NOAA Technical Memorandum NMFS

FEBRUARY 1996

THE HAWAIIAN MONK SEAL IN THE NORTHWESTERN HAWAIIAN ISLANDS, 1993

Compiled and Edited by

Thea C. Johanos
Timothy J. Ragen

NOAA-TM-NMFS-SWFSC-227

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

NOAA Technical Memorandum NMFS

The National Oceanic and Atmospheric Administration (NOAA), organized in 1970, has evolved into an agency which establishes national policies and manages and conserves our oceanic, coastal, and atmospheric resources. An organizational element within NOAA, the Office of Fisheries is responsible for fisheries policy and the direction of the National Marine Fisheries Service (NMFS).

In addition to its formal publications, the NMFS uses the NOAA Technical Memorandum series to issue informal scientific and technical publications when complete formal review and editorial processing are not appropriate or feasible. Documents within this series, however, reflects sound professional work and may be referenced in the formal scientific and technical literature.

NOAA Technical Memorandum NMFS

This TM series is used for documentation and timely communication of preliminary results, interim reports, or special purpose information. The TMs have not received complete formal review, editorial control, or detailed editing.

FEBRUARY 1996

THE HAWAIIAN MONK SEAL IN THE NORTHWESTERN HAWAIIAN ISLANDS, 1993

Compiled and Edited by

Thea C. Johanos
Timothy J. Ragen

Honolulu Laboratory,SWFSC
National Marine Fisheries Service, NOAA
2570 Dole Street
Honolulu, Hawaii 96822-2396

NOAA-TM-NMFS-SWFSC-227

U.S. DEPARTMENT OF COMMERCE
Ronald H. Brown, Secretary
National Oceanic and Atmospheric Administration
D. James Baker, Under Secretary for Oceans and Atmosphere
National Marine Fisheries Service
Rolland A. Schmitten, Assistant Administrator for Fisheries

EXECUTIVE SUMMARY

During 1993, field studies of the endangered Hawaiian monk seal (*Monachus schauinslandi*) were conducted at all of its main reproductive sites in the Northwestern Hawaiian Islands, although studies were intermittent at Midway Islands and Kure Atoll, and brief at Pearl and Hermes Reef. These studies provide information necessary to partially 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. The availability of up-to-date information is essential for ongoing efforts to mitigate the decline of this species and enhance its recovery.

Studies conducted during 1993 indicated that significant problems continued to impede recovery. The total number of births at the main reproductive sites, 193 pups, was lower than the previous year's total of 204 pups, but still well above the marked low of 142 in 1990. However, mortality of immature seals remained extremely high at French Frigate Shoals, the largest population, and the total of mean beach counts remained well below counts in the mid 1980s. Mobbing continued to be a significant problem; although no deaths were known to have occurred because of mobbing in 1993, moderate to severe mounting injuries were documented at Necker Island, French Frigate Shoals, Laysan Island, and Lisianski Island.

In 1993, three management activities or events occurred which have significant implications for the recovery and management of this species. First, the Midway Islands U.S. Naval Air Facility was closed. The Navy is in the process of vacating the atoll, and primary management authority will probably be transferred to the U.S. Fish and Wildlife Service. Thus, although human disturbance will continue, and may increase, during the shutdown phase, disturbance should ultimately be reduced, increasing the recovery potential of the seal population at this site. Second, immature female seals were collected from French Frigate Shoals and transported to Oahu for rehabilitation to salvage the reproductive potential lost to the high mortality of immature seals. Third, rehabilitated female seals, collected from French Frigate Shoals in 1992 and 1993, were released at Midway Islands and Kure Atoll to enhance the recovery of these long-depleted populations. This document describes these and other field studies conducted during 1993.

CONTENTS

(**CONTENTS**, continued)

Page

(**CONTENTS**, continued)

Page

CHAPTER 1. GENERAL INTRODUCTION

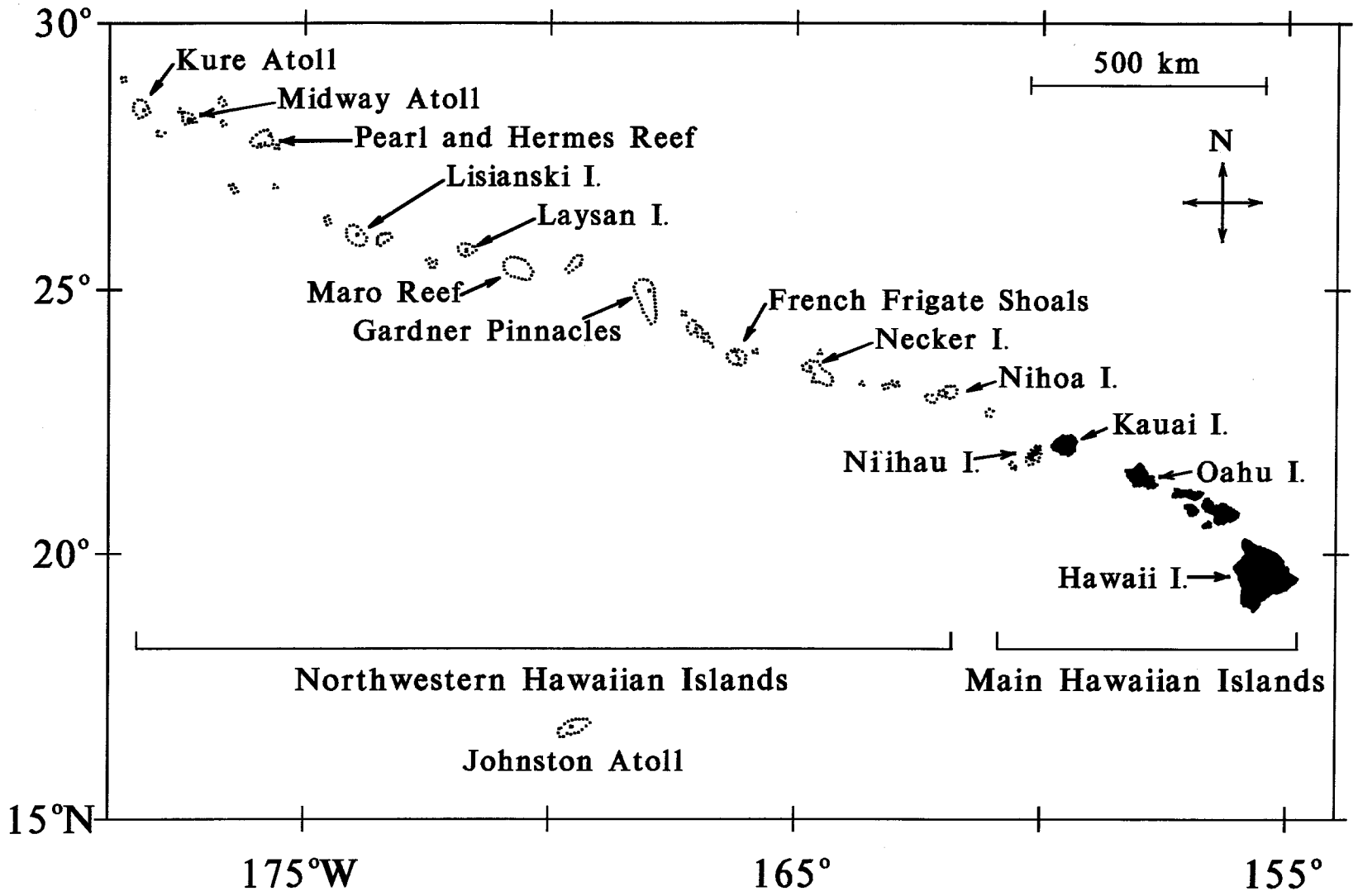


Fig. 1.1 The Hawaiian Archipelago.

The endangered Hawaiian monk seal (*Monachus schauinslandi*) hauls out and breeds in the Northwestern Hawaiian Islands, (NWHI, Fig. 1.1). The Southwest Fisheries Science Center, Honolulu Laboratory, National Marine Fisheries Service (NMFS), began research on Hawaiian monk seals at most major reproductive sites in the NWHI during 1981 (Kure Atoll, Laysan Island, and Lisianski Island) and 1982 (French Frigate Shoals (FFS) and Pearl and Hermes Reef). 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 Midway Islands, where current pup production is well below historical levels, and at Nihoa and Necker Islands, where pup production is limited by haulout area. Reports summarizing past NMFS research are listed in Appendix A.

In 1993, the objectives of Hawaiian monk seal research 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 habit analysis, (7) collect tissue samples for DNA analysis of paternity patterns and genetic variation within and among populations, and (8) inventory, sample, and destroy debris capable of entangling seals. Location-specific objectives and summaries of data collected during the 1993 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, animals 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), 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 or mobbings), (2) animal handling, (3) photography, and (4) documentation of tag condition (e.g., good or broken). In addition, on Laysan and Lisianski Islands behavior data (focusing on associations and interactions between seals) were collected, and vestibule status was recorded for adult and large subadult females to determine its utility as an indicator of their reproductive status. A sample census form and guidelines for its completion are included in Appendix B. Censuses were conducted once at Midway Islands, daily (at Pearl and Hermes Reef, Necker Island, and Nihoa Island), or every 5 to 8 days (at all other locations), starting at 1300 Hawaii standard time when possible, using census methods and criteria outlined in Johanos et al. (1987). Atoll-wide counts for locations with more than a single island (French Frigate Shoals, Pearl and Hermes Reef, Midway Islands, 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 all or a portion of an 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 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, (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), efforts were made to identify the pup and document changes in the nursing relationship from birth to weaning. A pup exchange occurred when the pups of two lactating females were switched. 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 would then actively search for, and obtain, another nursing relationship.

The average nursing period was calculated for the pups at each location. In addition, the average lactation period of parturient females was calculated for the population at FFS because of difficulties in tracking pups (and obtaining nursing periods) at that site due to the higher population density and the resulting high number of pup exchanges (Boness 1990). 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 four days or less, then the midpoint of that range was used in the calculation of the 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

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 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 fat 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.

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 $\geq$5 cm; (2) an amputation of more than one digit (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 $\geq$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). We did not include injuries that were already healed when they were first observed.

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.

Individual Identification

During censuses and patrols, individual seals were identified by tags, applied bleach marks, scars, or natural markings. After weaning, all pups were tagged as soon as possible 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 each weaned pup (see Lombard et al., 1994, for detailed tagging procedures).

Most immature seals were tagged as weaned pups, and therefore were of known age. Temple Tags have been applied to nearly all weaned pups, beginning in 1981 at Kure Atoll, 1982 at Lisianski Island, 1983 at Laysan Island and Pearl and Hermes Reef, and 1984 at French Frigate Shoals. Temple Tags were applied to weaned pups opportunistically at Midway Islands, Necker and Nihoa Islands, and the main Hawaiian Islands beginning in 1983. In addition, PIT tags have been implanted into most weaned pups since 1991. In 1993, untagged immature seals were tagged with Temple Tags which were uniquely coded to indicate that their ages and birth locations were unknown. Immature seals with lost or broken tags were retagged to maintain their identities.

At two locations (Laysan and Lisianski Islands), adult and subadult seals were bleach-marked for individual identification (Stone, 1984), using the solution described in Johanos et al. (1987). Molting adults and subadults 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

---

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

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; partial composition was determined where all seals within certain size and sex classes were identified. These statistics included all individuals seen alive, and in the wild, at the location from March through August and all 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 first seen unless it pupped at another location. A parturient female was always included in the population where it pupped, if it was seen there anytime during March-August.

Measurements of Seals

Measurements of seals were taken to determine monk seal growth patterns and to assess the effects of size on survival. Straight dorsal length (Winchell, 1990) and axillary girth (American Society of Mammalogists, 1967) were measured on weaned pups at the time of tagging. At two locations (FFS and Laysan Island), weights of weaned pups, yearlings, and juveniles were measured by suspending the seal in a net from a spring scale. In addition to the straight dorsal length and axillary girth, standard length (measured along the ventral side; American Society of Mammalogists, 1967) was measured on seals weighed at FFS.

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 sloughed epidermis and fur from molting seals were also collected on an opportunistic basis for DNA analysis. 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. The skull was collected for all seals except pups. 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 from seals were collected, following the methods in Alcorn (1984), for analysis of food habits. Emphasis was placed on collecting scat and spew 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 items capable of entangling seals and turtles were inventoried and destroyed, following the methods in Johanos and Kam (1986).

