawaii standard time and ended between 1430 and 1755. Round Island, Mullet Island, and Disappearing Island were censused either from a boat or on foot, while the remaining islands were censused on foot by one or two persons. Patrols were conducted on noncensus days. East, Mullet, Round, and Trig Islets were visited at least every 3 d to monitor pupping activity and factors affecting survival. Patrols of Tern Island were conducted every 4 d.

Individual Identification

A total of 412 individuals (303 excluding pups) were identified by existing or applied tags, scars, or natural markings. Most weaned pups (88 of 97) were tagged with Temple Tags; 76 of these same pups were tagged with passive integrated transponder (PIT) tags. One juvenile female, 5 adult males and 1 adult female were tagged, and 23 juvenile, subadult or adult seals (13 male, 10 female) were retagged with Temple Tags.

Collection of Samples

Sixty-two scat and spew samples were collected. Tissue plug samples were collected from 89 seals during tagging. Necropsies were performed on two dead seals found at the study site, and tissue samples were collected from both seals. In total, 10 pieces of potentially entangling debris were inventoried and destroyed.

Special Studies

Health and Disease Study

In July, biologists collected blood, fecal samples, and blubber biopsies from 33 seals (13 adult and 10 immature seals, and 10 weaned pups) restrained specifically for epidemiological studies. Blood, fecal samples were also collected from five seals instrumented with video cameras for a habitat use study and two seals translocated to Johnston Atoll. The purpose of the sampling was to obtain baseline information to assess the health and disease status of the Hawaiian monk seal population.

Habitat Use Study

In July and August, five molted adult males were instrumented with video cameras for 4 to 34 d. The seals were instrumented as part of a habitat use study conducted in collaboration with the National Geographic Society**.**

Prey Availability

The Insular Resources Investigation (IRI) of the Honolulu Laboratory, NMFS, conducted a study at FFS to determine if a decline had occurred in fish stocks that are potential prey for seals (DeMartini et al., 1993). In August, the IRI conducted transects at nine stations around FFS to estimate densities of higher taxonomic categories of reef fishes. These surveys replicated surveys conducted at FFS during 1980-83, 1992, and 1995-97. In 1998, this study was expanded to assess prey availability at deeper sites (50-60m). The results of this ongoing research will be reported at the conclusion of these studies.

Adult Male Translocation

Two adult male seals known to drown and kill pups during mounting attempts were captured in June, instrumented with satellite linked time-depth recorders, and translocated to Johnston Atoll, 860 km south of FFS. Neither seal had returned to FFS by September. The last transmitter contact from both seals was received in July.

Galapagos Shark (*Carcharhinus galapagoensis*) Assessment

Fourteen individual Galapagos sharks were tagged with colored Floy® spaghetti tags near shore to Trig Island. Galapagos sharks were also identified near shore to East Island and Round Island. Two pups were observed being killed by Galapagos sharks. At least one Galapagos shark was observed patrolling near to Trig Island on most of the 89 d researchers were present between May 2 and September 4. Nine different Galapagos sharks were the most observed in 1 d at Trig Island.

Large-Scale Debris Removal from Fringing Reef

A cooperative multi-agency reef cleanup at FFS involved the USCGC *Kukui* and the NOAA ship *Townsend Cromwell.* Personnel representing eight different agencies removed debris from a section of fringing reef to reduce these hazards to monk seals and other marine life, and assess the extent of reef fouling.

RESULTS

Population Abundance and Composition

The means (±SD) for 10 atoll censuses were 167.0 seals (±9.0) including pups, and 108.5 seals (±7.0) excluding pups (Table 2.1). The total spring-summer population was 412 individuals, 303 excluding pups (Table 2.2). This number may be a subset of the total identified in the calendar year, but is not in this case. The numbers of tagged known-age seals born at FFS during the period from 1984 to 1997 and resighted there in 1998 are summarized in Table 2.3.

Reproduction

At least 109 pups were born; 97 were weaned and 12 died or disappeared prior to weaning (Table 2.4a). Four pups were born after September 5. One fetus was found, but not counted in the total number of pups born. Nursing periods and measurements of weaned pups are summarized in Table 2.4b. The birth rate, measured as number of pups born to the number of adult-sized females in the population was 71.2% (109/153). The birth rate was 70.6% (60/85) for older (>14 years old) and unknown-age adult females and 69.1% (47/68) for younger females of adult size (≤ 14 years old). The mean (±SD) lactation period for 49 females was 39.9 d (±5.7 d). At least 26 pups were fostered by mothers other than their own.

Interatoll Movement

Interatoll movement was documented for five seals that made a total of seven movements between FFS and either Laysan Island or Pearl and Hermes Reef (Tables 2.5a and b).

Factors Affecting Survival

Attacks by large sharks, mounting attempts by males, entanglement, emaciation, and other-unknown factors resulted in 43 life-threatening conditions, which led to the confirmed deaths of 8 animals and the probable death of 14 seals (Table 2.6). Two seals were found entangled; both were released by observers. In addition to the events presented in Table 2.6, one aborted fetus was found on Tern Island in January and six incidents of adult male aggression were observed; each incident involved an adult male attempting to mount a weaned pup but did not result in obvious injury.

ACKNOWLEDGMENTS

We acknowledge the support of the U.S. Fish and Wildlife Service and the Hawaiian Islands National Wildlife Refuge staff. We thank the captain, officers, and crew of the NOAA ships *Townsend Cromwell* and *Ka'imimoana*, and Coast Guard cutters *Kiska* and *Kukui* for logistical assistance.

TABLES
for French Frigate Shoals

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Table 2.1.--Summary statistics for atoll censuses (n = 10) of Hawaiian monk seals at French Frigate Shoals from June 9 to July 30, 1998.

Size/Sex	Mean number of individuals	Standard deviation
Adults	90.7	5.6
Male	25.8	2.3
Female	62.3	5.0
Unknown	2.6	1.3
Subadults	12.8	2.7
Male	4.0	1.6
Female	8.1	2.2
Unknown	0.7	0.9
Juveniles	4.9	2.0
Male	1.9	1.3
Female	2.6	1.3
Unknown	0.4	0.7
Pups	58.5	4.1
Male	20.2	4.2
Female	12.8	3.7
Unknown	25.5	3.9
Non-pup Total	108.5	7.0
Grand Total	167.0	9.0

Table 2.2.--Composition of the Hawaiian monk seal population at French Frigate Shoals during the spring and summer of 1998. Includes all pups born during the calendar year.

	Number of seals				
Size	Male	Female	Unknown	Total	Sex ratio male:female
Adults	102	153	0	255	0.7:1
Subadults	10	21	0	31	0.5:1
Juveniles	7	10	0	17	0.7:1
Pups	55[a]	48	6	109[b]	1.1:1
Non-pup Total	119	184	0	303	0.6:1
Grand Total	174	232	6	412	0.8:1

[a] Includes one neonatal pup death.
[b] One fetus is not included in this total.

Table 2.3.--Summary of tagged known-age seals born at French Frigate Shoals and resighted there in 1998.

Age (years)	Sex	Number originally tagged	Number resighted in 1998
14	Male	49	8
	Female	43	14
13	Male	48	3
	Female	38	9
12	Male	52	11
	Female	48	16
11	Male	55	13
	Female	51	14
10	Male	52	5
	Female	62	8
9	Male	51	6
	Female	50	5
8	Male	39	1
	Female	40	2
7	Male	24	1
	Female	44	3
6	Male	36	2
	Female	55	6
5	Male	40	3
	Female	39	2
4	Male	47	1
	Female	48	4
3	Male	29	2
	Female	26	3
2	Male	39	5
	Female	30	5
1	Male	32	1
	Female	19	6

Table 2.4a.--Summary of Hawaiian monk seals born at French Frigate Shoals in 1998.

Event	Number of pups			
	Male	Female	Unknown	Total
Born	55	48	6	109[a]
Died/probably died prior to weaning	4	3	5	12
Weaned	51[b]	45[c]	1	97
Tagged	49	39	0	88[d]

[a]One male fetus was also found but is not included in the total number of pups born.
[b]Two weaned male pups were not tagged due to a shark injury or ulcerated eye.
[c]Five weaned female pups were not tagged due to shark injury. One weaned female pup was not tagged due to death from male mounting.
[d]One female pup, born in 1998, was tagged in January 1999.

Table 2.4b.--Summary of nursing periods and measurements of weaned pups at French Frigate Shoals in 1998. 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	40.9	106.3	126.8
St. Dev.	7.7	10.5	7.2
n	18	68	68

Table 2.5a.--Known movement of Hawaiian monk seals to French Frigate Shoals from other locations in 1998, summarized by movements between two locations.

Original location	Number, size, and sex class
Laysan Island	2 adult females
Pearl and Hermes Reef	1 juvenile female

Table 2.5b.--Known movement of Hawaiian monk seals from French Frigate Shoals to other locations in 1998, summarized by movements between two locations. One seal made two trips.

Destination	Number, size, and sex class
Laysan Island	1 adult male, 3 adult females

Table 2.6.--Factors affecting Hawaiian monk seal survival at French Frigate Shoals in 1998.

			Outcome		
Size	**Sex**	**Total**	**Injured**	**Died**	**Probably died**
		Attack by Large Shark			
Adult	Male	1	1	0	0
	Female	2	2	0	0
Juvenile	Female	1	1	0	0
Weaned pup	Male	6	5	1	0
	Female	3	1	2[a]	0
Nursing pup	Male	3	1	2[a]	0
	Female	4	4	0	0
		Mounting by Males			
Adult	Female	1	1	0	0
Weaned pup	Male	1	1	0	0
	Female	1	0	1	0
		Entanglement			
Adult	Female	1[b]	0	0	0
Weaned pup	Female	1[b]	0	0	0
		Emaciation			
Juvenile	Male	1	0	0	1
		Other/Unknown			
Adult	Female	2[c]	1	0	0
Weaned pup	Male	1	0	0	1
	Female	3	0	0	3
	Unknown	1	0	0	1
Nursing pup	Male	2	0	1	1
	Female	3	0	0	3
	Unknown	5	0	1	4

[a]One female weaned pup and one male nursing pup were observed beingeaten by Galapagos sharks.

[b]Seal was released by observers.

[c]Seal with an evulsed uterus or retained placenta was lethargic and had restricted mobility, but was resighted alive the following month.