CHAPTER 2. THE HAWAIIAN MONK SEAL ON FRENCH FRIGATE SHOALS, 1993

Mitchell P. Craig, Lisa M. Hiruki, Steve L. Gregg, Kyler J. Abernathy, Shawn C. Farry, Heather L. Johnson, Kelly K. Hastings, Roberta Swift, Susan A. Scott, and Patrick A. Ching

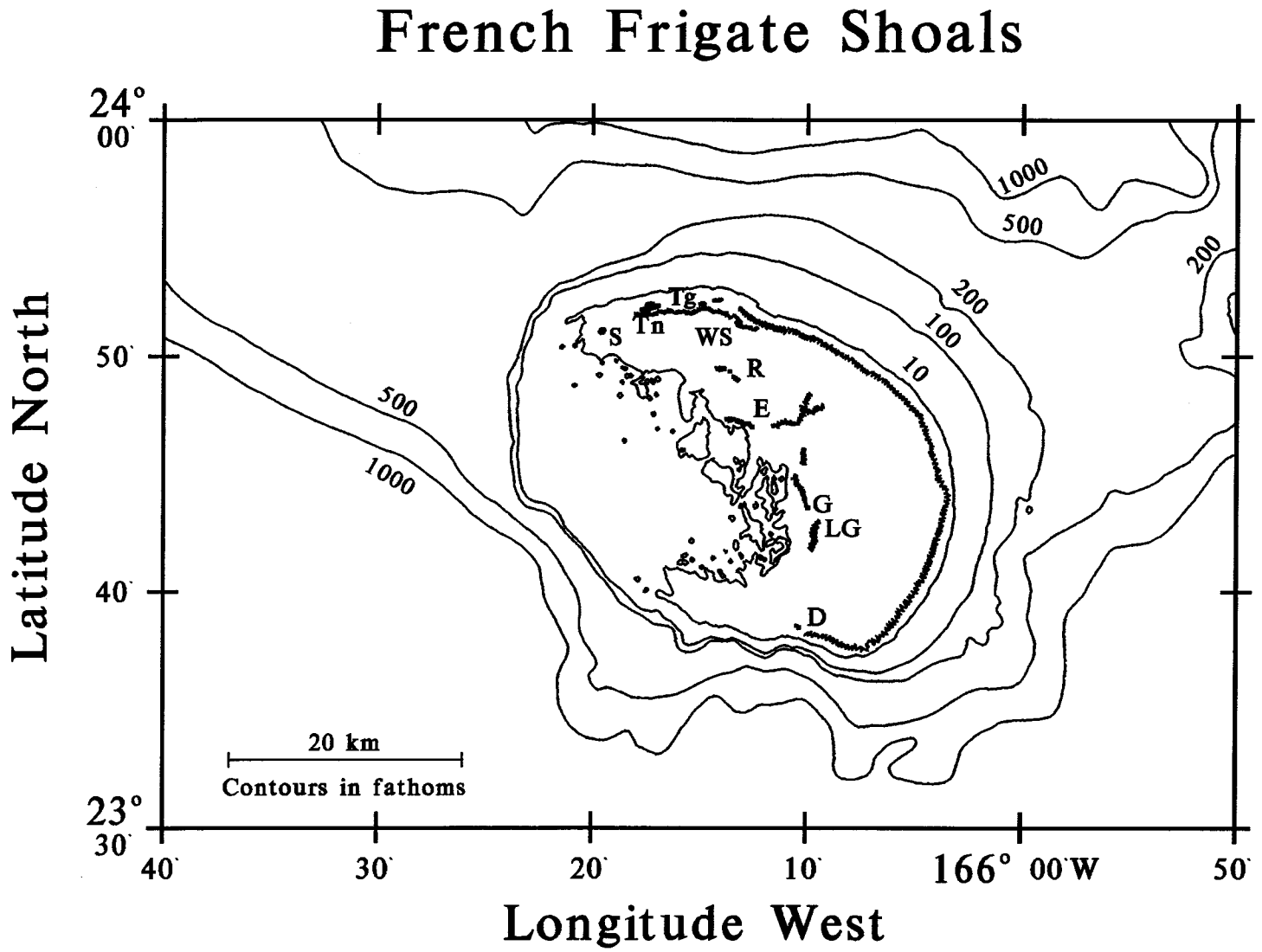


Fig. 2.1 French Frigate Shoals in the Northwestern Hawaiian Islands.

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 permanent islands and 7 semi-permanent sand spits (Fig. 2.1).

RESEARCH

Research was conducted by the National Marine Fisheries Service (NMFS) during January 9-February 6 and April 25-October 2. In addition, Tern Island censuses and incidental observations were recorded by the U.S. Fish and Wildlife Service (FWS) personnel during the rest of the year. The perimeters of six of the larger islands were divided into sectors using artificial or natural landmarks. In 1993, research objectives specific to this population included (1) capture of undersized weaned pups and emaciated juveniles for rehabilitation, (2) measurement of weaned pups and juvenile seals for a growth and condition study, and (3) investigation of habitat use patterns using satellite-linked telemetry.

Censuses and Patrols

Atoll censuses (n = 16) were conducted every 7.5 d, on average, from April 28 to August 27. Each atoll census began between 0900 and 1000 Hawaii standard time and ended between 1500 and 1900. Round Island and Mullet Island were censused from a boat, while the remaining islands were censused on foot by one or two persons. From January 2 to August 28, 1993, FWS and NMFS personnel conducted 32 censuses of seals on Tern Island.

Patrols were conducted on non-census days. East, Mullet, Round, and Whaleskate Islets were visited every 3-5 d to monitor pupping activity. Patrols of Tern Island were conducted every 3-4 d.

Individual Identification

A total of 514 individuals (426 excluding pups) were identified by existing or applied tags, scars, or natural markings. Most weaned pups were tagged (n = 79; 78 in 1993 and 1 in February 1994) with Temple Tags; 72 of these same pups were tagged with passive integrated transponder (PIT) tags. Thirty-one immature seals (21 male, 10 female) were retagged with Temple Tags.

Collection of Samples

One hundred and forty-one scat and spew samples were collected. Ninety-two tissue samples were collected from weaned pups and other seals during tagging. Blood samples were

collected from five yearlings and one weaned pup. Necropsies were performed on four dead seals found at the study site, two seals that died in captivity after collection for rehabilitation, and one fetus. Tissue samples were collected from all necropsied seals, and skulls were collected from five of these seals. In total, seven pieces of potentially entangling debris were inventoried and destroyed.

Special Studies

Seals Collected for Rehabilitation

Since 1984, NMFS has collected female pups whose size at weaning indicated their chance of survival to age 1 was low relative to survival of larger seals (Gilmartin and Gerrodette, 1986). From 1984 to 1991, female pups with an axillary girth <90 cm at weaning were captured and transported by airplane or ship to rehabilitation facilities on Oahu. After 8-12 mo of rehabilitation, they were reintroduced at Kure Atoll or Midway Islands. In 1992, the collection criteria (axillary girth at weaning) were raised to ≤95 cm because recent survival data (NMFS unpublished data) revealed that pups with girths of 90-95 cm also had substantially lower survival rates than larger seals.

Eleven female pups were collected for rehabilitation in 1993. Beginning in January, 8 emaciated or thin yearling females and 1 emaciated 3-year-old female were also collected for rehabilitation. These seals were held on Tern Island for up to 48 d before transport to Oahu. During the holding period, they were treated for bacterial infections and dehydration and were tube-fed fluids, including a milk replacer formula, and both force-fed and free-fed herring. Of the 20 females collected, 1 weaned pup and the 3-year-old died, and the remaining 18 seals were transported to Oahu. Of the 18 females transported from FFS, 2 weaned pups died on Oahu, 8 weaned pups remained in rehabilitation on Oahu for the rest of 1993, and the remaining 8 yearlings were transported to Kure Atoll in 1993 after rehabilitation on Oahu.

Growth Study

As part of a study comparing growth between the weaned pups and juveniles at Laysan Island and FFS, 63 weaned pups were weighed and measured within two weeks of weaning. In addition, 54 1-year-olds and 13 2-year-olds were weighed and measured in 1993.

Habitat Use Study

In September, three molted subadult males were instrumented with satellite-linked time-depth recorders as part of a habitat use pilot study.

RESULTS

Population Abundance and Composition

The means (±SD) for 16 atoll censuses were 197 seals (±22.6) including pups, and 156 seals (±20.8) excluding pups (Table 2.1). The total spring-summer population included 261 immature individuals (subadults, juveniles, and pups), of which 174 were subadults or juveniles (Table 2.2). The numbers of tagged known-age seals born at FFS during the period from 1984 to 1992 and resighted there in 1993, are summarized in Table 2.3.

Reproduction

At least 91 pups were born: 81 were weaned, 7 died or disappeared prior to weaning, 2 pups were still nursing at the end of this study, and the fate of one pup was unknown (Table 2.4a). Three fetuses were found, but not counted in the total number of pups born. Nursing periods and measurements of weaned pups are summarized in Table 2.4b.

A total of 176 adult-sized females were identified and 72 (41%) of those were parturient. An unknown number of adult-sized females remained unidentified at FFS. The birth rate was 50% (56/112) for untagged adult females (>9 years old) and 25% (16/64) for tagged females of adult size ($\leq$9 years old). Parturient females were more likely to be identified during lactation, which probably biased the estimates of birth rate upward. The mean (±SD) lactation period was 37.8 d (±5.9 d). At least 13 pups were fostered by mothers other than their own.

Interatoll Movement

Interatoll movement was documented for 28 seals that made a total of 41 movements between FFS and either Nihoa, Necker, or Laysan Islands (Tables 2.5a and b).

Factors Affecting Survival

Attacks by large sharks, mounting attempts by males, entanglement, emaciation, and other-unknown factors resulted in 31 life-threatening conditions, which led to the confirmed deaths of seven animals and the probable death of five seals (Table 2.6). Two incidents of adult male aggression were observed, but no seals were known to have died following male mounting incidents. Three emaciated seals died. Three seals were entangled; one was released by observers, another freed itself, and observers attempted to release the third seal, but it escaped capture and was not resighted. In addition to the deaths presented in Table 2.6, a small weaned female pup and an emaciated and severely injured 3-year-old female, captured for

rehabilitation, died at FFS while awaiting transportation to Oahu, and three aborted fetuses were found (one on Trig Island in April and two on Tern Island in March and July).

ACKNOWLEDGMENTS

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

TABLES

Table 2.1.--Summary statistics for atoll censuses (n = 16) of Hawaiian monk seals at French Frigate Shoals from April 28 to August 27, 1993.

Size/Sex	Mean number of individuals	Standard deviation
Adults	110.8	16.7
Male	23.4	7.6
Female	54.6	7.9
Unknown	32.8	14.1
Subadults	33.6	14.7
Male	14.5	6.8
Female	11.9	5.5
Unknown	7.1	4.8
Juveniles	10.1	3.9
Male	2.1	0.9
Female	7.0	3.5
Unknown	1.1	1.5
Pups	40.7	9.2
Male	10.6	6.6
Female	8.3	5.2
Unknown	21.8	9.3
Non-pup Total	156.3	20.8
Grand Total	196.9	22.6

Table 2.2.--Composition of the Hawaiian monk seal population at French Frigate Shoals during the spring and summer of 1993. Includes all pups born during the calendar year. Dashed lines indicate that the number of seals in a size-sex class was undetermined.

	Number of seals				
Size	Male	Female	Unknown	Total	Sex ratio male:female
Adults	--	--	--	--	--
Subadults	59	43	0	102	1.4:1
Juveniles	22	50[a]	0	72	0.4:1
Pups	41	44[b]	6	91	0.9:1
Non-pup Total	--	--	--	--	--
Grand Total	--	--	--	--	--

[a]Number includes 4 emaciated or thin seals collected for rehabilitation in May, 1993.
[b]Two neonatal pup deaths. Number includes 11 weaned pups collected for rehabilitation in 1993.

Table 2.3.--Summary of tagged known-age seals born at French Frigate Shoals and resighted there in 1993.

Age (years)	Sex	Number originally tagged	Number resighted in 1993
9	Male	49	19
	Female	43	26
8	Male	48	17
	Female	38	20
7	Male	52	21
	Female	48	21
6	Male	55	20
	Female	51	19
5	Male	52	16
	Female	62	11
4	Male	51	14
	Female	50	10
3	Male	41	4
	Female	38	4[a]
2	Male	24	3
	Female	44	12
1	Male	36	15
	Female	55	33[b]

[a]Number includes one emaciated seal collected for rehabilitation in January 1993.
[b]Number includes 8 emaciated or thin seals collected for rehabilitation, 4 each in January and May, 1993.

Table 2.4a.--Summary of Hawaiian monk seals born at French Frigate Shoals in 1993.