CHAPTER 3. THE HAWAIIAN MONK SEAL ON LAYSAN ISLAND, 1998

Brenda L. Becker, Barbie L. Byrd, and Dorothy M. Dick

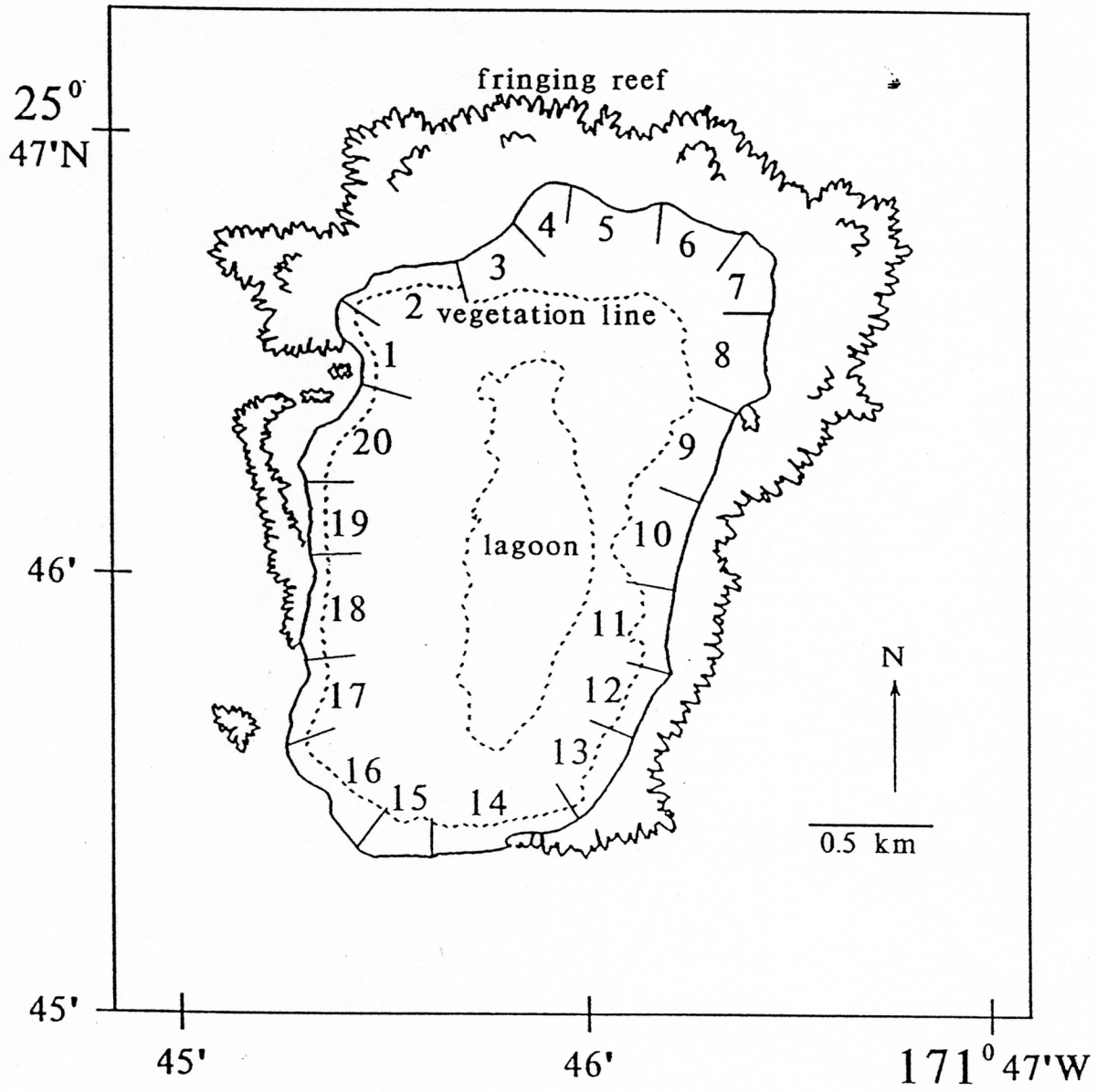

Fig. 3.1 Laysan Island in the Northwestern Hawaiian Islands.

Laysan Island (lat. 25°46'N, long. 171°46'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 major 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 1998, research was conducted by NMFS during March 16-July 26, and incidental observations were recorded by U.S. Fish and Wildlife Service (USFWS) personnel during the rest 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 population in 1998 included identification of all seals, assessment of maternity and pup exchanges, comparison of two methods to measure length of weaned pups, description of male behavioral patterns and aggression to determine if the removal of 22 adult males from Laysan Island in 1994 reduced the incidence of mobbing, and identification of any of those males that may have returned to Laysan after translocation to the main Hawaiian Islands.

Censuses and Patrols

Censuses and patrols were scheduled to ensure that the entire island perimeter was monitored at least once each day during March 30-July 18. Censuses (n = 26) were conducted by two observers every fourth day from April 8 to July 18. Each census began at 1300 Hawaii standard time and continued for 2.6 to 4.2 h.

Standardized behavior patrols were conducted on 76 noncensus days from March 30 to July 16 to assess activity patterns of adults and large subadults, document male aggression, and detect mobbing incidents. During behavior patrols, attention was directed out to sea as much as possible because mobbings have been observed most frequently in the water. Two full-island incidental patrols to record noteworthy events were conducted on noncensus and nonbehavior patrol days.

Individual Identification

A total of 291 individuals (245 excluding pups) were identified by existing or applied tags, bleach marks, scars, or natural markings. All weaned pups (n = 45) and one yearling were tagged with Temple Tags and passive integrated transponder (PIT) tags. Two seals (one yearling and one weaned pup) were retagged with a Temple Tag to replace lost or broken tags.

Collection of Samples

One hundred and thirty-three scat and spew samples were collected. Tissue plug samples were collected from 44 weaned pups and one yearling during tagging. Two necropsies were performed, tissue samples and skulls were collected from both dead seals. Eighteen placentas were also collected. In total, 592 pieces of potentially entangling debris were inventoried; all were destroyed, with the exception of five items that were removed and collected from an

entangled animal (three from seals and two seabirds). Three fishhooks used in commercial fisheries were found on the beach and were collected.

Noteworthy Events

Translocated Adult Males

Twenty-two adult male seals were collected from Laysan Island in 1994: 1 male died shortly after capture and the remaining 21 males were translocated to the main Hawaiian Islands. In 1998, none of the translocated males had migrated back to Laysan Island, nor were they seen elsewhere in the Northwestern Hawaiian Islands; one was sighted at Nihoa Island in 1996.

Oiled Seals

Eleven of 17 seals observed with oiled pelage on Laysan Island in the spring of 1993 were sighted there in 1998. These seals appeared to be in good health, but sublethal or long-term effects could not be evaluated. Of the six not sighted in 1998, one was last seen in 1995, four were last seen in 1994 (one of these, an adult male, was translocated to the main Hawaiian Islands in 1994), and one was last seen in 1993.

Debris Plots

In May, three plots to monitor debris accumulation rates on the beaches of Laysan were established by the crew and officers of the *Townsend Cromwell.*

RESULTS

Population Abundance and Composition

The means (±SD) for 26 censuses were 118.3 seals (±18.1) including pups, and 92.7 seals (±14.1) excluding pups (Table 3.1). The total spring-summer population was 285 individuals, 239 excluding pups (Table 3.2). This number is a subset of the total identified in the calendar year. The sex ratios of non-pup immature seals and adults were ca. 0.9:1 (44 males: 49 females) and 0.9:1 (69 males: 77 females), respectively. The sex ratio for older (>15 years of age) and unknown-age adults was ca. 1.0:1 (34 males: 33 females), whereas the ratio for younger adults (≤15 years of age) was ca. 0.8:1 (35 males: 44 females). The numbers of tagged known-age seals born at Laysan Island during the period from 1983 to 1997 and resighted there in 1998 are summarized in Table 3.3.

Reproduction

At least 46 pups were born: 45 were successfully weaned and 1 pup was mortally injured near the time of weaning (Table 3.4a). Nursing periods and measurements of weaned pups are summarized in Table 3.4b. The birth rate, measured as number of pups born to the number of adult-sized females in the population was 59.7% (46/77). At least 5 pup exchanges occurred between 10 nursing females; none of these incidents were observed.

Interatoll Movement

Interatoll movement was documented for 21 seals that made a total of 29 movements between Laysan Island and either French Frigate Shoals, Lisianski Island, Midway Atoll, or Maro Reef (Tables 3.5a and b).

Factors Affecting Survival

Attacks by large sharks, mounting attempts by males, entanglement, and other/unknown factors led to 26 life-threatening conditions, which resulted in the confirmed deaths of four animals (Table 3.6). Although incidents of adult male aggression were not observed, one seal died from injuries chacteristic of a male mounting incident. One seal disappeared after sustaining moderate to severe injuries characteristic of a mobbing event, yet is it unclear if this disappearance was a result of the injuries. Five seals were entangled: one escaped independently, three were released by observers, and one died while entangled in a net ensnared on an offshore reef. In addition to the incidents presented in Table 3.6, a weaned pup disappeared 17 days after weaning and was not seen the remaining 2.5 months of the camp. Nothing unusual was observed prior to this seal's disappearance. One subadult male still had a tumor or cyst that was first observed when the seal was a pup in 1996. One subadult female had a bluish eye, although it is unknown if its vision was affected. One nursing pup lost mass (based on visual observations) during its first 3 weeks of life and then started to gain weight and nursed for an extended period (51-52 days). This pup was smaller than average size at the time of weaning, and its mother was probably not initially producing an adequate milk supply.

ACKNOWLEDGMENTS

We acknowledge the support of the U.S. Fish and Wildlife Service and the Hawaiian Islands National Wildlife Refuge staff and thank the captain and crew members of the NOAA ship *Townsend Cromwell.* Special thanks are extended to Petra Bertilsson-Friedman, Russell Bradley, Chris Depkin, Christopher Dodge, Jay Kelly, Elizabeth Mitchell, Chuck Monnett, Matthew Patterson, Vanessa Pepi, Cindy Rehkemper, Michelle Reynolds, Patty Scifres, Christina Sulzman, Mark Vekasy, and Natalie and Thomas Wilkie for their data collection and seal tagging and disentangling assistance.

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TABLES
for Laysan Island

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Table 3.1.--Summary statistics for censuses (n = 26) of Hawaiian monk seals at Laysan Island from April 8 to July 18, 1998.

Size/Sex	Mean number of individuals	Standard deviation
Adults	54.2	6.6
Male	22.5	3.8
Female	31.4	5.9
Unknown	0.3	0.5
Subadults	21.5	7.3
Male	9.1	3.7
Female	12.2	4.0
Unknown	0.1	0.3
Juveniles	17.0	4.6
Male	9.6	2.7
Female	7.3	3.1
Unknown	0.0	0.2
Pups	25.6	7.5
Male	15.1	3.5
Female	10.2	4.3
Unknown	0.3	0.5
Non-pup Total	92.7	14.1
Grand Total	118.3	18.1

Table 3.2.--Composition of the Hawaiian monk seal population at Laysan Island during the spring and summer of 1998. Includes all pups born during the calendar year.

	Number of seals				
Size	Male	Female	Unknown	Total	Sex ratio male:female
Adults	69	77	0	146	0.9:1
Subadults	20	28	0	48	0.7:1
Juveniles	24	21	0	45	1.1:1
Pups	25	20	1	46	1.2:1
Non-pup Total	113	126	0	239	0.9:1
Grand Total	138	146	1	285	0.9:1

Table 3.3.--Summary of tagged known-age seals born at Laysan Island and resighted there in 1998.

Age (years)	Sex	Number originally tagged	Number resighted in 1998
15	Male	10	1
	Female	10	6
14	Male	16	1
	Female	13	5
13	Male	16	1
	Female	14	5
12	Male	15	2
	Female	17	2
11	Male	13	3
	Female	15	5
10	Male	23	4
	Female	17	3
9	Male	16	2
	Female	13	2
8	Male	7	2
	Female	9	3
7	Male	18	8
	Female	13	7
6	Male	18	2
	Female	14	3
5	Male	23	3
	Female	14	3
4	Male	18	8
	Female	29	8
3	Male	16	6
	Female	21	11
2	Male	23	14
	Female	21	14
1	Male	19	13
	Female	16	11

Table 3.4a.--Summary of Hawaiian monk seals born at Laysan Island in 1998.

Event	Number of pups			
	Male	Female	Unknown	Total
Born	25	20	1	46
Died prior to weaning	1[a]	0	0	1
Weaned	24	20	1	45
Tagged	24	20[b]	1[c]	45

[a]After the NMFS camp, a nursing pup was injured, and died immediately before or after the mother left.
[b]Includes two pups weaned and tagged after the NMFS camp; one of these was also born after the NMFS camp.
[c]Includes one pup weaned and tagged after the NMFS Camp.

Table 3.4b.--Summary of nursing periods and measurements of weaned pups at Laysan Island in 1998. 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	37.8	106.6	126.6
St. Dev.	4.9	7.7	6.0
n	38	45	45

Table 3.5a.--Known movement of Hawaiian monk seals to Laysan Island from other locations in 1998, summarized by movements between two locations. One seal made more than one trip.

Original location	Number, size, and sex class
French Frigate Shoals	1 adult male, 3 adult females
Lisianski Island	2 adult males, 4 adult females, 1 subadult male, 1 subadult female
Midway Atoll	1 adult female

Table 3.5b.--Known movement of Hawaiian monk seals from Laysan Island to other locations in 1998, summarized by movements between two locations.

Destination	Number, size, and sex class
French Frigate Shoals	2 adult females
Lisianski Island	5 adult males, 6 adult females, 2 subadult males
Maro Reef	1 adult male

Table 3.6.--Factors affecting Hawaiian monk seal survival at Laysan Island in 1998.

			Outcome		
Size	Sex	Total	Injured	Died	Probably died
		Attack by Large Shark			
Adult	Male	1	1	0	0
	Female	1	1	0	0
Subadult	Male	1	1	0	0
	Female	1	1	0	0
Juvenile	Male	2[a]	2	0	0
		Mounting by Males			
Adult	Female	1	1[b]	0	0
Subadult	Male	1	0	1	0
		Entanglement			
Adult	Male	1[c]	0	0	0
Juvenile	Male	1[d]	0	0	0
Weaned pup	Male	2[e]	0	1	0
	Female	1[f]	1	0	0
		Other/Unknown			
Adult	Male	3	3	0	0
	Female	4	4	0	0
Subadult	Female	2	2	0	0
Juvenile	Female	1	1	0	0
Weaned pup	Male	2	1	1	0
Nursing pup	Male	1[g]	0	1	0

[a]Same seal received injuries from two separate encounters with a shark.
[b]The last sighting of this injured seal was >1 month before end of observations. It is uncertain why this animal disappeared.
[c]Seal was released by researchers and sustained minor injuries from the entanglement.
[d]Seal escaped by itself with minor injuries.
[e]One seal was entangled in net ensnared on an offshore reef and died, probably drowned. The other seal was released by researchers.
[f]Seal was released by researchers.
[g]Seal was mortally injured near weaning, cause unknown.

CHAPTER 4. THE HAWAIIAN MONK SEAL ON LISIANSKI ISLAND, 1998

Carolyn Cornish, Amber Pairis, and Rebecca Seymour

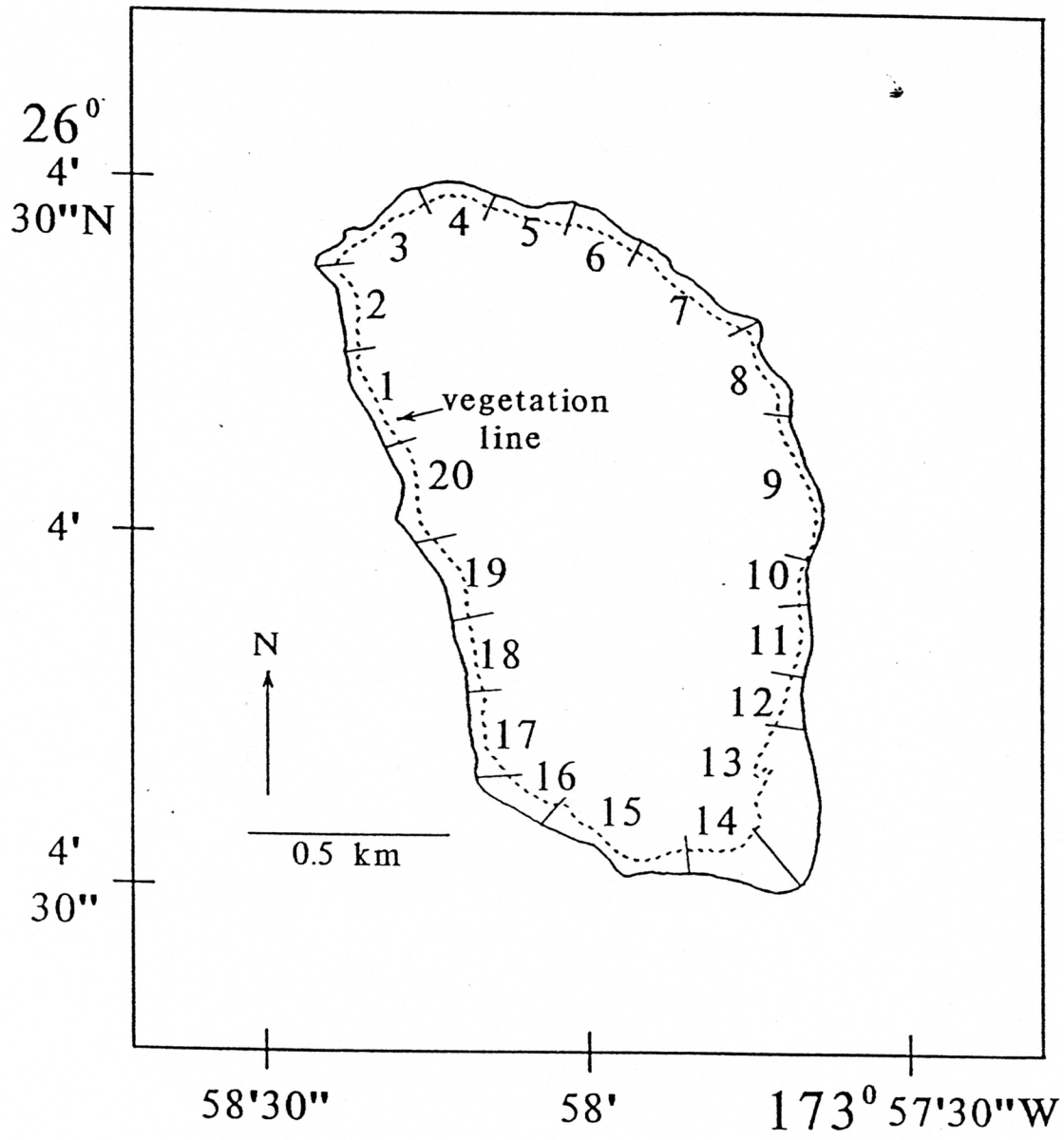

Fig. 4.1 Lisianski Island in the Northwestern Hawaiian Islands.

Lisianski Island (lat. 26°04'30"N, long. 173°58'30"W) is one of the major 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 1998, research was conducted by NMFS during March 19-July 22. The perimeter of the island was divided into 20 sectors using artificial or natural landmarks (Fig. 4.1). Research objectives specific to this population in 1998 included identification of all seals, assessment of maternity and pup exchanges, and documentation of adult male behavioral patterns and aggression.

Censuses and Patrols

Censuses and patrols were scheduled to ensure that the entire island was monitored at least once each day during March 19-July 22. Censuses (n = 29) were conducted by two observers every fourth day from April 1 to July 22, beginning at 1300 Hawaii standard time and continuing for 1.6 to 3.0 h.

Standardized behavior patrols were conducted on noncensus days to assess activity patterns of adults and large subadults, document male aggression, and detect mobbing incidents. During these patrols (n = 66), attention was directed out to sea as much as possible because mobbing has been observed most frequently in the water.

Individual Identification

A total of 191 individuals (166 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.

Collection of Samples

One hundred and seven scat and spew samples were collected. Tissue plug samples were collected from 14 seals during tagging. Necropsies were performed and tissue samples were collected from three dead seals. Skeletal samples were collected from five dead seals; two samples consisted of miscellaneous seal bones found at two different sites on the beach. In total, 984 pieces of potentially entangling debris were inventoried and destroyed.

RESULTS

Population Abundance and Composition

The means (±SD) for 29 censuses were 72.0 seals (±8.4) including pups, and 58.6 seals (±6.4) excluding pups (Table 4.1). The total spring-summer population was 187 individuals, 162 excluding pups (Table 4.2). This number is a subset of the total identified during the calendar year. The sex ratios of non-pup immatures and adults were ca. 1.1:1 (24 males: 22 females) and 1.6:1 (71 males: 45 females), respectively. The sex ratio for older (>16 years of age) and unknown aged adults was strongly skewed toward males at ca. 2.7:1 (38 males: 14 females), whereas the ratio for younger adults (≤16 years of age) was ca. 1.1:1 (33 males: 31 females). The numbers of tagged known-age seals born at Lisianski Island during the period from 1982 to 1997 and resighted there in 1998 are summarized in Table 4.3.

Reproduction

At least 25 pups were born: 21 were weaned, 2 died or probably died prior to weaning, the weaning status of 1 pup was unknown, and 1 was still nursing at the end of this study (Table 4.4a). Nursing periods and measurements of weaned pups are summarized in Table 4.4b. The birth rate, measured as number of pups born to the number of adult-sized females in the population was 55.6% (25/45). At least 43 pup exchanges occurred between eight nursing females; researchers observed four of these incidents. Four of the females nursed two pups at the same time over the course of the nursing period.

Interatoll Movement

Interatoll movement was documented for 10 seals that made a total of 24 movements between Lisianski Island and Laysan Island or Pearl and Hermes Reef (Tables 4.5a and b).

Factors Affecting Survival

Attacks by large sharks, mounting attempts by males, entanglement, and other/unknown factors led to 24 life-threatening conditions, which resulted in the confirmed deaths of four animals and the probable death of two other seals (Table 4.6). Two incidents of adult male aggression were observed, yet no seals were known to have died following male mounting incidents. Four entanglements were observed involving three seals: two escaped independently and one was released by observers twice from the same debris. In addition to the incidents presented in Table 4.6, one pup disappeared after 34 days of nursing, and one weaned pup disappeared mid-season.

ACKNOWLEDGMENTS

We acknowledge the support of the U.S. Fish and Wildlife Service and the 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

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Table 4.1.--Summary statistics for censuses (n = 29) of Hawaiian monk seals at Lisianski Island from April 1 to July 22, 1998.

Size/Sex	Mean number of individuals	Standard deviation
Adults	43.2	5.3
Male	24.3	3.9
Female	17.3	2.9
Unknown	1.6	2.0
Subadults	10.9	4.2
Male	5.6	2.6
Female	4.8	2.3
Unknown	0.6	0.9
Juveniles	4.4	1.6
Male	2.8	1.5
Female	1.6	0.9
Unknown	0.1	0.3
Pups	13.4	3.4
Male	7.1	1.6
Female	6.3	3.0
Unknown	0.1	0.3
Non-pup Total	58.6	6.4
Grand Total	72.0	8.4

Table 4.2.--Composition of the Hawaiian monk seal population at Lisianski Island during the spring and summer of 1998. Includes all pups born during the calendar year.

	Number of seals				
Size	Male	Female	Unknown	Total	Sex ratio male:female
Adults	71	45	0	116	1.6:1
Subadults	16	15	0	31	1.1:1
Juveniles	8	7	0	15	1.1:1
Pups	10	14	1	25	0.7:1
Non-pup Total	95	67	0	162	1.4:1
Grand Total	105	81	1	187	1.3:1

Table 4.3.--Summary of tagged known-age seals born at Lisianski Island and resighted there in 1998.

Age (years)	Sex	Number originally tagged	Number resighted in 1998
16	Male	7	2
	Female	6	1
15	Male	6	2
	Female	18	7
14	Male	10	3
	Female	5	2
13	Male	5	2
	Female	9	1
12	Male	11	5
	Female	9	3
11	Male	12	1
	Female	6	0
10	Male	10	5
	Female	8	6
9	Male	--	--
	Female	--	--
8	Male	8	4
	Female	9	3
7	Male	9	5
	Female	6	2
6	Male	13	6
	Female	8	4
5	Male	4	2
	Female	9	2
4	Male	4	2
	Female	5	1
3	Male	7	2
	Female	10	2
2	Male	9	3
	Female	13	2
1	Male	10	6
	Female	9	4

Table 4.4a.--Summary of Hawaiian monk seals born at Lisianski Island in 1998.

Event	Number of pups			
	Male	Female	Unknown	Total
Born	10	14	1	25
Died/probably died prior to weaning	0	1	1	2
Still nursing	0	1	0	1
Weaning status unknown	0	1[a]	0	1
Weaned	10	11	0	21
Tagged	10	11	0	21

[a]Pup disappeared after 34 days of nursing.