Event	Number of pups			
	Male	Female	Unknown	Total
Born	41	44	6	91
Died/probably died prior to weaning	1	4	2	7
Fate unknown	0	0	1	1
Still nursing	0	0	2	2
Weaned	40	40	1	81
Tagged	40	39	0	79[a]

[a]At the end of the field season, one weaned female pup had not been tagged. This pup was tagged in February 1994.

Table 2.4b.--Summary of nursing periods and measurements of weaned pups at French Frigate Shoals in 1993. Nursing periods were calculated where both birth and weaning date ranges were ≤4 d. All measurements were taken within two weeks after weaning. Measurements include 27 pups with an axillary girth of ≤95 cm.

	Nursing period (d)	Axillary girth (cm)	Straight dorsal length (cm)	Weight (kg)
Mean	37.1	97.3	122.0	57.3
St. Dev.	4.8	10.3	6.6	14.9
n	22	65	64	63

Table 2.5a.--Known movement of Hawaiian monk seals to French Frigate Shoals from other locations in 1993, summarized by movements between two locations. Some seals made more than one trip.

Original location	Number, size, and sex class
Laysan Island	5 adult females
Nihoa Island	2 adult females
Necker Island	1 adult male, 3 adult females, 2 subadult males, 3 subadult females

Table 2.5b.--Known movement of Hawaiian monk seals from French Frigate Shoals to other locations in 1993, summarized by movements between two locations. Some seals made more than one trip.

Destination	Number, size, and sex class
Laysan Island	2 adult females
Nihoa Island	4 adult males, 3 adult females, 1 subadult male
Necker Island	3 adult males, 2 adult females, 4 subadult males, 5 subadult females, 1 juvenile male

Table 2.6.--Factors affecting Hawaiian monk seal survival at French Frigate Shoals in 1993. Does not include captive seals.

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

[a]A seal was observed being mounted on 18 and 22 June, by 4 and 3 males, respectively.
[b]One seal was released by observers, and the other freed itself.
[c]This seal remained entangled. Observers attempted to release the seal, but it escaped capture and was not resighted.

CHAPTER 3. THE HAWAIIAN MONK SEAL ON LAYSAN ISLAND, 1993

Karen B. Lombard, Brenda L. Becker, John R. Klavitter, and Paul S. Armstrong

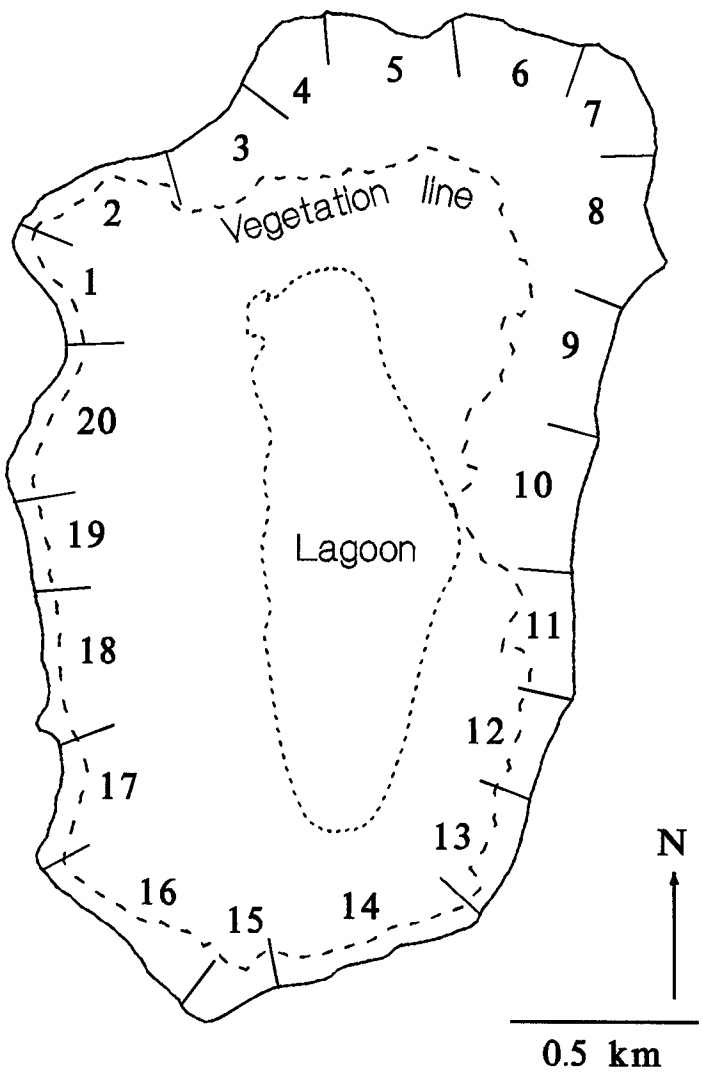


Fig. 3.1 Laysan Island in the Northwestern Hawaiian Islands.

Laysan Island (lat. 25°42'N, long. 171°44'W) is located ca. 1300 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.

RESEARCH

Research was conducted by the National Marine Fisheries Service (NMFS) during April 18-June 22 and August 2, and incidental observations were recorded by U.S. Fish and Wildlife Service (FWS) 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). In 1993, research objectives specific to this population included identification of all seals, documentation of male behavioral patterns and aggression, assessment of maternity and pup exchanges, and measurement of weaned pups and juveniles for a growth and condition study.

Censuses and Patrols

Censuses and patrols were scheduled to ensure that the entire island perimeter was monitored 6 times per week during April 19-June 19. Ten censuses were conducted by two observers every sixth day from April 22 to June 15. Each census began at 1300 Hawaii standard time and continued for 2.4 to 3.2 h.

Standardized behavior patrols were conducted on 44 non-census days, 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 documented to occur most frequently in the water.

Individual Identification

A total of 253 individuals (211 excluding pups) were identified by existing or applied tags, bleach marks, scars, or natural markings. Bleach marks were applied to 138 seals, including 24 nursing pups. Most weaned pups (n = 37) and 2 juvenile seals (1 male, 1 female) were tagged with Temple Tags and passive integrated transponder (PIT) tags. Three immature seals (2 male, 1 female) were retagged with PIT Tags.

Collection of Samples

One hundred and seven scat and spew samples were collected. Thirty-seven tissue samples were collected from weaned pups and other seals during tagging. A necropsy was performed and tissue samples were collected from one dead seal. In total, 363 pieces of potentially entangling debris were inventoried and destroyed

with the exception of one that was recovered and collected after a seal disentangled itself.

Special Studies/Noteworthy Events

Growth Study

In 1993, 35 weaned pups, 19 one-year-olds, and 17 two-year-olds were measured to compare growth of immature seals at Laysan Island and French Frigate Shoals.

Oiled Seals

On March 26, an oil spill was observed by FWS personnel on Laysan Island. Approximately 8 km of the 11 km coastline (sectors 5 to 15) were affected by pea-sized tar balls and clumps of oil 0.3 m wide, at 2-5 m intervals along the shoreline. Fifteen seals (11 identified, 4 unidentified) were seen with oil on them; and 5 of these seals were reported to be heavily matted with oil. The oil was raked up and burned by FWS personnel, and by April 16, when NMFS personnel arrived, no oil was observed on the beaches. During the 1993 field season, all 11 identified seals oiled in March were resighted and 6 additional immature seals were observed with small oil spots. All seals seemed to be in good health; however, sub-lethal or long-term effects could not be evaluated.

RESULTS

Population Abundance and Composition

The means (±SD) for 10 censuses were 100 seals (±9.3) including pups, and 74 seals (±7.7) excluding pups (Table 3.1). The total spring-summer population was 248 individuals, 206 excluding pups (Table 3.2). The sex ratios of non-pup immature seals and adults were 1.1:1 (30 males: 28 females) and 1.4:1 (85 males: 63 females), respectively. Within the adult class, the male-skewed sex ratio was due to older, unknown-aged seals, where the male to female ratio was 1.6:1 (58 males: 36 females); in the seals of adult size, but $\leq$10 years of age, the sex ratio was 1.0:1 (27 males: 27 females). The numbers of tagged known-age seals born at Laysan Island during the period from 1983 to 1992 and resighted there in 1993, are summarized in Table 3.3.

Reproduction

At least 42 pups were born: 38 were weaned, 1 died prior to weaning, 2 pups were still nursing at the end of this study, and 1 pup was born after the field season (Table 3.4a). Nursing periods and measurements of weaned pups are summarized in Table

3.4b. Forty-two of 64 (66%) adult-sized females were parturient. At least seven pup exchanges occurred between eight nursing females; none of these incidents were observed. Two weaning events were observed.

Interatoll Movement

Interatoll movement was documented for seven seals that made a total of 12 movements between Laysan Island and either French Frigate Shoals or Lisianski Island (Tables 3.5a and b).

Factors Affecting Survival

Attacks by large sharks, mounting attempts by males, entanglement, and other-unknown factors led to 14 life-threatening conditions, which resulted in the confirmed deaths of three animals and the probable deaths of three other seals (Table 3.6). One incident of adult male aggression was observed. No seals were known to have died following male mounting incidents. One seal was entangled and escaped by itself.

ACKNOWLEDGMENTS

We acknowledge the support of the U.S. Fish and Wildlife Service, Hawaiian Islands National Wildlife Refuge staff and thank the captain and crew members of the NOAA ship *Townsend Cromwell*. Special thanks are extended to Dick Bauer, Nathan Darnell, Vanessa Gauger, Becky Howard, Cindy Newton, Willie Joe Rogers, Rick Schauffer, and Tim White for their data collection and tagging assistance.

TABLES

Table 3.1.--Summary statistics for censuses (n = 10) of Hawaiian monk seals at Laysan Island from April 22 to June 15, 1993.

Size/Sex	Mean number of individuals	Standard deviation
Adults	52.8	4.3
Male	22.3	3.3
Female	27.1	3.1
Unknown	3.4	2.3
Subadults	3.4	1.3
Male	1.0	0.8
Female	1.7	0.9
Unknown	0.7	0.8
Juveniles	17.5	5.0
Male	8.9	2.7
Female	7.3	2.9
Unknown	1.3	1.3
Pups	25.8	5.3
Male	12.8	4.3
Female	9.5	2.3
Unknown	3.5	3.2
Non-pup Total	73.7	7.7
Grand Total	99.5	9.3

Table 3.2.--Composition of the Hawaiian monk seal population at Laysan Island during the spring and summer of 1993. Includes all pups born during the calendar year.

	Number of seals				
Size	Male	Female	Unknown	Total	Sex ratio male:female
Adults	85	63	0	148	1.4:1
Subadults	8	9	0	17	0.9:1
Juveniles	22	19	0	41	1.2:1
Pups	23	14	5[a]	42	1.6:1
Non-pup Total	115	91	0	206	1.3:1
Grand Total	138	105	5	248	1.3:1

[a]One neonatal pup death.

Table 3.3.--Summary of tagged known-age seals born at Laysan Island and resighted there in 1993.

Age (years)	Sex	Number originally tagged	Number resighted in 1993
10	Male	10	1
	Female	10	6
9	Male	16	3
	Female	13	5
8	Male	16	5
	Female	14	5
7	Male	15	4
	Female	17	3
6	Male	13	3
	Female	15	6
5	Male	23	6
	Female	17	3
4	Male	16	4
	Female	13	4
3	Male	7	3
	Female	9	5
2	Male	18	10
	Female	13	10
1	Male	18	12
	Female	14	9

Table 3.4a.--Summary of Hawaiian monk seals born at Laysan Island in 1993.

	Number of pups			
Event	Male	Female	Unknown	Total
Born	23	14	5	42
Died prior to weaning	0	0	1	1
Still nursing	0	0	3[a]	3
Weaned	23	14	1	38
Tagged	23	14	0	37

[a]Includes one pup born after the field season.

Table 3.4b.--Summary of nursing periods and measurements of weaned pups at Laysan Island in 1993. Nursing periods were calculated where both birth and weaning date ranges were ≤4 d. All measurements were taken within 2 weeks after weaning. Measurements include six pups with an axillary girth of ≤95 cm.

	Nursing period (d)	Axillary girth (cm)	Straight dorsal length (cm)	Weight (kg)
Mean	37.3	103.5	124.1	63.9
St. Dev.	4.2	7.2	5.5	11.0
n	14	30	30	30

Table 3.5a.--Known movement of Hawaiian monk seals to Laysan Island from other locations in 1993, summarized by movements between two locations. Some seals made more than one trip.

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

Table 3.5b.--Known movement of Hawaiian monk seals from Laysan Island to other locations in 1993, summarized by movements between two locations. Some seals made more than one trip.