Table 4.4b.--Summary of nursing periods and measurements of weaned pups at Lisianski Island in 1998. 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	42.0	105.8	124.2
St. Dev.	11.0	12.5	9.6
n	16	17	18

Table 4.5a.--Known movement of Hawaiian monk seals to Lisianski Island from other locations in 1998, summarized by movements between two locations. Some seals made more than one trip.

Original location	Number, size, and sex class
Laysan Island	5 adult males, 6 adult females, 2 subadult males
Pearl and Hermes Reef	1 adult male

Table 4.5b.--Known movement of Hawaiian monk seals from Lisianski Island to other locations in 1998, summarized by movements between two locations. Some seals made more than one trip.

Destination	Number, size, and sex class
Laysan Island	2 adult males, 4 adult females, 1 subadult male, 1 subadult female
Pearl and Hermes Reef	1 adult male, 1 adult female

Table 4.6.--Factors affecting Hawaiian monk seal survival at Lisianski Island in 1998.

			Outcome		
Size	Sex	Total	Injured	Died	Probably died
		Attack by Large Shark			
Juvenile	Male	1	1	0	0
		Mounting by Males			
Adult	Female	5[a]	3	0	0
Subadult	Female	1	1	0	0
Weaned pup	Female	1	0	1[b]	0
		Entanglement			
Adult	Female	3[c]	0	0	0
Weaned pup	Female	1[d]	0	0	0
		Other/Unknown			
Adult	Male	4	4	0	0
	Female	1	1	0	0
Subadult	Male	1	1	0	0
Juvenile	Male	1	1	0	0
Weaned pup	Male	1	0	0	1[e]
	Female	2	0	2[f]	0
Nursing pup	Female	1	0	1	0
	Unknown	1	0	0	1[g]

[a]Two incidents were observed, but did not result in injury. A seal was mounted by one to three males 4 d after her pup died, and a nursing female was mounted by two males 2 days before her pup weaned.

[b] At least three adult seals were fighting at the water's edge. After they dispersed, a dead pup was found floating in the water. Carcass very fresh, eyes clear, with fresh dorsal scratches.

[c]One seal freed itself, one seal was entangled twice and released each time by observers.

[d]Seal freed itself.

[e]Prematurely weaned,in deteriorating condition throughout season. Incurred dorsal scratches 2 weeks prior to disappearance. Last seen floating listlessly in water.

[f]One weaned pup got caught in rocks and died.

[g]Disappeared within 2 d of birth.

CHAPTER 5. THE HAWAIIAN MONK SEAL ON PEARL AND HERMES REEF, 1998

Chad Yoshinaga, Irene Kinan, Albert Harting,
Dyanna Lambourn, Mitch Craig, Alonso Aguirre,
Lizabeth Kashinsky, and Andrew McClung

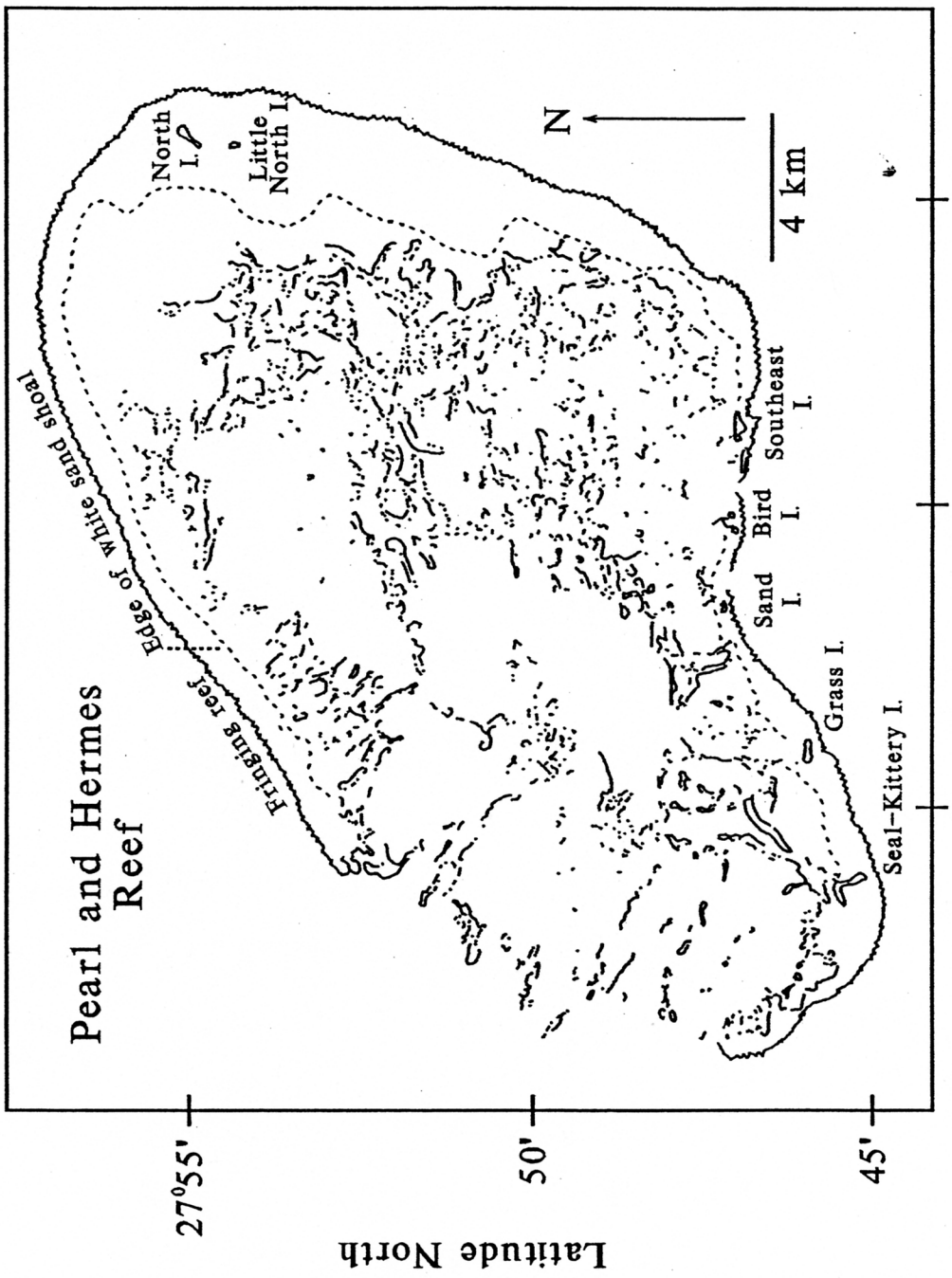

Fig. 5.1 Pearl and Hermes Reef in the Northwestern Hawaiian Islands.

Pearl and Hermes Reef (lat. 27°55'N, long. 175°45'W) is one of the major 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 islands enclosed in a fringing reef (Fig. 5.1).

RESEARCH

The National Marine Fisheries Service (NMFS) began research on Hawaiian monk seals at Pearl and Hermes Reef in 1982. In 1998, research was conducted by NMFS during February 15-23 and May 25-July 19. The perimeters of the four larger vegetated islands were divided into sectors using natural landmarks. The smaller sand islands were counted as single sectors. The research objectives specific to this population in 1998 included (1) obtain baseline information to assess the health and disease status of the Hawaiian monk seal population, (2) investigate habitat use patterns using satellite-linked telemetry, and (3) remove or destroy hazardous marine debris from the fringing reef and all haulout areas. In addition, seabird counts were conducted on all islands for the U.S. Fish and Wildlife Service, and efforts were made to document and remove two harmful exotic plant species.

Censuses and Patrols

Atoll censuses (n = 8) were conducted every 4 d, on average, during June 9-July 10, beginning at 1000 Hawaii standard time and continuing for approximately 5 h. All islands were censused on foot by one or two persons. In addition, incidental patrols were conducted opportunistically to resight seals tagged in previous years.

Individual Identification

A total of 255 individuals (223 excluding pups) were identified by existing or applied tags, scars, or natural markings. All weaned pups (n = 29) were tagged with Temple Tags and 28 of these were also tagged with passive integrated transponder (PIT) tags. Three immature seals (two male, one female) were also tagged with Temple Tags. In addition, 11 seals (7 adults, 2 sub-adults, and 2 juveniles) were retagged, and one adult male seal was tagged with Temple Tags.

Collection of Samples

Eighty-three scat and spew samples were collected and processed. Tissue plug samples were collected from 27 seals during tagging. One skull from a pup and one whole juvenile skeletal sample were collected. In total, 172 pieces of potentially entangling debris were inventoried and destroyed.

Special Studies

Habitat Use Study

Satellite transmitters, deployed in November 1997, were retrieved opportunistically from eight seals (four adults and four immature seals) hauled out on beaches during the February 1998 field effort.

Health and Disease Study

In February, a team of NMFS and USFWS biologists collected blood, fecal samples, and blubber biopsies from 26 seals (11 adult and 15 immature seals) for epidemiological studies. The purpose of the sampling was to obtain baseline information to assess the health and disease status of the Hawaiian monk seal population

Debris Removal from Fringing Reef and Shore Study Plots

In February, personnel aboard the NOAA ship *Townsend Cromwell* removed debris from a section of fringing reef to reduce hazards to monk seals and other marine life, assess the extent of reef fouling, and determine the feasibility of a large-scale debris removal effort. In May, ship personnel established study plots onshore at Seal-Kittery to assess the rate of debris accumulation.

RESULTS

Population Abundance and Composition

The means (±SD) for eight atoll censuses were 93.1 seals (±8.7) including pups, and 74.3 seals (±10.6) excluding pups (Table 5.1). The total summer population was 244 individuals, 212 excluding pups (Table 5.2). This number is a subset of the total identified in the calendar year. The numbers of tagged known-age seals born at Pearl and Hermes Reef during the period from 1983 to 1997 and resighted there in 1998 are summarized in Table 5.3.

Reproduction

At least 32 pups were born in 1998: 29 were weaned, 1 was found dead at the beginning of the season, 1 was still nursing at the end of the study, and the weaning status of 1 pup was unknown (Table 5.4). Measurements of weaned pups are summarized in Table 5.4. The birth rate, measured as number of pups born to the number of adult-sized females in the population was 52.5% (32/61).

Interatoll Movement

Interatoll movement was documented for 22 seals that made a total of 32 movements between Pearl and Hermes Reef and either French Frigate Shoals, Lisianski Island, Midway Atoll, or Kure Atoll. (Tables 5.5a and 5.5b).

Factors Affecting Survival

Entanglement and other/unknown factors affecting survival resulted in four life-threatening conditions (Table 5.6). Remains of two seals, a pup and a juvenile, were found. Cause of death for both is unknown; however, the pup was found near a large net with its head severed. In addition, a female pup was disentangled from debris and an adult female was observed blind in her right eye due to trauma.

ACKNOWLEDGMENTS

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

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TABLES
for Pearl and Hermes Reef

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Table 5.1.--Summary statistics for atoll censuses (n = 8) of the Hawaiian monk seal at Pearl and Hermes Reef from June 9 to July 10, 1998.

Size/Sex	Mean number of individuals	Standard deviation
Adults	50.6	9.0
Male	21.5	4.8
Female	23.8	4.2
Unknown	5.4	1.6
Subadults	13.5	3.2
Male	5.3	1.6
Female	6.6	1.7
Unknown	1.6	1.6
Juveniles	10.1	2.1
Male	3.9	1.6
Female	5.1	2.1
Unknown	1.1	0.8
Pups	18.9	4.1
Male	3.8	1.8
Female	12.3	2.5
Unknown	2.9	1.0
Non-pup Total	74.3	10.6
Grand Total	93.1	8.7

Table 5.2.--Composition of the Hawaiian monk seal population at Pearl and Hermes Reef during the spring and summer of 1998. Includes all pups born during the calendar year.

	Number of seals				
Size	Male	Female	Unknown	Total	Sex ratio male:female
Adults	70	61	1	132	1.1:1
Subadults	16	19	0	35	0.8:1
Juveniles	23	22	0	45	1.0:1
Pups	8	21	3	32	0.4:1
Non-pup Total	109	102	1	212	1.1:1
Grand Total	117	123	4	244	0.9:1

Table 5.3.--Summary of tagged known-age seals born at Pearl and Hermes Reef and resighted there in 1998.

Age (years)	Sex	Number originally tagged	Number resighted in 1998
15	Male	8	4
	Female	2	1
14	Male	5	3
	Female	8	2
13	Male	9	0
	Female	6	3
12	Male	10	2
	Female	7	2
	Unknown	1	0
11	Male	14	8
	Female	7	2
10	Male	12	9
	Female	6	3
9	Male	8	5
	Female	6	2
8	Male	5	3
	Female	1	0
7	Male	10	8
	Female	11	3
6	Male	13	8
	Female	10	7
5	Male	14	5
	Female	7	3
4	Male	–	–
	Female	–	–
3	Male	16	8
	Female	11	6
2	Male	11	5
	Female	12	7
1	Male	16	12
	Female	11	8

Table 5.4a.--Summary of Hawaiian monk seals born at Pearl and Hermes Reef in 1998.

Event	Number of pups			
	Male	Female	Unknown	Total
Born	8	21	3	32
Died prior to weaning	0	0	1	1
Still nursing	0	0	1	1
Weaning status unknown	0	0	1	1
Weaned	8	21	0	29
Tagged	8	21	0	29

Table 5.4b.--Summary of measurements of weaned pups at Pearl and Hermes Reef in 1998. All measurements were taken within 2 weeks after weaning.

	Axillary girth (cm)	Straight dorsal length (cm)
Mean	110.9	127.1
St. Dev.	5.5	3.2
n	7	7

Table 5.5a.--Known movement of Hawaiian monk seals to Pearl and Hermes Reef from other locations in 1998, summarized by movements between two locations.

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

Table 5.5b.--Known movement of Hawaiian monk seals from Pearl and Hermes Reef to other locations in 1998, summarized by movements between two locations.

Destination	Number, size, and sex class
French Frigate Shoals	1 juvenile female
Lisianski Island	1 adult male
Midway Atoll	7 adult males, 6 adult females, 2 subadult females
Kure Atoll	1 adult male, 1 adult female, 1 subadult male

Table 5.6.--Factors affecting Hawaiian monk seal survival at Pearl and Hermes Reef in 1998.

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

[a]Seal released by observers.
[b]Seal unilaterally blinded by fresh injury of unknown cause.
[c]Possible entanglement, decomposed carcass with severed head found near net.

CHAPTER 6. THE HAWAIIAN MONK SEAL AT MIDWAY ATOLL, 1998

Suzanne Canja, Cynthia Vanderlip, and Wayne Sentman

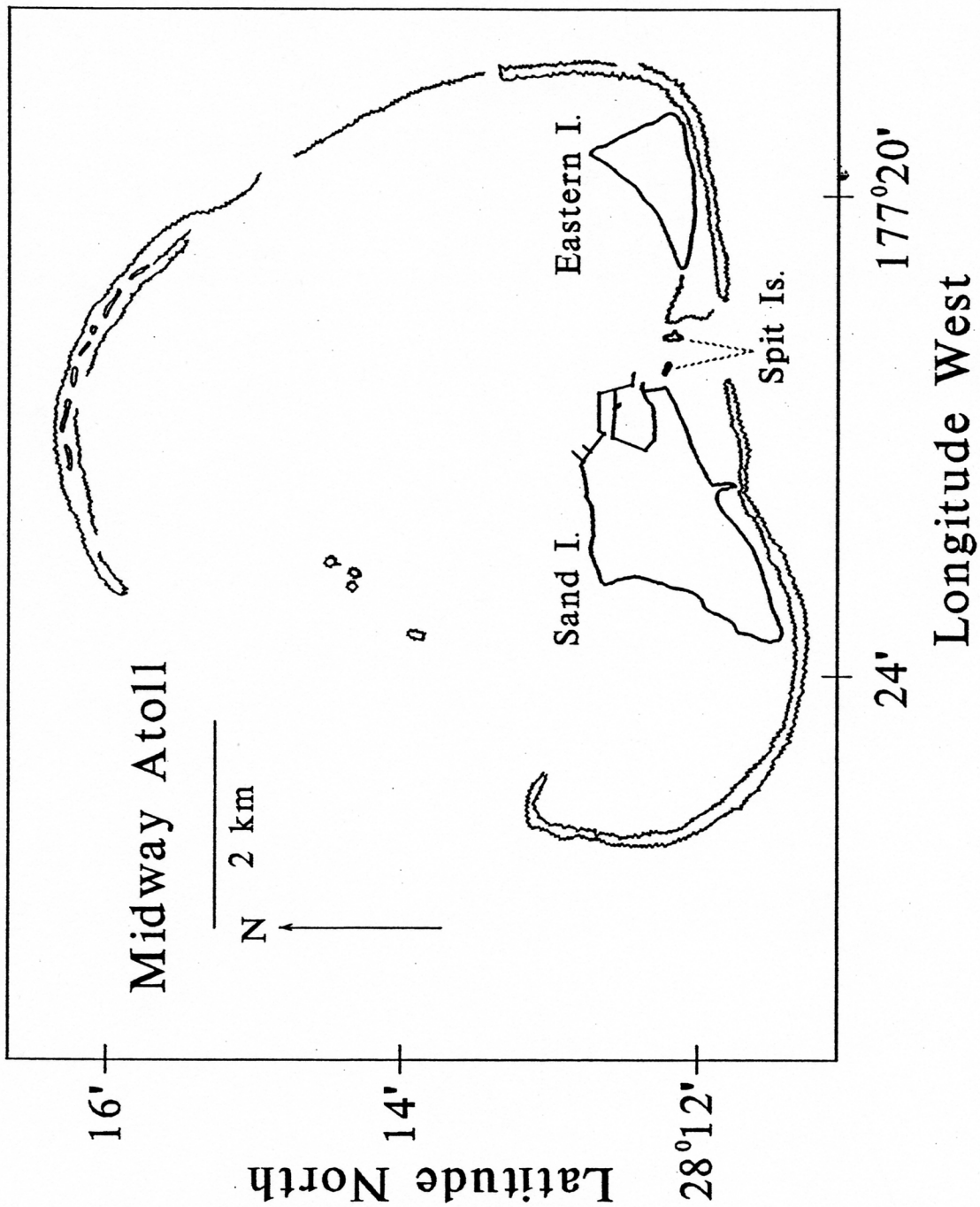

Fig. 6.1 Midway Atoll in the Northwestern Hawaiian Islands.

Midway Atoll (lat. 28°14'N, long. 177°22'W) has historically been one of the major haulout and pupping locations of the endangered Hawaiian monk seal, although current population levels and pup production are 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 islands (Sand, Spit, and Eastern Islands) inside the southern part of the reef (Fig. 6.1). Eastern and Spit Islands are uninhabited. Sand Island was the site of a U.S. Naval Air Facility until 1993 when the facility was closed. The U.S. Fish and Wildlife Service (USFWS) has maintained an overlay refuge (Midway Atoll National Wildlife Refuge) at the site since 1988, and full authority was transferred to the USFWS in October, 1996. In 1996, USFWS joined Midway Phoenix Corporation (MPC) in a joint cooperative agreement. Through this agreement MPC maintains the island infrastructure, and operates the airport and harbor (both serve as mid-Pacific refueling stations for private, commercial, and military aircraft and ships). Additionally, this agreement enables MPC to operate island ecotourism and recreational ventures. In 1998, approximately 5,000 people visited Midway Atoll National Wildlife Refuge. Thus, there is the potential for human impact to the ecosystem and resident monk seal population at this site.

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). From the late 1960s to the late 1980s the population failed to recover, but recent assessments suggest that recovery may be beginning due to an influx of immigrants from nearby sites (Kure Atoll and Pearl and Hermes Reef) and an increasing number of seals born on Midway Atoll. The earlier counts indicate that the Midway population has significant potential for growth, and recovery of this population is 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 researchers from Hawaii Wildlife Fund (HWF). In 1998, year-round monitoring was continued by HWF researchers. In addition, research was conducted by NMFS personnel during June 24-29 and July 2 to November 11. Perimeters of the three permanent islands were divided into sectors using artificial or natural landmarks. In 1998, research objectives specific to Midway Atoll included the identification of all seals in the resident population, tagging pups and other untagged seals, blood sampling for a disease survey of the wild population, scat collection, resightings of immature seals to estimate survival, and conducting reef surveys to determine haulout patterns on the fringing reef.

Censuses and Patrols

Atoll censuses (n = 52) were conducted every 7 d, on average, from January 6 to December 30. All islands were censused on foot by one or two persons. Each atoll census began between 0830 and 1802 Midway time, and ended between 1156 and 1830. Patrols of Sand Island (n = 100), Eastern Island (n = 92), or Spit Island (n = 92) were conducted on non-atoll census days during January 5 to December 28 to identify and resight seals.

Individual Identification

A total of 81 individuals (68 excluding pups) were identified by existing or applied tags, bleach marks, scars, or natural markings. All weaned pups (n = 10) were tagged with Temple Tags and passive integrated transponder (PIT) tags. Seven seals were retagged during the NMFS health assessment study: four adult females and one adult male with both Temple tags and PIT tags, one juvenile male with a Temple tag, and one adult female with a PIT tag.

Collection of Samples

Two hundred and thirteen scat and spew samples were collected and sorted. Tissue plug samples were collected from 10 weaned pups during tagging. Twenty molt samples (sloughed pelage) were collected. In total, 744 pieces of potentially entangling debris were inventoried and destroyed.

No necropsies were performed at Midway Atoll. However, a dead female pup and two fetuses were collected and shipped to Fort Collins, Colorado for necropsy. A blood sample was collected from one of the fetuses prior to shipment. The female pup had an unusual number of congenital anomalies, most obvious was the seal's disproportionate skeletal structure (the right side significantly smaller than the left).

Special Studies

Health and Disease Survey

In June, a team of NMFS and HWF biologists collected blood, fecal samples, and blubber biopsies from 10 seals (6 adults and 4 immature seals) for epidemiological studies. The purpose of the sampling was to obtain baseline information to assess the health and disease status of the Hawaiian monk seal population. All but one seal appeared healthy at the time of sampling; one subadult female was very thin and appeared to be small for her age.

Emergent Reef Surveys

Patrols (n = 54) were conducted along the emergent reef areas of the North Reef (n = 27, East Reef (n = 21), Southwest Reef (n = 5) and Southeast Reef (n = 1) year round, weather permitting, via motorboat or kayak. A detailed sector map of the reef was created by using latitude and longitude position fixes as a guide. A GPS unit was used to allow for more accurate documentation of the location of seals. Findings from these data were used to assist USFWS in management decisions about placement of a swim/snorkel/kayak platform with the least possible disturbance to seals.

Debris Survey and Retrieval along the Atoll Reef

In September, a collaborative effort between HWF, NMFS, and USFWS began to remove nets and lines from the surrounding emergent reef areas on a regular basis. This included removing entangling debris that washed up on top of the emergent reef as well as debris that was submerged in the water along the reef.

RESULTS

Population Abundance and Composition

The means (±SD) for 52 atoll censuses were 23.3 seals (±6.0) including pups, and 19.5 seals (±5.8) excluding pups (Table 6.1). The total spring-summer population was 58 seals, 47 excluding pups (Table 6.2). This number is a subset of the total identified in the calendar year. The estimation of population abundance is confounded by movement of seals among Midway Atoll, Kure Atoll, and Pearl and Hermes Reef. The numbers of tagged known-age seals born at Midway Atoll during the period from 1988 to 1997 and resighted there in 1998 are summarized in Table 6.3.