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

Table 3.6.--Factors affecting Hawaiian monk seal survival at Laysan Island in 1993.

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

[a]Seal had fresh minor scratches from mounting by males at the time she incurred the new (and more severe) shark injury.
[b]Event was observed and involved five males. The resulting injuries appeared to be minor.
[c]Seal escaped by itself.

CHAPTER 4. THE HAWAIIAN MONK SEAL ON LISIANSKI ISLAND, 1993

Heather L. Johnston, Babette F. Fahey, and Thea C. Johanos

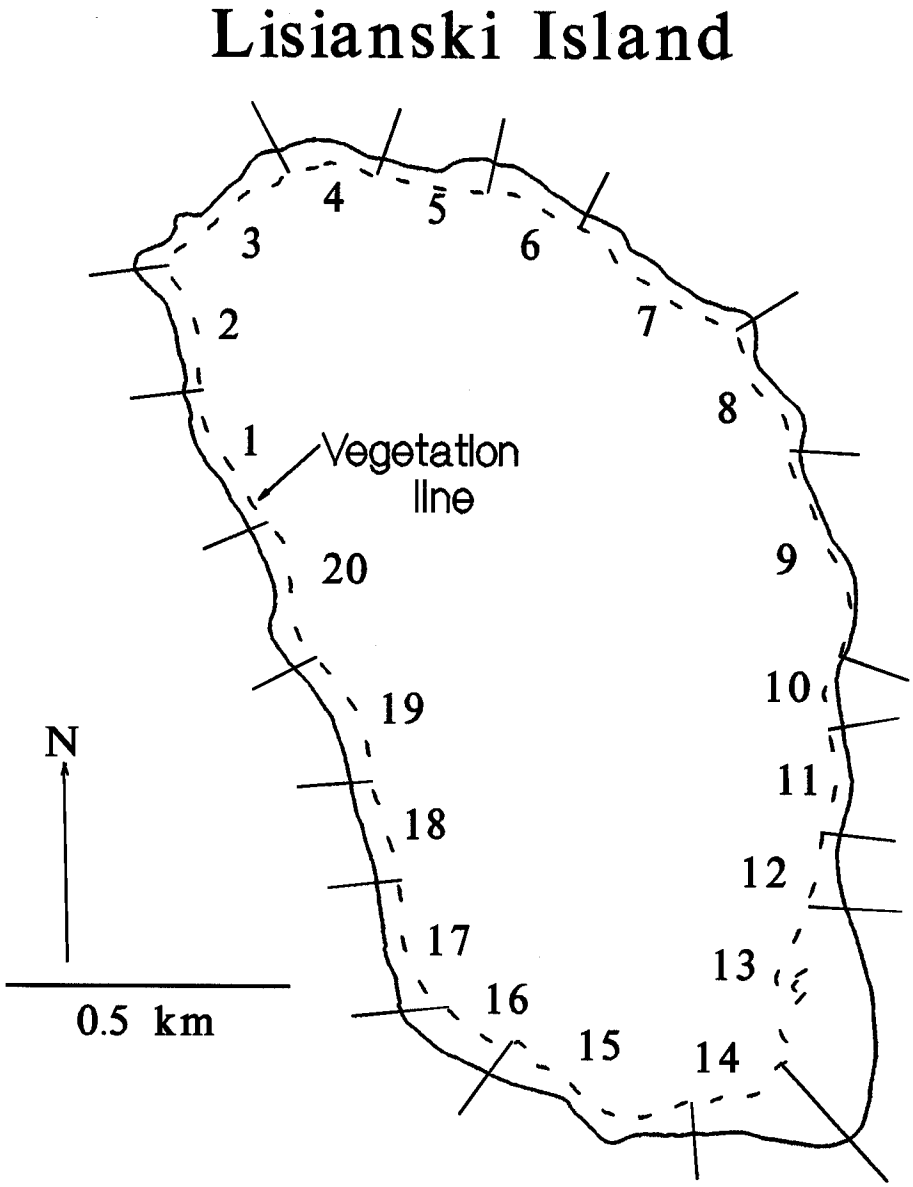


Fig. 4.1 Lisianski Island in the Northwestern Hawaiian Islands.

Lisianski Island (lat. 26°02'N, long. 174°00'W) is one of the major haulout and pupping locations of the Hawaiian monk seal. The island is located ca. 1760 km northwest of Oahu (Fig. 1.1), and is part of Neva Shoal, a shallow reef bank within the Hawaiian Islands National Wildlife Refuge.

RESEARCH

Research was conducted by the National Marine Fisheries Service during April 19-June 21, and incidental observations were recorded by U.S. Fish and Wildlife Service Personnel during August 2-8. The perimeter of the island was divided into 20 sectors using artificial or natural landmarks (Fig. 4.1). In 1993, research objectives specific to this population included identification of all adult and subadult seals, 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 April 19-June 19.

Censuses (n = 13) were conducted by two observers every fifth day from April 20 to June 19, beginning at 1300 Hawaiian Standard Time and continuing for 1.0 to 1.7 h. Standardized patrols were conducted on non-census days to assess activity patterns of adults and large subadults, document male aggression, and detect mobbing incidents. During these patrols (n = 25), attention was directed out to sea as much as possible because mobbing has been documented to occur most frequently in the water.

Individual Identification

A total of 204 individuals (187 excluding pups) were identified by existing or applied tags, bleach marks, scars, or natural markings. All weaned pups (n = 13) were tagged with Temple Tags and passive integrated transponder (PIT) tags. One juvenile female was tagged, and one juvenile female was retagged with Temple Tags.

Collection of Samples

One hundred and three scat and spew samples were collected. Fourteen tissue samples were collected from weaned pups and other seals during tagging. Skeletal samples were collected from one dead seal. In total, 479 pieces of potentially entangling debris were inventoried and destroyed.

RESULTS

Population Abundance and Composition

The means (±SD) for 13 censuses were 74 seals (±11.0) including pups, and 64 seals (±10.4) excluding pups (Table 4.1). The total spring-summer population was 202 individuals, 185 excluding pups (Table 4.2). The sex ratios of non-pup immatures and adults were 1.4:1 (39 males: 27 females) and 1.7:1 (75 males: 44 females), respectively. Within the adult class, the male-skewed sex ratio was due to older, unknown-aged seals, where the male to female ratio was 2.7:1 (52 males: 19 females); in the seals of adult size, but for animals ≤11 years of age, the sex ratio was 0.9:1 (23 males: 25 females). The numbers of tagged known-age seals born at Lisianski Island during the period from 1982 to 1992 and resighted there in 1993, are summarized in Table 4.3.

Reproduction

At least 17 pups were born; 13 were weaned and 4 were still nursing at the end of this study (Table 4.4a). Nursing periods and measurements of weaned pups are summarized in Table 4.4b. Seventeen of 44 (39%) adult-sized females were parturient. At least eight pup exchanges occurred between five nursing females; researchers observed one of these incidents.

Interatoll Movement

Interatoll movement was documented for four seals that made a total of six movements between Lisianski Island and either 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 unknown factors) led to 13 life-threatening conditions, which resulted in the probable death of one seal (Table 4.6). Two seals were entangled: one escaped by itself and the other was released by observers. In addition to the cases summarized in Table 4.6, the carcass of a dead subadult or adult male was found; this seal had died of unknown causes since the 1992 field season.

ACKNOWLEDGMENTS

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

TABLES

Table 4.1.--Summary statistics for censuses (n = 13) of Hawaiian monk seals at Lisianski Island from April 20 to June 19, 1993.

Size/Sex	Mean number of individuals	Standard deviation
Adults	43.8	9.6
Male	20.7	6.3
Female	15.6	4.6
Unknown	7.5	5.4
Subadults	13.6	5.3
Male	6.7	3.2
Female	4.1	2.6
Unknown	2.8	2.1
Juveniles	6.5	2.2
Male	3.5	1.1
Female	2.6	1.5
Unknown	0.5	0.7
Pups	9.9	1.5
Male	2.4	1.3
Female	6.2	2.0
Unknown	1.3	1.6
Non-pup Total	64.0	10.4
Grand Total	73.9	11.0

Table 4.2.--Composition of the Hawaiian monk seal population at Lisianski Island during the spring and summer of 1993. Includes all pups born during the calendar year.

	Number of seals				
Size	Male	Female	Unknown	Total	Sex ratio male:female
Adults	75	44	0	119	1.7:1
Subadults	24	14	0	38	1.7:1
Juveniles	15	13	0	28	1.2:1
Pups	4	12	1	17	0.3:1
Non-pup Total	114	71	0	185	1.6:1
Grand Total	118	83	1	202	1.4:1

Table 4.3.--Summary of tagged known-age seals born at Lisianski Island and resighted there in 1993.

Age (years)	Sex	Number originally tagged	Number resighted in 1993
11	Male	7	3
	Female	6	2
10	Male	6	2
	Female	18	8
9	Male	10	5
	Female	5	2
8	Male	5	2
	Female	9	2
7	Male	11	5
	Female	9	4
6	Male	12	3
	Female	6	2
5	Male	10	6
	Female	8	6
4	Male	--	--
	Female	--	--
3	Male	8	5
	Female	9	5
2	Male	9	7
	Female	6	4
1	Male	13	9
	Female	8	8

Table 4.4a.--Summary of Hawaiian monk seals born at Lisianski Island in 1993.

Event	Number of pups			
	Male	Female	Unknown	Total
Born	4	12	1	17
Died prior to weaning	0	0	0	0
Still nursing	0	3	1	4
Weaned	4	9	0	13
Tagged	4	9	0	13

Table 4.4b.--Summary of nursing periods and measurements of weaned pups at Lisianski Island in 1993. Nursing periods were calculated where both birth and weaning date ranges were ≤4 days. All measurements were taken within 2 weeks after weaning. Measurements include four pups with an axillary girth of ≤95 cm.

	Nursing period (d)	Axillary girth (cm)	Straight dorsal length (cm)	Weight (kg)
Mean	38.8	101.3	125.7	--
St. Dev.	2.7	7.7	4.7	--
n	4	12	12	--

Table 4.5a.--Known movement of Hawaiian monk seals to Lisianski Island from other locations in 1993, summarized by movements between two locations. Some seals made more than one trip.

Original location	Number, size, and sex class
Laysan Island	1 adult male, 1 adult female, 1 subadult male
Pearl and Hermes Reef	1 subadult female

Table 4.5b.--Known movement of Hawaiian monk seals from Lisianski Island to other locations in 1993, summarized by movements between two locations. Some seals made more than one trip.

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

Table 4.6.--Factors affecting Hawaiian monk seal survival at Lisianski Island in 1993.

			Outcome		
Size	Sex	Total	Injured	Died	Probably died
Attack by Large Shark					
Adult	Male	3	2	0	1[a]
	Female	1	1	0	0
Mounting by Males					
Adult	Female	3	3	0	0
	Unknown	1	1	0	0
Subadult	Male	1	1	0	0
	Female	1	1	0	0
Entanglement					
Subadult	Male	1[b]	0	0	0
Weaned pup	Female	1[c]	0	0	0
Unknown					
Subadult	Male	1	1	0	0

[a]An emaciated seal was then severely injured by a shark.
[b]Seal escaped by itself.
[c]Seal released by observers.