Reproduction

At least 11 pups were born, and 10 survived to weaning (Table 6.4a). Two fetuses were found, but not counted in the total number of pups born. Measurements of weaned pups and nursing periods are summarized in Table 6.4b. The birth rate, measured as the number of pups born to the number of adult-sized females in the population was 50.0% (11/22).

Interatoll Movement

Interatoll movement was documented for 32 seals that made a total of 48 movements between Midway Atoll and either Laysan Island, Pearl and Hermes Reef, or Kure Atoll. The movement from Midway Atoll to Laysan Island is the first recorded between these two points (Tables 6.5a and b). In addition to the trips documented above, an adult female, first sighted in mid June, was not seen elsewhere and probably made an undetected movement.

Factors Affecting Survival

Attacks by large sharks, entanglements, and other factors led to eight life-threatening conditions which resulted in the confirmed death of one seal and the probable death of another animal (Table 6.6). In addition to the perinatal death of a female pup with congenital abnormalities, a subadult female was severely injured by sharks, disappeared, and probably died a week after injuries were first observed. This same animal was sampled and noted in poor condition during the health assessment project 12 days prior to injury. Four entanglements were documented: three male weaned pups were entangled and released by observers, and one adult male freed itself after observers attempted to free it. In addition to the incidents presented in Table 6.6, a juvenile female was found by USFWS personnel on January 3 hauled up on the alternate runway in sector 5. Upon assessing the situation, they decided to move the seal to the nearest beach. This seal has not been resighted since. Two aborted fetuses were also found: one on Spit Island in October and a second on Eastern Island in December.

ACKNOWLEDGMENTS

We thank the officers and crew of the NOAA ship *Townsend Cromwell* for logistical assistance. We also acknowledge the support of the U.S. Fish and Wildlife Service, Midway

Atoll National Wildlife Refuge, National Marine Fisheries Service, The Oceanic Society, San Francisco, and the Midway Phoenix Corporation. Special thanks to Robert Shallenberger, Nanette Seto, Ken Niethammer, Nancy Hoffman, Bob Dieli, James Aliberti, Bart McDermot, Carolyn Rogers, Lisa King, Bruce Casler, Annarie Shallenberger, Sam Whitcraft, Andi Shluker, Bob Wilson, Norm Garon, Bruce Jones, Shawn, Gilbert, Noriel, Carlito, and the USFWS volunteers for all their kind support.

TABLES
for Midway Atoll

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Table 6.1.--Summary statistics for atoll censuses (n = 52) of Hawaiian monk seals at Midway Atoll from January 6 to December 30, 1998.

Size/Sex	Mean number of individuals	Standard deviation
Adults	11.2	3.9
Male	3.8	1.8
Female	7.0	3.0
Unknown	0.4	0.7
Subadults	3.2	1.7
Male	1.3	0.9
Female	1.7	1.0
Unknown	0.1	0.4
Juveniles	5.2	1.7
Male	1.5	0.9
Female	3.6	1.3
Unknown	0.1	0.3
Pups	3.8	2.1
Male	3.3	1.7
Female	0.6	0.7
Unknown	0.0	0.1
Non-pup Total	19.5	5.8
Grand Total	23.3	6.0

Table 6.2.--Composition of the Hawaiian monk seal population at Midway Atoll during the spring and summer of 1998. Includes all pups born in the calendar year.

	Number of seals			
Size	Male	Female	Total	Sex ratio male:female
Adults	9	22	31	0.4:1
Subadults	2	4	6	0.5:1
Juveniles	3	7	10	0.4:1
Pups	8	3	11	2.7:1
Non-pup Total	14	33	47	0.4:1
Grand Total	22	36	58	0.6:1

Table 6.3.--Summary of tagged known-age seals born at Midway Atoll and resighted there in 1998.

Age (years)	Sex	Number originally tagged	Number resighted in 1998
10	Male	0	NA
	Female	1	1
9	Male	0	NA
	Female	0	NA
8	Male	0	NA
	Female	0	NA
7	Male	1	1
	Female	1	1
6	Male	0	NA
	Female	1	0
5	Male	1	0
	Female	0	NA
4	Male	0	NA
	Female	0	NA
3	Male	1	0
	Female	6	1
	Unknown	1	0
2	Male	1	0
	Female	4	1
1	Male	3	2
	Female	6	6

Table 6.4a.--Summary of Hawaiian monk seals born at Midway Atoll in 1998.

Event	Number of pups		
	Male	Female	Total
Born	8	3	11
Died prior to weaning	0	1	1
Weaned	8	2	10
Tagged	8	2	10

Table 6.4b.--Summary of nursing periods and measurements of weaned pups at Midway Atoll in 1998. All measurements were taken within 2 weeks after weaning.

	Nursing period (d)	Axillary girth (cm)	Straight dorsal length (cm)
Mean	39.4	107.5	126.2
St. Dev.	3.9	9.4	4.8
n	8	10	10

Table 6.5a.--Known movement of Hawaiian monk seals to Midway Atoll from other locations in 1998, summarized by movements between three locations.

Original location	Number, size, and sex class
Pearl and Hermes Reef	7 adult males, 6 adult females, 2 subadult females
Kure Atoll	5 adult males, 4 adult female, 1 subadult male, 2 weaned male pups

Table 6.5b.--Known movement of Hawaiian monk seals from Midway Atoll to other locations in 1998, summarized by movements between two locations. One seal made more than one trip.

Destination	Number, size, and sex class
Laysan Island	1 adult female
Pearl and Hermes Reef	4 adult males, 3 adult females
Kure Atoll	4 adult males, 4 adult females, 3 subadult males, 1 subadult female, 1 juvenile male

Table 6.6.--Factors affecting Hawaiian monk seal survival at Midway Islands in 1998.

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

[a]The seal incurred a severe gaping wound on left side of the face, became emaciated, and disappeared a week later.
[b]Seal freed itself after an attempt by observers to free it.
[c]All seals were released by observers. One seal incurred a long, deep wound from serious rope entanglement.
[d]Perinatal death of abnormal pup.

CHAPTER 7. THE HAWAIIAN MONK SEAL AT KURE ATOLL, 1998

Allison C. Veit, Katherine W. McFadden,
and Wayne Sentman

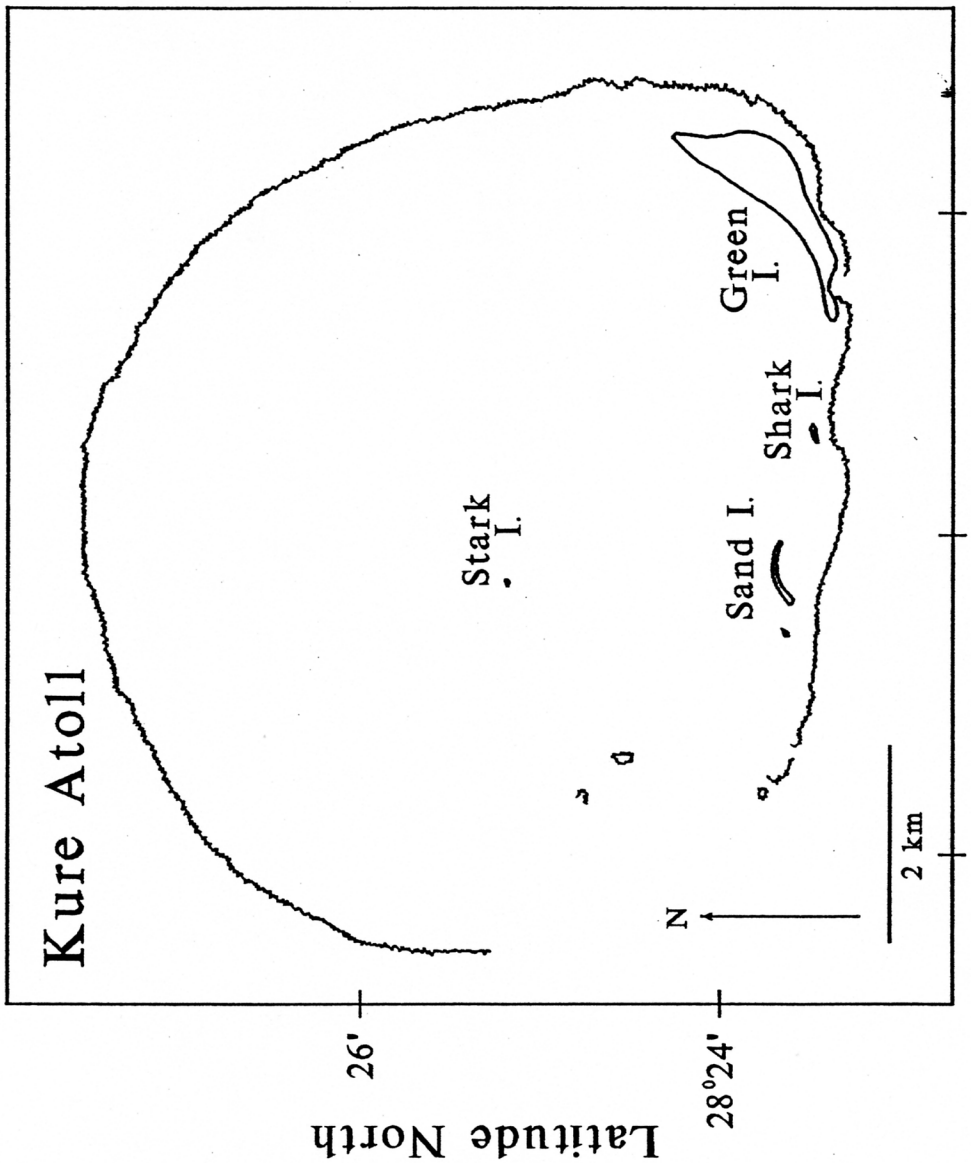

Fig. 7.1 Kure Atoll in the Northwestern Hawaiian Islands.

Kure Atoll (lat. 28°24'N, long. 178°20'W) is one of the major 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 Islets), and a sometimes emergent area known locally as Stark Reef (Fig. 7.1). Until 1992, Green Island was the site of a U.S. Coast Guard (USCG) LORAN station, commissioned in 1961 and 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 removal of buildings and other structures on Green Island.

The Kure Atoll population of Hawaiian monk seals has been increasing in recent years due, in part, to a reduction of human disturbance and two capture and release programs designed to increase recruitment of females. The Head Start Project (1981-1991) involved the capture and protection of weaned female pups from Kure 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, rehabilitation on Oahu, and then transport to Kure Atoll for release.

RESEARCH

The National Marine Fisheries Service (NMFS) began research on the Hawaiian monk seal at Kure Atoll in 1981. In 1998, research was conducted by NMFS during May 23-July 21, October 8-12, October 19-20, and November 1. The perimeter of Green Island was divided into eight sectors using artificial or natural landmarks. Research objectives for the Kure Atoll monk seal population in 1998 included identification of all seals, evaluating the success of past management efforts (primarily seal introductions), evaluating the use of photogrammetry as a tool to estimate body size, and 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 approximately every 4-5 d, weather permitting, from June 3 to July 15. Each census began between 1220 and 1345 Hawaii standard time and ended between 1556 and 1752. All islands were censused on foot by one or two persons. Stark Reef was not emergent during the 1998 field season. Shark Island was present only until June. Patrols were conducted to identify seals and monitor locations used by parturient females.

Individual Identification

A total of 122 individuals (99 excluding pups) were identified by existing or applied tags, bleach marks, scars, or natural markings. All but one weaned pup (n = 22) were tagged with Temple Tags, and passive integrated transponder (PIT) tags. Three juvenile seals (one male and two females) were also tagged with Temple Tags and PIT tags.