CHAPTER 5. THE HAWAIIAN MONK SEAL ON PEARL AND HERMES REEF, 1993

John R. Henderson, Kyler J. Abernathy, Mitchell P. Craig, Babette F. Fahey, Steven L. Gregg, Lisa M. Hiruki, Heather L. Johnston, John R. Klavitter, and Karen B. Lombard

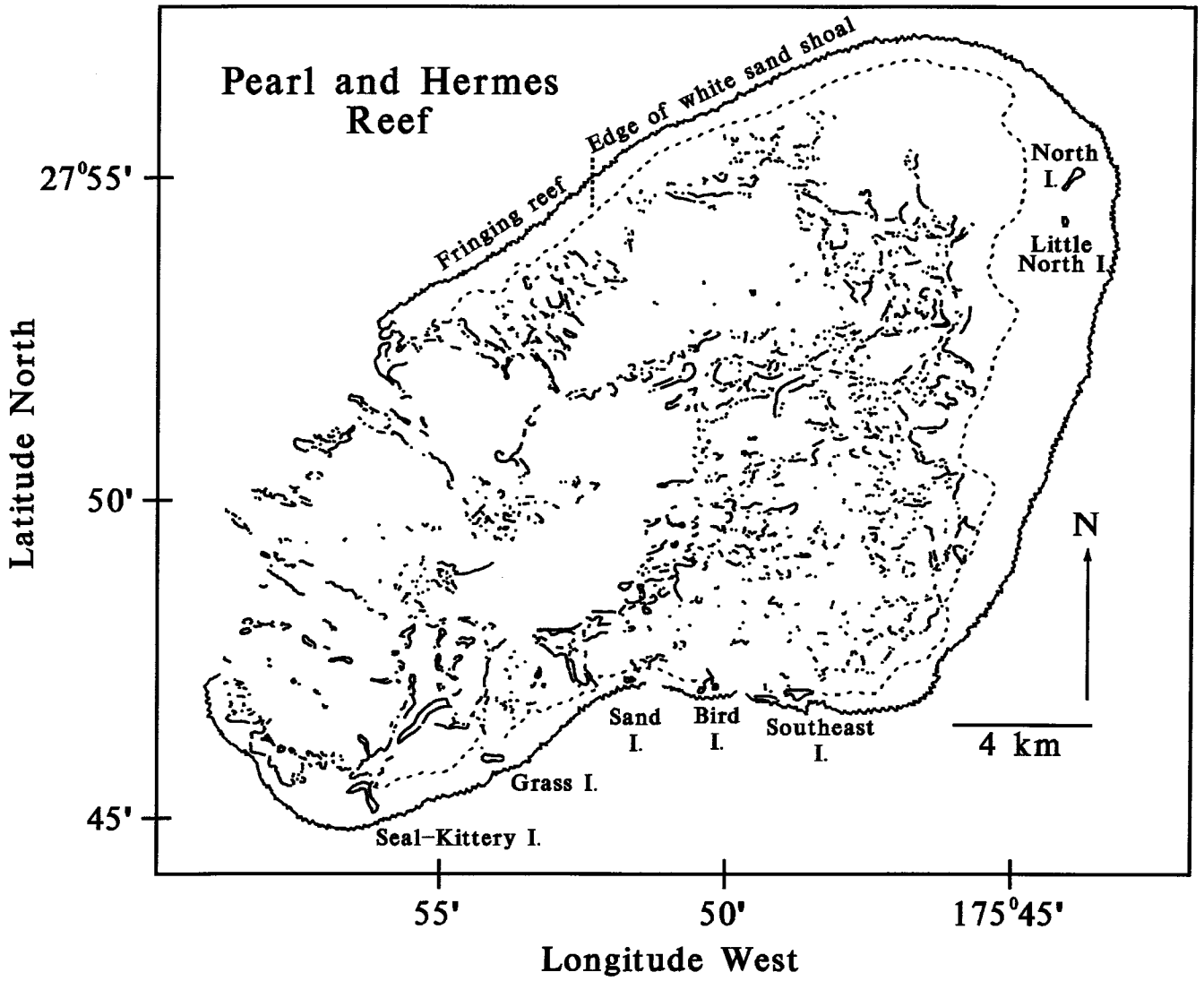


Fig. 5.1 Pearl and Hermes Reef in the Northwestern Hawaiian Islands.

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. 1900 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

Research was conducted by the National Marine Fisheries Service during April 18-22 and June 27-30. The perimeters of the four larger vegetated islands were divided into sectors using natural landmarks. In 1993, research objectives for the Pearl and Hermes monk seal population were to conduct basic population research as outlined in Chapter 1.

Censuses and Patrols

Atoll censuses (n = 4) were conducted during April 18-22, and on June 28, beginning at 1000 Hawaiian Standard Time and continuing for approximately 8 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 131 individuals (120 excluding pups) were identified by existing or applied tags, scars, or natural markings. Weaned pups were tagged (n = 21) with Temple Tags and passive integrated transponder (PIT) tags. Three immature seals (one male, two female) were also tagged with Temple Tags and PIT tags.

Collection of Samples

Two scat samples were collected. Seven tissue samples were collected from weaned pups and other seals during tagging. In total, 212 pieces of potentially entangling debris were inventoried and destroyed, representing only part of the potentially entangling debris present in 1993. The remaining potentially dangerous debris items were destroyed without being inventoried.

RESULTS

Population Abundance and Composition

The means (±SD) for four atoll censuses were 72 seals (±11.7) including pups, and 58 seals (±6.2) excluding pups (Table

5.1). Due to limited effort, the composition of the spring-summer population was not determined. The numbers of tagged known-age seals born at Pearl and Hermes Reef during the period from 1983 to 1992 and resighted there in 1993, are summarized in Table 5.3.

Reproduction

At least 28 pups were born: 21 were weaned, 6 pups were still nursing at the end of this study, and 1 pup was born after the end of the field season (Table 5.4). Due to the abbreviated field season, weaning dates were not determined for any of the tagged pups, and no measurements were known to have been within 2 weeks of weaning.

Interatoll Movement

Interatoll movement was documented for five seals that made a total of seven movements between Pearl and Hermes Reef and either Lisianski Island or Midway Islands (Tables 5.5a and b).

Factors Affecting Survival

Factors affecting survival were not observed at Pearl and Hermes Reef in 1993.

ACKNOWLEDGMENTS

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

TABLES

Table 5.1.--Summary statistics for atoll censuses (n = 4) of the Hawaiian monk seals at Pearl and Hermes Reef, April 18-22 and June 27-30, 1993.

Size/Sex	Mean number of individuals	Standard deviation
Adults	30.3	5.4
Male	11.3	1.0
Female	14.8	3.8
Unknown	4.3	1.7
Subadults	15.0	3.6
Male	5.5	1.7
Female	5.8	1.5
Unknown	3.8	3.0
Juveniles	12.5	2.6
Male	5.0	1.4
Female	7.0	3.2
Unknown	0.5	0.6
Pups	13.8	5.7
Male	5.3	4.6
Female	1.8	2.9
Unknown	6.8	2.5
Non-pup Total	57.8	6.2
Grand Total	71.5	11.7

Table 5.2.--Composition of the Hawaiian monk seal population at Pearl and Hermes Reef during the spring and summer of 1993.

	Number of seals			
Size	Male	Female	Total	Sex ratio male:female
Adults				
Subadults				
Juveniles	(Composition not determined as described on page 51.)			
Pups				
Non-pup Total				
Grand Total				

Table 5.3.--Summary of tagged known-age seals born at Pearl and Hermes Reef and resighted there in 1993.

Age (years)	Sex	Number originally tagged	Number resighted in 1993
10	Male	8	3
	Female	2	0
9	Male	5	3
	Female	8	3
8	Male	9	1
	Female	6	2
7	Male	10	3
	Female	7	3
	Unknown	1	0
6	Male	14	7
	Female	7	3
5	Male	12	8
	Female	6	4
4	Male	8	5
	Female	6	3
3	Male	5	1
	Female	1	0
2	Male	10	8
	Female	11	7
1	Male	13	8
	Female	9	9

Table 5.4.--Summary of Hawaiian monk seals born at Pearl and Hermes Reef in 1993.

Event	Number of pups			
	Male	Female	Unknown	Total
Born	14	7	7	28
Died prior to weaning	0	0	0	0
Still nursing	0	0	7[a]	7
Weaned	14	7	0	21
Tagged	14	7	0	21

[a]Number includes one pup born after the field season, and sighted by U.S. Fish and Wildlife Service personnel on August 12, 1993.

Table 5.5a.--Known movement of Hawaiian monk seals to Pearl and Hermes Reef from other locations in 1993, summarized by movements between two locations. Some seals made more than one trip.

Original location	Number, size, and sex class
Midway Islands	2 adult males

Table 5.5b.--Known movement of Hawaiian monk seals from Pearl and Hermes Reef to other locations in 1993, summarized by movements between two locations. Some seals made more than one trip.

Destination	Number, size, and sex class
Lisianski Island	1 subadult female
Midway Islands	1 adult male, 3 adult females

CHAPTER 6. THE HAWAIIAN MONK SEAL AT MIDWAY ISLANDS, 1993

Tonya Holonko, Timothy J. Ragen, and Thea C. Johanos

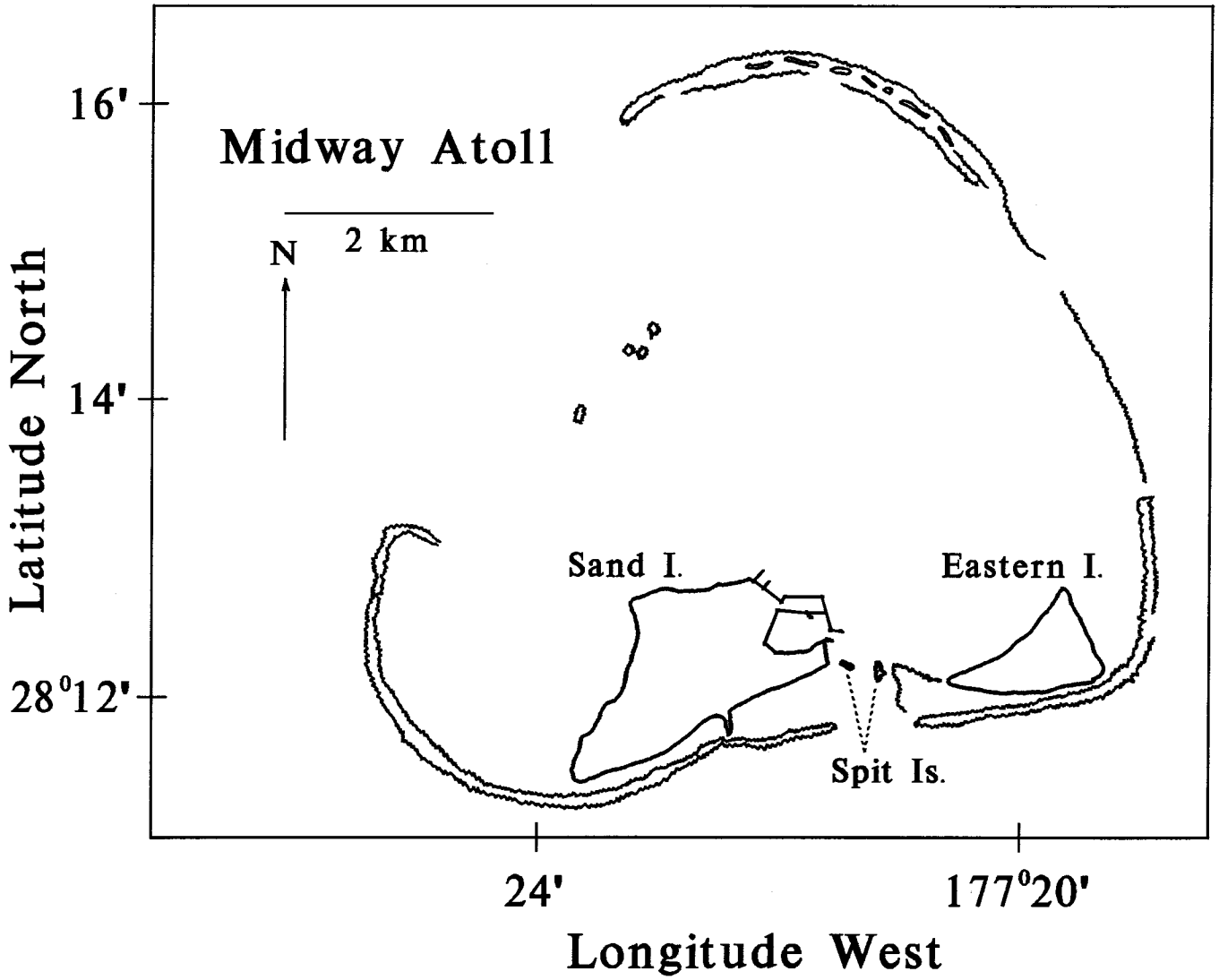


Fig. 6.1 Midway Atoll in the Northwestern Hawaiian Islands.

Midway Island (lat. 28°15'N, long. 177°35'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 2100 km northwest of Oahu in the Northwestern Hawaiian Islands (Fig. 1.1) and comprises a circular fringing 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 Navy is in the process of vacating the atoll, and primary management authority will be transferred to the U.S. Fish and Wildlife Service (FWS), which has maintained a refuge (Midway Atoll National Wildlife Refuge) at the site since 1988.

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). Since the late 1960s, the population has failed to recover, and the majority of the seals currently at the site appear to be immigrants or offspring of immigrants. However, the earlier counts indicate that the Midway population has significant potential for growth, and recovery of this population is an important management goal.