Collection of Samples

Ninety-two scat and spew samples were collected. Tissue plug samples were collected from 22 weaned pups and 2 other seals during tagging. In total, 634 pieces of potentially entangling debris were inventoried and all but one were destroyed before the end of the field season. Two entanglement items were removed from seals and one of the two items was collected.

Special Studies

The Assessment of Photogrammetry as a Tool to Estimate Body Size

During the 1998 field season, weaned pups were photographed, measured, and weighed in order to evaluate whether photographs can be used as a noninvasive means to assess size and condition. A rigid measuring pole was positioned over the seals while they were sleeping, and photographs of two views (either anterior/posterior or lateral) were taken at various camera heights and distances. The goal of this project was to determine if a predictive relationship can be established between photographically measured variables (digitized side, anterior/posterior area, length, width) which may aid researchers in more accurately predicting size and condition.

Paradise Queen II Grounding

On the night of October 16, 1998 the 120-ft lobster boat, *Paradise Queen II*, went aground on the emergent reef at Kure Atoll. The wreck location was immediately east of Green Island (off sector 3). There were 11,000 gallons of diesel fuel on board; 7,500 gallons were recovered and the remainder spilled and apparently was carried away from the atoll by currents. All bait washed overboard, and most may have been carried away from the atoll. Most of the 1,040 lobster traps, 5,000 bait holders, and other deck items and material washed overboard into the lagoon. In addition, 7.5 miles of a 11.5 mile heavy ½ in ground line washed overboard, forming a large ball of line behind the boat. A NMFS researcher accompanied salvage operations on October 19-20, October 27, October 31, and November 1, 1998 to assess the beach area adjacent to the wreck for possible oil/fuel contamination and debris accumulation, to monitor seals for entanglement and other adverse effects, and to minimize disturbance to seals during cleanup operations. Although beaches on Green Island, sectors 2-4, were heavily covered with debris, oil was not found on the beach, and no entangled or oiled wildlife were found.

RESULTS

Population Abundance and Composition

The means (±SD) for 10 atoll censuses were 54.4 seals (±5.8) including pups, and 40.9 seals (±5.2) excluding pups (Table 7.1). The total spring-summer population was 119 individuals, 96 excluding pups (Table 7.2). This number is a subset of the total identified in the calendar year. The numbers of tagged known-age seals born at Kure Atoll during the period from 1981 to 1997 and resighted there in 1998 are summarized in Table 7.3.

Reproduction

At least 23 pups were born and 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 to the number of adult-sized female in the population was 56.1% (23/41). At least 4 of these 23 parturient females had been temporarily maintained as pups in the Kure Atoll Head Start enclosure (one in 1984, two in 1985, and one in 1988), and none were rehabilitated seals from FFS introduced to Kure as yearlings via the Head Start enclosure.

Interatoll Movement

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

Factors Affecting Survival

Entanglement in debris and other factors resulted in three life-threatening conditions (Table 7.6). Two adult female seals were entangled; one female freed herself and the other female was released by observers. One adult female, not included in Table 7.6, was observed with limited vision and an opacity in the right eye. This seal's eye impairment was not noted before the 1998 field season.

ACKNOWLEDGMENTS

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

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TABLES
for Kure Atoll

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Table 7.1.--Summary statistics for atoll censuses (n = 10) of Hawaiian monk seals at Kure Atoll from June 3 to July 15, 1998.

Size/Sex	Mean number of individuals	Standard deviation
Adults	29.0	3.9
Male	9.6	2.6
Female	18.6	3.1
Unknown	0.8	1.1
Subadults	8.7	2.1
Male	6.5	2.2
Female	1.9	0.9
Unknown	0.3	0.5
Juveniles	3.2	1.0
Male	2.2	0.8
Female	0.6	0.5
Unknown	0.4	0.8
Pups	13.5	3.2
Male	9.9	2.1
Female	3.6	1.6
Unknown	0.0	0.0
Non-pup Total	40.9	5.2
Grand Total	54.4	5.8

Table 7.2.--Composition of the Hawaiian monk seal population at Kure Atoll during the spring and summer of 1998. Includes all pups born during the calendar year.

	Number of seals			
Size	Male	Female	Total	Sex ratio male:female
Adults	29	41	70	0.7:1
Subadults	12	5	17	2.4:1
Juveniles	5	4	9	1.2:1
Pups	17	6	23	2.8:1
Non-pup Total	46	50	96	0.9:1
Grand Total	63	56	119	1.1:1

Table 7.3.--Summary of tagged known-age seals born at Kure Atoll and resighted there in 1998.

Age (years)	Sex	Number originally tagged	Number resighted in 1998
17	Male	3	2
	Female	5	1
16	Male	1	0
	Female	3	3
15	Male	4	2
	Female	0	NA
14	Male	4	1
	Female	2	2
13	Male	2	1
	Female	3	2
12	Male	1	0
	Female	0	NA
11	Male	1	1
	Female	3	2
10	Male	2	2
	Female	5	2
9	Male	5	3
	Female	4	1
8	Male	3	0
	Female	3	1
7	Male	7	4
	Female	6	2
6	Male	5	3
	Female	8	5
5	Male	9	5
	Female	4	2
4	Male	3	0
	Female	0	NA
3	Male	6	4
	Female	5	2
2	Male	10	4
	Female	6	0
1	Male	9	3
	Female	7	4

Table 7.4a.--Summary of Hawaiian monk seals born at Kure Atoll in 1998.

Event	Number of pups		
	Male	Female	Total
Born	17	6	23
Died prior to weaning	0	0	0
Weaned	17	6	23
Tagged	16	6	22

Table 7.4b.--Summary of nursing periods and measurements of weaned pups at Kure Atoll in 1998. 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	36.2	108.9	129.8
St. Dev.	1.3	10.2	6.9
n	3	9	9

Table 7.5a.--Known movement of Hawaiian monk seals to Kure Atoll from other locations in 1998, summarized by movements between two locations. One seal made more than one trip.

Original location	Number, size, and sex class
Pearl and Hermes Reef	1 adult male, 1 adult female, 1 subadult male
Midway Atoll	4 adult males, 4 adult females, 3 subadult males, 1 subadult female, 1 juvenile male

Table 7.5b.--Known movement of Hawaiian monk seals from Kure Atoll to other locations in 1998, summarized by movements between two locations.

Destination	Number, size, and sex class
Pearl and Hermes Reef	1 adult male, 1 adult female, 1 subadult male
Midway Atoll	5 adult males, 4 adult females, 1 subadult male, 2 weaned male pups[a]

[a]One pup was prematurely weaned.

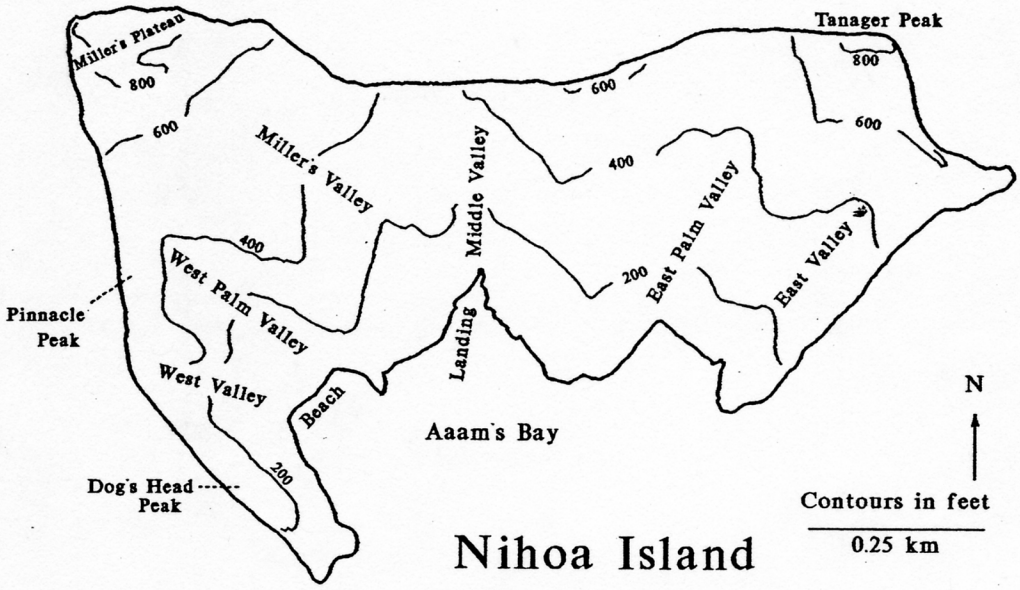
Table 7.6.--Factors affecting Hawaiian monk seal survival at Kure Atoll in 1998.

		Outcome			
Size	Sex	Total	Injured	Died	Probably died
Attack by Large Shark					
(none observed)					
Mounting by Males					
(none observed)					
Entanglement					
Adult	Female	2[a]	1	0	0
Other					
Juvenile	Male	1	1	0	0

[a]One seal released by observers, the other seal freed herself.

CHAPTER 8. THE HAWAIIAN MONK SEAL ON NECKER ISLAND, 1998

Chad Yoshinaga and George A. Antonelis



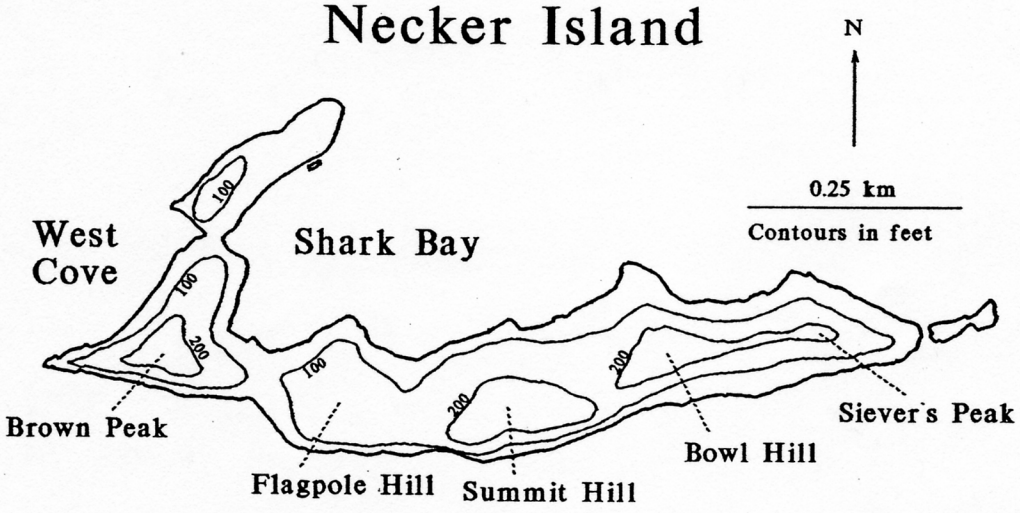


Fig. 8.1 Nihoa and Necker Islands in the Northwestern Hawaiian Islands.

Necker Island (lat. 23°36'N, long. 164°42'W) is located ca. 750 km northwest of Oahu in the Northwestern Hawaiian Islands (Fig. 1.1). This island lies within the Hawaiian Islands National Wildlife Refuge (Fig. 8.1). Although endangered Hawaiian monk seals use this island, pup production is limited by lack of haulout area.

RESEARCH

Research was conducted by the National Marine Fisheries Service on May 17, 1998. The perimeter of the island was divided into 10 sectors using natural landmarks. Beginning in 1989, the monk seal population at French Frigate Shoals began to decline, largely from loss of juvenile seals. In 1998, research objectives specific to the Necker Island monk seal population included assessment of the extent of migration from French Frigate Shoals to this location to determine if migration may have contributed to the decline observed at French Frigate Shoals.

Censuses and Patrols

One census was conducted beginning at 0830 Hawaii standard time and continuing for approximately 4 h. The island was censused both on foot and by boat.

Individual Identification

One seal had tags applied at French Frigate Shoals, but both tags were unreadable.