RESEARCH

Research was conducted by the National Marine Fisheries Service during May 22-June 30. In addition, periodic surveys were conducted from January 7 to April 18, and incidental observations were recorded by FWS personnel during the rest of the year. The perimeters of the three permanent islands were divided into sectors using artificial or natural landmarks. In 1993, research objectives specific to this population included (1) identification of as many seals as possible, (2) release of seals translocated from French Frigate Shoals (FFS), (3) determining the fate of translocated seals released at Midway Islands in 1992-93, and (4) monitoring disturbance to seals due to human activities.

Censuses and Patrols

One atoll census was conducted on January 17. All islands were censused on foot by one or two persons. Sand Island was patrolled almost daily from May 22 to June 30, whereas Eastern Island was patrolled 1 to 2 times per week, depending on availability of boat transportation, and Spit Island was patrolled approximately once every 10 days during this time

period. Patrols generally started at approximately 1000 Hawaii Standard Time, and lasted 2 to 3 hours. Sighting effort, particularly late in June, was increased by occasional early morning and late evening patrols.

Individual Identification

A total of 25 individuals (23 excluding pups) were identified by existing or applied tags, scars, or natural markings: 23 were from the resident population and the remainder (3 immature females) were translocated to Midway in 1993. The identified individuals represent an unknown portion of the total Midway Islands population. One weaned male pup was tagged with Temple Tags and passive integrated transponder (PIT) tags.

Collection of Samples

No samples were collected at Midway Islands in 1993.

Special Studies

Rehabilitation Program

Three immature female seals were released at Midway Islands on January 7, 1993 as part of an effort to augment the Midway population. When collected from FFS in 1992, they were of a size or weight smaller than other seals in their age class. These seals were rehabilitated on Oahu and then translocated to Midway Islands in 1992, where they were temporarily maintained in a mesh enclosure for additional rehabilitation prior to their anticipated release. These three seals were returned to Oahu in early December 1992 for further rehabilitation. When the immature females were returned to Midway in January, 1993, they were released directly from their cages onto a concrete boat ramp on the northeast side of Sand Island.

RESULTS

Population Abundance and Composition

The total beach count for an atoll census conducted on January 17 was 14 seals, all older than pups (Table 6.1). Due to limited effort, the composition of the spring-summer population was not determined. The numbers of tagged known-age seals born at Midway during the period from 1988 to 1992 and resighted there in 1993, are summarized in Table 6.3.

Reproduction

At least two pups were born (one male and one of undetermined sex). Both survived to weaning, but one disappeared

after 28 May (Table 6.4a). Measurements from the male pup are in Table 6.4b.

Interatoll Movement

Interatoll movement was documented for eight seals that made a total of thirteen movements between Midway Islands and either Pearl and Hermes Reef or Kure Atoll (Tables 6.5a and b).

Factors Affecting Survival

Factors affecting survival were not observed at Midway Islands in 1993.

ACKNOWLEDGMENTS

We acknowledge the support of the U.S. Fish and Wildlife Service, Midway Atoll National Wildlife Refuge. Special thanks are extended to Don Williamson, Biologist, and Mike Nishimoto, Refuge Manager. We also thank the officers and crew of the NOAA ship *Townsend Cromwell* for logistical assistance.

TABLES

Table 6.1.--Summary statistics for an atoll census (n = 1) of Hawaiian monk seals at Midway Islands on January 17, 1993.

Size/Sex	Number of individuals	Standard deviation
Adults	3	NA
Male	1	NA
Female	2	NA
Unknown	0	NA
Subadults	1	NA
Male	0	NA
Female	1	NA
Unknown	0	NA
Juveniles	8	NA
Male	1	NA
Female	7	NA
Unknown	0	NA
Pups	0	NA
Male	0	NA
Female	0	NA
Unknown	0	NA
Non-pup Total	14	NA
Grand Total	14	NA

Table 6.2.--Composition of the Hawaiian monk seal population at Midway Islands during the spring and summer of 1993.

	Number of seals			
Size	Male	Female	Total	Sex ratio male:female
Adults				
Subadults				
Juveniles	(Composition not determined as described on page 64.)			
Pups				
Non-pup Total				
Grand Total				

Table 6.3.--Summary of tagged known-age seals born at Midway Islands and resighted there in 1993.

Age (years)	Sex	Number originally tagged	Number resighted in 1993
5	Male	0	NA
	Female	1	0
2	Male	1	1
	Female	1	1
1	Male	O	NA
	Female	1	1

Table 6.4a.--Summary of Hawaiian monk seals born at Midway Islands in 1993.

	Number of pups			
Event	Male	Female	Unknown	Total
Born	1	0	1	2
Died prior to weaning	0	0	0	0
Weaned	1	0	1	2
Tagged	1	0	0	1

Table 6.4b.--Summary of nursing periods and measurements of weaned pups at Midway Islands in 1993. All measurements were taken within 2 weeks after weaning.

	Nursing period (d)	Axillary girth (cm)	Straight dorsal length (cm)	Weight (kg)
Mean	--	114.0	140.0	--
St. Dev.	--	NA	NA	--
n	--	1	1	--

Table 6.5a.--Known movement of Hawaiian monk seals to Midway Islands from other locations in 1993, summarized by movements between two locations. Some seals made more than one trip.

Original location	Number, size, and sex class
Pearl and Hermes Reef	1 adult male, 3 adult females
Kure Atoll	1 adult female

Table 6.5b.--Known movement of Hawaiian monk seals from Midway Islands to other locations in 1993, summarized by movements between two locations. Some seals made more than one trip.

Destination	Number, size, and sex class
Pearl and Hermes Reef	2 adult males
Kure Atoll	1 adult male, 2 adult females, 3 subadult females

CHAPTER 7. THE HAWAIIAN MONK SEAL AT KURE ATOLL, 1993

John R. Henderson, Ramona M. Visnak, and Jose P. Tavares

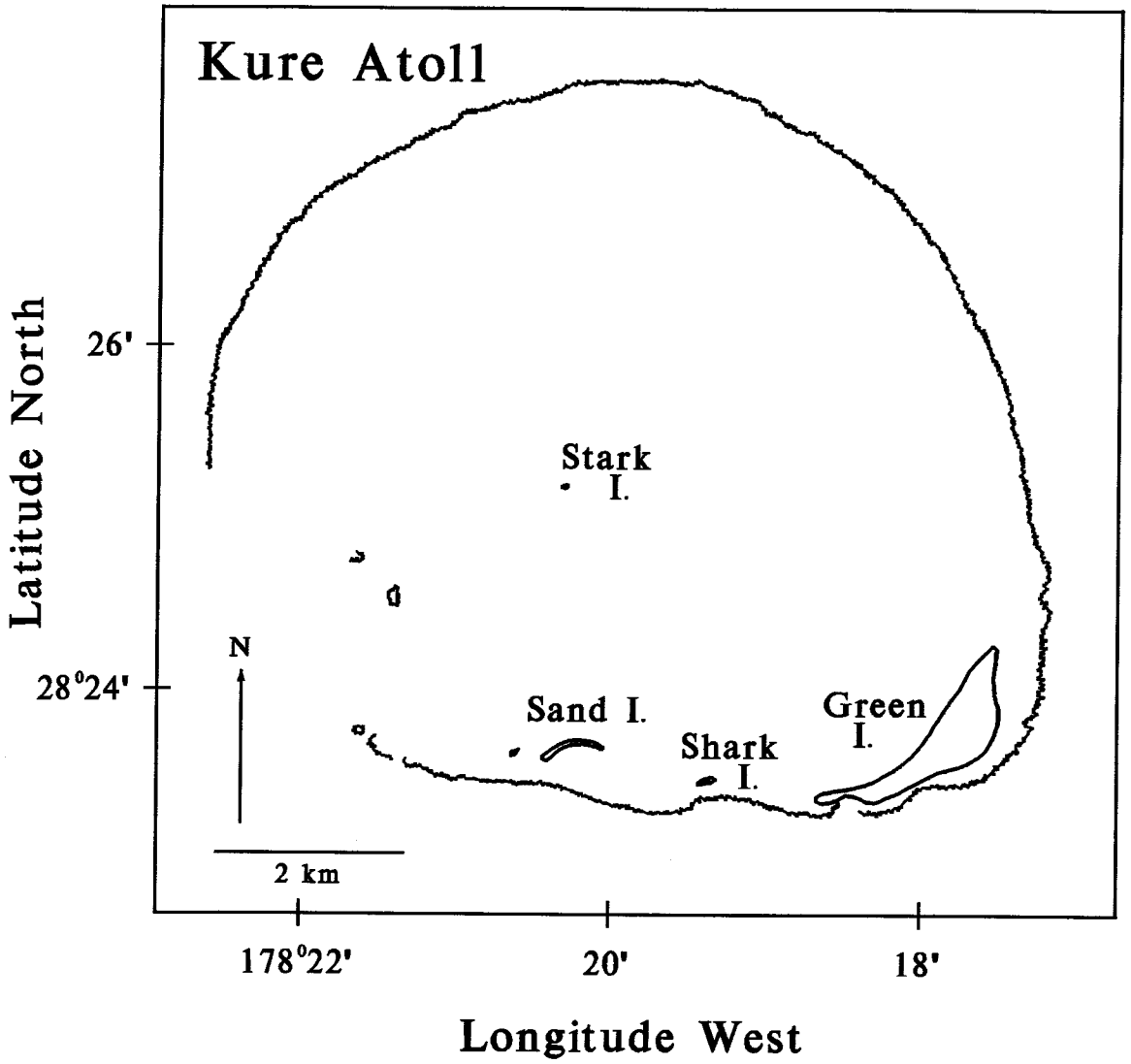


Fig. 7.1 Kure Atoll in the Northwestern Hawaiian Islands.

Kure Atoll (lat. 28°25'N, long. 178°10'W) is one of the major haulout and pupping locations of the Hawaiian monk seal. The atoll is located ca. 2300 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, enclosing a 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.

RESEARCH

Research was conducted by the National Marine Fisheries Service during April 19-21, July 11-August 16, August 19-25, and September 14-17. The perimeter of the largest vegetated island was divided into eight sectors, using artificial or natural landmarks. In 1993, research objectives for the Kure Atoll monk seal population included assessing the survival of weaned female pups in an effort to identify impacts from discontinuation of the Headstart Project, and release of seals translocated from French Frigate Shoals (FFS).

Censuses and Patrols

Atoll censuses (n = 15) were conducted on April 20 and 21, and approximately twice a week, weather permitting, from July 17 to August 20. Each census began between 1300 and 1430 Hawaii standard time and ended between 1600 and 1800. All islands were censused on foot by one or two persons. Stark Reef was not emergent during the 1993 field season.

In addition, patrols were conducted to identify seals and monitor locations used by parturient females.

Individual Identification

A total of 110 individuals (97 excluding pups) were identified by existing or applied tags, scars, or natural markings. This total does not include the entire population, as a small but unknown number of adult male seals were not identified. All weaned pups (n = 13) were tagged with Temple Tags, and passive integrated transponder (PIT) tags.

Collection of Samples

Tissue samples were collected from one weaned pup during tagging. In total, 893 pieces of potentially entangling debris were inventoried and destroyed.

Special Studies

Monitoring Impacts of Past Management Efforts

The Head Start Project (1981-91) and the Rehabilitation Project (1984-91) used a temporary enclosure, stocked with locally trapped live reef fish, to enhance the first year survival of weaned female seal pups and reintroduce rehabilitated yearlings from French Frigate Shoals (FFS) into the wild (Gilmartin and Gerrodette, 1986). Because of the logistical constraints imposed by the closure of the USCG LORAN Station on Kure in 1992, both projects were discontinued, and the enclosure was removed. In 1993, observers assessed the survival of weaned female pups and seals that had gone through the Head Start and Rehabilitation Projects in previous years, to determine the effectiveness of these management efforts.

Introduction of Rehabilitated Seals

Although the temporary enclosure for seals was permanently removed in 1991, the Rehabilitation Project was resumed in 1993 with the introduction of 14 yearling females. These animals were not maintained in any beach enclosure but were released directly from their cages onto the west beach of Green Island. Seven animals were released in April, 3 were released in July, and 4 were released in September.

RESULTS

Population Abundance and Composition

The means (±SD) for 15 atoll censuses were 32 seals (±7.6) including pups, and 27 seals (±6.6) excluding pups (Table 7.1). The total spring-summer adult female population consisted of 22 seals. The total spring-summer immature population was 71 individuals, 58 excluding pups (Table 7.2). The numbers of tagged known-age seals born at Kure Atoll during the period from 1981 to 1992 and resighted there in 1993, are summarized in Table 7.3.