Collection of Samples

No samples were collected during the census of the island.

RESULTS

Population Abundance and Composition

The census total was 16 seals (10 adults, 3 subadults, 2 juveniles, and an unknown sized seal). Four of the adults were males, and the other seven were of unknown sex. Because of limited effort, the composition of the spring-summer population was not determined.

Reproduction

No pups were observed during the census of the island.

Interatoll Movement

Interatoll movement was not documented. One seal was observed with French Frigate Shoals tags, but it is unknown if this seal is new to the Necker Island population.

Factors Affecting Survival

No factors affecting survival were observed.

ACKNOWLEDGMENTS

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

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APPENDIXES

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

All islands

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Appendix A.--Continued.

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Appendix B.--Hawaiian monk seal census form and 1998 census form directions.

(See following pages.)

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SEAL CENSUS FORM

ENTERED ☐

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

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

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

Line No.	Continue	Time	Sector	Size	Sex	Beach Pos	Condition	ID T/P	ID No.	ID ?	TAG No.	TAG L/R	TAG Col	TAG ?	MOLT %	MOLT ?	Disturb	ASSOCIATION Line No.	ASSOCIATION Dist	ASSOCIATION Behavior	Notes	Notes	EVENT Type	EVENT Codes
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Line No.	Continue	Time	Sector	Size	Sex	Beach Pos	Condition	ID			TAG				MOLT		Disturb	ASSOCIATION			Notes	Notes	EVENT	
								T/P	No.	?	No.	L/R	Col	?	%	?		Line No.	Dist	Behavior			Type	Codes
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1998

CENSUS FORM DIRECTIONS

(Unabridged - Laysan and Lisianski Islands only)

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.).

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).
A = Atoll-wide census (must be completed within 2 days)
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 1998).
P = Patrol: A complete, untimed count where size, sex, ID, and disturbance are recorded. Behavior data is not taken.
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.)

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 one 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 three-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.

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

WIND

Speed:	0 = no wind, calm (<5 knots)
	1 = light breeze (5-15 knots)
	2 = strong wind (>15 knots)
Direction:	NN,NE,EE,SE,SS,SW,WW,NW
Thus,	2 N N = strong wind from north

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

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

LINES

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

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

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

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

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

Pup	Seals born within the calendar year. Newborn pups are black, and 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 pelage 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
- 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 < 90 cm 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

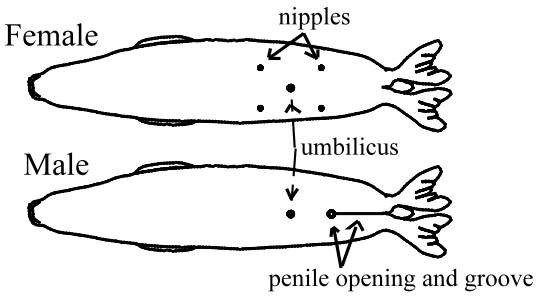
Adults
- A = Adult

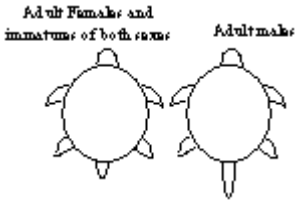
Unknowns
- U = Seal of unknown size

Turtles
- T = Turtle
  - T1 = Turtle, juvenile (<65 cm straight carapace length)
  - T2 = Turtle, subadult (65 - 80 cm)
  - T3 = Turtle, adult (>80 cm)

Only code the sex as known if the ventral is seen or if the seal is the mother in a mother/pup pair, even if you "know" the sex because of the tag, bleach, scars, or behavior.

SEX M = Male
F = Female
U = Unknown





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

1998), make a continuation line previous to the original line to indicate that the seal changed beach position before you come abreast of it.

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
9 = on an offshore rock (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 mom on her first sighting postpartum, and of the mom and pup on their first sighting post-weaning, regardless of data type. Always note condition when recording a survival factor.

Condition codes:
M = medium
P = probably pregnant
F = fat
T = thin, includes emaciated
X = data not taken
If the condition code is left **blank** during an atoll or census count, condition is assumed to be 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, use for data types C, A, B, or P (for unident. cruisers moving ahead of you on census, etc.).
blank = number is certain and complete if present

PERMANENT ID NO. Record the four-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 place-holders within the number to indicate missing digits. Put the alpha prefix of the temple tag (combined with tag ? column code = 5) if you can determine the hole drilling pattern, but can't decipher the number (e.g., A--RT5 for a right tan tag with a 1983 drill pattern).

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 so that you will be aware, and can record, if a specific tag breaks or is lost 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) 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)

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 and 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 only one 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.
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%; .. 9 = 90-99%. The first record of a $\geq$ 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.

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? 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 premolt
4 = seal postmolt

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 $\leq$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 1998. Don't record associations involving turtles. If you wish to indicate that a seal was alone, use the O 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 O 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 O, Z, or X behavior only (with no line number or distance), or have a line number, a distance, and some behavior code (other than O or X) all present. Don't code behaviors of an animal after it has been disturbed by the observer (but record the behaviors in Notes).

All associations should be in pairs, i.e., between animals on two different lines. If the behavior is active, you should fill in the line numbers, distances, and behavior codes for both animals involved in the association. If the behavior is N or L, however, you may record the association on only one of the lines, and the entry/checking program will fill in the other line. When recording an active behavior that requires a corresponding code, 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) noted for all except behaviors between mother and nursing pup
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).

1) individual seal
   a) active behavior
      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 (reciprocal association filled by computer)
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).
L = association by location only (distance ≤10 m apart, for all except mother-pup pairs)

c) additional codes (Laysan and Lisianski 1998)
*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 before and after contest if displacement occurs.
*Q = loser (quitter)
*W = winner
*Y = tie

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

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

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

2) nothing nearby
O = no behavior or association

3) no data
X = no association data recorded on Census or Atoll Count

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

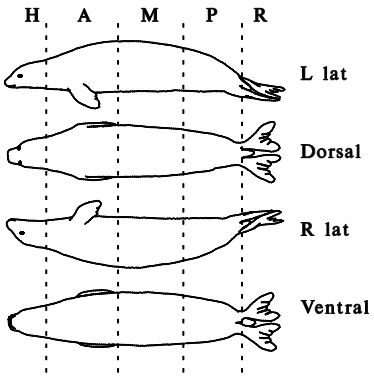
A = artwork (scars drawn) - attach drawing, labeled with date, island, observer, data type, page number, and line number
B = birth, 1st sighting postpartum (mom and pup)
G = seal is green with algae
H = handwritten notes
M = marked, indicate each time a seal is bleached
W = weaning, 1st sighting post-weaning (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.

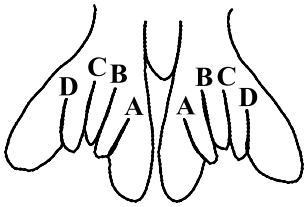
FOR DATA TYPE "T", STATUS OF NON-ACTIVE TAGS:
F = found
R = recovered from seal in hand

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 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

TYPE	CODES COLUMN	CONTENT
P = photo		NON-SEAL OR TURTLE PHOTOS ARE NOT CODED ON THE CENSUS FORM, BUT SHOULD BE RECORDED IN NOTES AND TRANSFERRED TO THE PHOTO COMMENT FORM.
	1	Type of photo S = slide P = print
	2-3	Roll number (pad with zeros)
	4-5	Frame number (pad with zeros)
	6	Side L = left lateral or flipper R = right lateral or flipper D = dorsal side V = ventral side B = both (used for rear flippers only) X = other, describe in handwritten NOTES
	7	Part H = head A = anterior body (neck and shoulders) M = midbody (behind foreflippers and before posterior) P = posterior body (behind midbody and before rear flippers) F = foreflipper; write whether dorsal/ventral in comments R = rearflipper; write whether dorsal/ventral in comments O = overall view of a particular side X = other, describe in comments
	8	Purpose I = identification F = survival factor (link with survival factor EVENT using continuation lines) X = other, describe in comments



TYPE	CODES COLUMN	CONTENT
T = tag condition		RECORD TAG CONDITION FOR BOTH SIDES OF EACH TAG AT LEAST ONCE DURING THE SEASON. IF TAG CONDITION IS RECORDED FOR AN INCOMPLETELY READ TAG, COMPLETE THE TAG NUMBER (WITH APPROPRIATE TAG? CODE) PRIOR TO COMPUTER ENTRY.
	1	Web A-D = from inner (medial) to outer web. E = ankle P = posterior U = unknown
	2	Side of tag, the dorsal tag side is on the dorsal flipper surface unless the tag is reversed. For Temple Tags, the dorsal side is the bigger side; for Metal (Monel) tags, the dorsal side is the "male" side. For PIT tags, code the side as B (both). D = dorsal V = ventral B = both U = unknown
	3	Condition, code U (unreadable) if cannot use tag to ID seal (i.e., if broken so number gone). Also code U for a PIT tag if you completely scan for it with a reliable reader but get no reading. If reader is unreliable, put attempt in Notes and only code PIT tag as unreadable after 3 separate attempts. Combine the L or U codes with the tag questionable code of 8. You can combine the tag questionable code of 8 with other condition codes to describe why the tag is unreadable (i.e., worn or broken). 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)

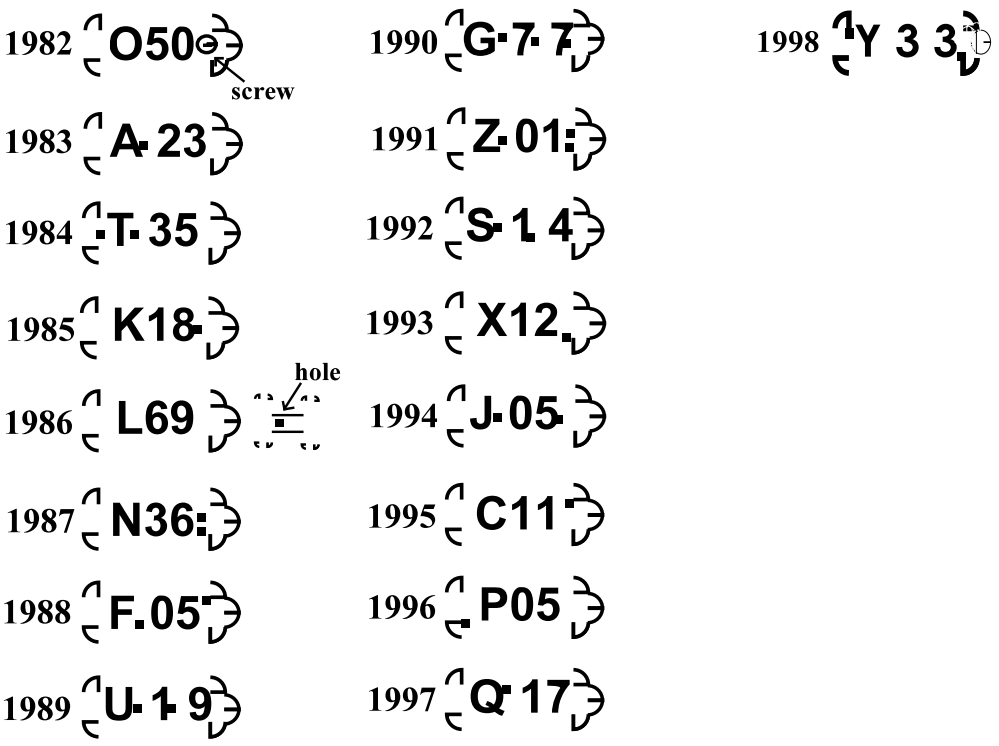
2. Definition of pair type (depends on associate of adult male):
   - Pair type **#1**: adult male with adult female (**L1**)
   - Pair type **#2**: adult male with juvenile or pup of either sex (**L1**)
   - Pair type **#3**: *single* adult male not pair type **#1** or **#2**

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 in the Bible.

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

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