Reproduction

At least 13 pups were born and weaned (Table 7.4a). No pup was observed from birth to weaning; hence, nursing periods were not calculated. Two pups were known to have weaned less then 2 weeks prior to being tagged, and their measurements are in Table 7.4b. Of the 22 adult-sized females identified, a minimum of 13 were parturient (59%). Because most pups weaned before field

observations commenced in July, only three parturient females were identified. Two of these three females had been temporarily maintained as pups in the Kure Atoll Head Start enclosure in 1985.

Interatoll Movement

Interatoll movement was documented for five seals that made a total of seven movements between Kure Atoll and Midway Islands (Table 7.5a and b).

Factors Affecting Survival

An attack by a large shark and an entanglement in debris resulted in two life-threatening conditions (Table 7.6). One juvenile seal was bitten in the head by a shark causing blindness in one eye. The injury was healing and the animal appeared thin but alert. A male weaned pup was entangled by a shard of net about its chest and right front flipper but freed itself without intervention.

ACKNOWLEDGMENTS

We acknowledge the USCG Air Station Barbers Point, and the officers and crew of the NOAA ship *Townsend Cromwell* and the USCGC *Sassafras* for logistical support and for transport to and from Kure Atoll. We also thank the State of Hawaii Division of Forestry and Wildlife.

TABLES

Table 7.1.--Summary statistics for atoll censuses (n = 15) of Hawaiian monk seals at Kure Atoll from April 20 to August 20, 1993.

Size/Sex	Mean number of individuals	Standard deviation
Adults	11.6	4.7
Male	5.4	2.3
Female	4.1	2.3
Unknown	2.1	2.3
Subadults	8.2	3.0
Male	4.3	1.8
Female	3.3	2.1
Unknown	0.5	0.7
Juveniles	7.6	2.8
Male	1.6	0.8
Female	5.9	2.4
Unknown	0.1	0.4
Pups	4.8	2.0
Male	2.4	1.6
Female	2.0	1.1
Unknown	0.4	1.1
Non-pup Total	27.4	6.6
Grand Total	32.2	7.6

Table 7.2.--Composition of the Hawaiian monk seal population at Kure Atoll during the spring and summer of 1993. Includes all pups born during the calendar year. Dashed lines indicate that the number of seals in a size-sex class was undetermined.

	Number of seals				
Size	Male	Female	Unknown	Total	Sex ratio male:female
Adults	--	22	--	--	--
Subadults	9	20	0	29	0.5:1
Juveniles	6	23[a]	0	29	0.3:1
Pups	9	4	0	13	2.3:1
Non-pup Total	--	--	--	--	--
Grand Total	--	--	--	--	--

[a]Number includes 14 rehabilitated yearlings released at Kure Atoll between April and August, 1993.

Table 7.3.--Summary of tagged known-age seals born at Kure Atoll and resighted there in 1993.

Age (years)	Sex	Number originally tagged	Number resighted in 1993
12	Male	3	2
	Female	5	2
11	Male	1	0
	Female	3	2
10	Male	4	2
	Female	0	NA
9	Male	4	2
	Female	2	2
8	Male	2	1
	Female	3	3
7	Male	1	1
	Female	0	NA
6	Male	1	1
	Female	3	1
5	Male	2	2
	Female	5	2
4	Male	5	3
	Female	4	1
3	Male	3	0
	Female	3	2
2	Male	7	5
	Female	6	4
1	Male	5	4
	Female	8	6

Table 7.4a.--Summary of Hawaiian monk seals born at Kure Atoll in 1993.

Event	Number of pups			
	Male	Female	Unknown	Total
Born	9	4	0	13
Died prior to weaning	0	0	0	0
Weaned	9	4	0	13
Tagged	9	4	0	13

Table 7.4b.--Summary of nursing periods and measurements of weaned pups at Kure Atoll in 1993. Nursing periods were calculated where both birth and weaning date ranges were ≤4 d. All measurements were taken within 2 weeks after weaning. Measurements include no pups with an axillary girth of ≤95 cm.

	Nursing period (d)	Axillary girth (cm)	Straight dorsal length (cm)	Weight (kg)
Mean	--	111.5	123.0	--
St. Dev.	--	22.6	11.3	--
n	--	2	2	--

Table 7.5a.--Known movement of Hawaiian monk seals to Kure Atoll from other locations in 1993, summarized by movements between two locations. Some seals made more than one trip.

Original location	Number, size, and sex class
Midway Islands	1 adult male, 2 adult females, 3 subadult females

Table 7.5b.--Known movement of Hawaiian monk seals from Kure Atoll to other locations in 1993, summarized by movements between two locations. Some seals made more than one trip.

Destination	Number, size, and sex class
Midway Islands	1 adult female

Table 7.6.--Factors affecting Hawaiian monk seal survival at Kure Atoll in 1993.

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

[a]Seal escaped by itself.

CHAPTER 8. THE HAWAIIAN MONK SEAL ON NIHOA AND NECKER ISLANDS, 1993

Timothy J. Ragen and Michele A. Finn

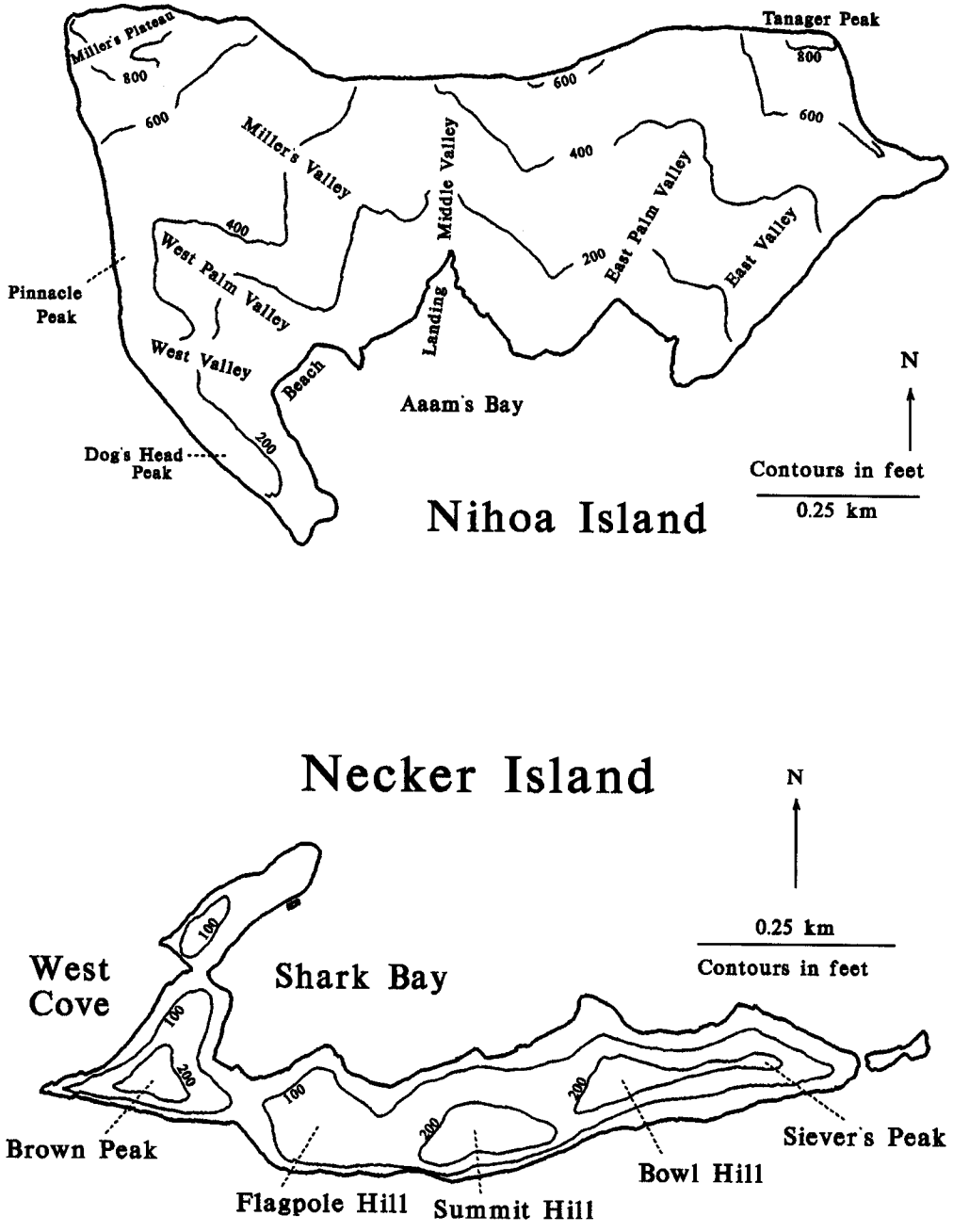


Fig. 8.1 Nihoa and Necker Islands in the Northwestern Hawaiian Islands.

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

RESEARCH

Research was conducted by the National Marine Fisheries Service at Nihoa Island during July 29-August 7, and at Necker Island on April 26 and during July 30-August 5, 1993. The perimeters of Nihoa and Necker Islands were divided into 3 and 10 sectors, respectively, using natural landmarks (Fig. 8.1). Beginning in 1989, the monk seal population at French Frigate Shoals began to decline, largely from loss of juvenile seals. In 1993, research objectives specific to the Nihoa and Necker Islands monk seal populations included assessment of the extent of migration from French Frigate Shoals to these locations, to determine if migration may have contributed to the decline observed at French Frigate Shoals.

Censuses and Patrols

Censuses (n = 7) were conducted daily on Nihoa Island by one observer from July 30 to August 7, beginning between 1300 and 1414 Hawaiian standard time and continuing for approximately 1 h. Censuses were limited to sectors 1 (rocky shelf area at the base of Miller's Valley) and 2 (sandy beach known as Derby's Landing). In addition, incidental patrols were conducted opportunistically to read tags previously applied to seals at Nihoa Island or French Frigate Shoals.

Censuses (n = 6) were conducted on Necker Island; one was completed on April 26, and five were conducted between July 31 and August 4 by two observers, beginning at 1300 Hawaiian standard time and continuing for approximately 2 h. In addition, incidental patrols (n = 19) were conducted opportunistically to read tags previously applied to seals at Necker Island or French Frigate Shoals, and to monitor injured seals.

Individual Identification

On Nihoa Island, 12 seals were identified by existing tags, including 2 2-yr-old males, 2 5-yr-old females, 2 5-yr-old males, 1 6-yr-old female, 1 7-yr-old female, 1 7-yr-old male, 1 8-yr-old female, and 2 8-yr-old males. The 2 2-yr-old males had been tagged at Nihoa Island in 1991, but all other seals had been tagged at French Frigate Shoals. Four of these animals (a 5-yr-old male, a 6-yr-old female, a 7-yr-old female, and an 8-yr-old male) had been seen at French Frigate Shoals in 1992. The small

number of tagged animals seen, and the fact that they were 5-yr-olds or older suggests that migration to Nihoa Island does not explain the recent decline in the number of juvenile seals at French Frigate Shoals. No weaned pups were tagged at Nihoa Island in 1993.

On Necker Island, 12 adult seals (5 males, 7 females) were identified by scars and natural markings. Fourteen seals were identified by existing tags applied at French Frigate Shoals, including 1 juvenile female of unknown age, 2 2-yr-old females, 1 3-yr-old male, 1 4-yr-old male, 1 5-yr-old males, 1 6-yr-old females, 1 6-yr-old male, 1 7-yr-old male, 1 8-yr-old male, and 2 9-yr-old males. Eleven of these animals had been seen at French Frigate Shoals in 1992, leaving only three seals (a 5-yr-old female, a 7-yr-old male, and a 9-yr-old male) that were not seen there in 1992. The small number of tagged animals seen, and the fact that most of these seals were 5-yr-olds or older suggests that migration to Necker Island does not explain the recent decline in the number of juvenile seals at French Frigate Shoals. One weaned female pup was tagged with Temple Tags on Necker Island in 1993.

Collection of Samples

No samples were collected. Potentially entangling debris was not detected on or around Nihoa and Necker Islands in 1993.

RESULTS

Population Abundance and Composition

The means (±SD) for seven censuses conducted on Nihoa Island were 21 seals (±7.1) including pups, and 18 seals (±7.3) excluding pups (Table 8.1a). Because of limited effort, the composition of the spring-summer population was not determined. The two tagged known-age seals born at Nihoa Island in 1991 were both resighted there in 1993 (Table 8.3a).

The means (±SD) for six censuses conducted on Necker Island were 23 seals (±5.6) including pups, and 22 seals (±5.2) excluding pups (Table 8.1b). Because of limited effort, the composition of the spring-summer population was not determined. The one tagged known-age seal born at Necker Island in 1983 was not resighted there in 1993 (Table 8.3b).

Reproduction

At least three pups were born on Nihoa Island in 1993; one pup was weaned and two pups were still nursing at the end of this study (Table 8.4a).

At least one female pup was born and weaned on Necker Island in 1993 (Table 8.4b).

Interatoll Movement

Interatoll movement was documented for nine seals that made a total of 10 movements between Nihoa Island and French Frigate Shoals (Tables 8.5a and b). Interatoll movement was documented for 14 seals that made a total of 24 movements between Necker Island and French Frigate Shoals (Tables 8.5c and d).

Factors Affecting Survival

Factors affecting survival were not observed on Nihoa Island in 1993. Mounting attempts by males led to four life-threatening conditions on Necker Island (Table 8.6). In addition, at least five adult females were documented with healed dorsal wounds probably caused by male aggression.

ACKNOWLEDGMENTS

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

TABLES

Table 8.1a.--Summary statistics for censuses (n = 7) of Hawaiian monk seals at Nihoa Island from July 30 to August 7, 1993.

Size/Sex	Mean number of individuals	Standard deviation
Adults	7.3	4.5
Male	0.9	0.9
Female	2.9	0.9
Unknown	3.6	3.1
Subadults	1.0	1.3
Male	0.1	0.4
Female	0.0	0.0
Unknown	0.9	1.2
Juveniles	0.3	0.5
Male	0.1	0.4
Female	0.0	0.0
Unknown	0.1	0.4
Pups	2.3	0.5
Male	0.0	0.0
Female	0.1	0.4
Unknown	2.1	0.7
Non-pup Total	18.3	7.3
Grand Total	20.6	7.1

Table 8.1b.--Summary statistics for censuses (n = 6) of Hawaiian monk seals at Necker Island from April 26 to August 4, 1993.

Size/Sex	Mean number of individuals	Standard deviation
Adults	18.8	5.9
Male	7.7	3.7
Female	5.5	2.1
Unknown	5.7	3.9
Subadults	1.5	1.9
Male	0.8	0.8
Female	0.0	0.0
Unknown	0.7	1.2
Juveniles	1.2	1.5
Male	0.3	0.8
Female	0.8	0.8
Unknown	0.0	0.0
Pups	0.5	0.5
Male	0.0	0.0
Female	0.5	0.5
Unknown	0.0	0.0
Non-pup Total	22.2	5.2
Grand Total	22.7	5.6

Table 8.2a.--Composition of the Hawaiian monk seal population at Nihoa Island during the spring and summer of 1993.

	Number of seals			
Size	Male	Female	Total	Sex ratio male:female
Adults				
Subadults				
Juveniles	(Composition not determined as described on page 92.)			
Pups				
Non-pup Total				
Grand Total				

Table 8.2b.--Composition of the Hawaiian monk seal population at Necker Island during the spring and summer of 1993.

	Number of seals			
Size	Male	Female	Total	Sex ratio male:female
Adults				
Subadults				
Juveniles	(Composition not determined as described on page 92.)			
Pups				
Non-pup Total				
Grand Total				

Table 8.3a.--Summary of tagged known-age seals born at Nihoa Island and resighted there in 1993.

Age (years)	Sex	Number originally tagged	Number resighted in 1993
2	Male	2	2
	Female	0	NA

Table 8.3b.--Summary of tagged known-age seals born at Necker Island and resighted there in 1993.

Age (years)	Sex	Number originally tagged	Number resighted in 1993
10	Male	1	0
	Female	0	NA

Table 8.4a.--Summary of Hawaiian monk seals born at Nihoa Island in 1993.

	Number of pups			
Event	Male	Female	Unknown	Total
Born	0	1	2	3
Died prior to weaning	0	0	0	0
Still nursing	0	1	1	2
Weaned	0	0	1	1
Tagged	0	0	0	0

Table 8.4b.--Summary of Hawaiian monk seals born at Necker Island in 1993.

	Number of pups			
Event	Male	Female	Unknown	Total
Born	0	1	0	1
Died prior to weaning	0	0	0	0
Still nursing	0	0	0	0
Weaned	0	1	0	1
Tagged	0	1	0	1

Table 8.5a.--Known movement of Hawaiian monk seals to Nihoa Island from other locations in 1993, summarized movements between two locations. Some seals made more than one trip.

Original location	Number, size, and sex class
French Frigate Shoals	4 adult males, 3 adult females, 1 subadult male

Table 8.5b.--Known movement of Hawaiian monk seals from Nihoa Island to other locations in 1993, summarized by movements between two locations. Some seals made more than one trip.

Destination	Number, size, and sex class
French Frigate Shoals	2 adult females

Table 8.5c.--Known movement of Hawaiian monk seals to Necker Island from other locations in 1993, summarized by movements between two locations. Some seals made more than one trip.

Original location	Number, size, and sex class
French Frigate Shoals	3 adult males, 2 adult females, 4 subadult males, 5 subadult females, 1 juvenile male

Table 8.5d.--Known movement of Hawaiian monk seals from Necker Island to other locations in 1993, summarized by movements between two locations. Some seals made more than one trip.

Destination	Number, size, and sex class
French Frigate Shoals	1 adult male, 3 adult females, 2 subadult males, 3 subadult females

Table 8.6.--Factors affecting Hawaiian monk seal survival at Necker Island in 1993.

			Outcome		
Size	Sex	Total	Injured	Died	Probably died
Attack by Large Shark					
(none observed)					
Mounting by Males					
Adult	Female	4	4	0	0
Entanglement					
(none observed)					

REFERENCES

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

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

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

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

Gilmartin, W. G., R. J. Morrow, and A. M. Houtman.
1986. Hawaiian monk seal observations and captive maintenance project at Kure Atoll, 1981. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFC-59, 9 p.

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

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

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

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

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

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

APPENDIXES

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

All islands

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

French Frigate Shoals

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

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

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

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

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

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

Appendix A.--Continued.

Laysan Island

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

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

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

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

Becker, B. L., R. J. Morrow, and J. K. Leialoha.
1989. Censuses and interatoll movements of the Hawaiian monk seal on Laysan Island, 1985. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-135, 25 p.

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

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

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

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

Appendix A.--Continued.

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

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

Lisianski Island

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

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

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

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

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

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

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

Appendix A.--Continued.

Pearl and Hermes Reef

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

Finn, M. A., J. R. Henderson, B. L. Becker, and T. J. Ragen.
1993. The Hawaiian monk seal and green turtle at Pearl and Hermes Reef, 1990 and 1992. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-182, 29 p.

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

Kure Atoll

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

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

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

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

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

Appendix A.--Continued.

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

Nihoa and Necker Islands

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

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

Morrow, R. J., and E. K. Buelna.
1985. The Hawaiian monk seal and green turtle on Necker Island, 1983. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFC-55, 1 p.

Appendix B.--Hawaiian monk seal census form and 1993 census form directions.

(See following pages.)

SEAL CENSUS FORM

ENTERED ☐

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

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

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

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

NOTES:

Line No.	Continue	Time	Sector	Size	Sex	Beach Pos	Condition	ID			TAG				MOLT		Disturb	ASSOCIATION			Notes	Notes	EVENT	
								T/P	No.	?	No.	L/R	Col	?	%	?		Line No.	Dist	Behavior			Type	Codes
15																								
16																								
17																								
18																								
19																								
20																								
21																								
22																								
23																								
24																								
25																								
26																								
27																								
28																								
29																								
30																								

NOTES:

1993
CENSUS FORM DIRECTIONS

Entry	Description
DATA TYPE	**C** = Census: a complete count on an island begun around 1300 **A** = Atoll: atoll-wide census (must be completed within 2 days) **B** = Behavior patrol: a former patrol where associations are recorded (Laysan and Lisianski Islands only, in 1993) **P** = Patrol: any other observation not on a timed census **I** = Incidental: incidental observations *Other letters may be used at your discretion to indicate specific kinds of noncensus data,* e.g., **M** *for male observations.*
COMPUTER PAGE NO.	Leave this blank during data collection. It will be assigned and displayed on the screen when you enter the data. At that time, *be sure* to fill in the computer page number on your census form, as this number is needed for data retrieval.
PAGE	Page number within a census or patrol. For example, if the census (or patrol) requires three pages, then mark the first page as " page 1 of 3" and so on. If more than 1 person conducts the census, then combine page numbers; person A has pages 1 and 2, while person B has pages 3 and 4 of a four-page census day.
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 and patrols may be assigned numbers at your discretion (3 digits). Atoll counts extending over more than 1 day must be numbered.
TEMP.	Temperature in degrees Celsius at beginning of census or patrol.

Entry	Description
WIND	Speed: **0** = no wind, calm (< 5 knots) **1** = light breeze (5-15 knots) **2** = strong wind (>15 knots) Direction: **NW**, **NN**, **NE**, **EE**, **SW**, **SS**, **SE**, **WW** 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
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 your are continuing *from* here. Lines may be continued only within the same page. All fields from **SECTOR** through **MOLT** will be copied from the original line if left blank on the continuation line. Small lines can have the same continuation line number.
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; **99** = no island)

Entry	Description
SIZE	**P** = Nursing pup: **P1** = wrinkles **P2** = mist/drizzle **P3** = blimp, black **P4** = molting **P5** = molted **PW** = Prematurely weaned/undersized weaned pup (weaned ≤2 weeks ago and <90 cm girth) **W** = Weaned pup **J** = Juvenile and **I** = Immature: **J1** = Juvenile I **J2** = Juvenile II **S** = Subadult and **I** = Immature: **S3** = Subadult III **S4** = Subadult IV **A** = Adult **T** = Turtle: **T1** = Juvenile (<65 cm) **T2** = Subadult (65-80 cm) **T3** = Adult (>80 cm) **U** = Seal of unknown size
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 1993), 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.

Entry	Description
CONDITION	Condition must be recorded for all seals (except nursing pups) on census or atoll count. During census or atoll count, record the condition of nursing pups on their first sighting post-partum, using the codes **N** or **A**. During patrol or incidental data collection, note the condition of the mom and pup on their first sighting post-partum or post-weaning, and note the condition of seals that are injured or in unusual condition. Condition codes: **P** = Probably pregnant **F** = Fat **M** = Medium **T** = Thin **E** = Emaciated **N** = Normal (for nursing pups) **A** = Abnormal/sick (primarily for nursing pups) **X** = Data not taken
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 temporary numbers.
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

(*Next entry on following page*)

TEMPORARY ID NO.	Record the temporary ID number (or bleach number) or 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-).

Entry	Description
	? 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 #). **<blank>** = Number is certain and complete if present.
PERMANENT ID NO.	Record the 4-digit permanent ID number of seal if known (put both the island-specific prefix and next digit in the first box provided). **?** column: **0** = seal is definitely not an IDed animal. **1** = ID number is questionable. **<blank>** = ID number is certain and complete if present.

Entry	Description
TAG NO.	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 the last 5 digits of a 10-digit PIT tag. **L/R** is the tag position: **L** = Tag on *left* flipper. **R** = Tag on *right* flipper. **B** = Tags on *both* flippers (enter one tag number). **COL** = Color: 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) / **P** = Plastic, Riese **G** = Green (Lisianski) / **C** = Clear, PIT tag **B** = Blue (Pearl & Hermes) **K** = Silver/gray (Kure) **R** = Red (Midway, Necker, Nihoa, Main Islands) **?** column: **0** = Seal is definitely not tagged. **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** = Tag lost. Fill out tag position (**L**/**R**/**B**) and the tag condition event. Complete the tag number and color from other data before entry. (**TAG NO.** *continued on following page*)
(**TAG NO**., *Continued*)	**<blank>** = Tag information is certain if present. Partial data (in the form of some fields 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 a partial Tag # must be completed by hand (use a **4** in the tag **?** column).

Entry	Description
MOLT	Percentage of old pelage lost, optional for nursing pups. **0** or ***<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 ≥ 2 molt is considered the first day of true molt. **10** = 100% molted, freshly molted, up to 1 month after molt. Put both digits of the **10** in the single box provided. **?** column: **0** = Seal is definitely not molting. **1** = Seal is molting, but % molt estimate is questionable. May or may not include an estimate in the molt column.
DISTURB	The degree to which the seal may have been disturbed by observer. **0** or ***<blank>*** = No disturbance, or seal merely looked at observer. **1** = Seal vocalized, gestured, or moved ≤2 body lengths. **2** = Seal alerted to observer and moved >2 body lengths. **3** = Seal alerted to observer and fled into water.
ASSOCIATION DATA	Use continuation lines to record more than one association. Don't record associations involving turtles. Record detailed association data at Laysan Island and Kure Atoll in 1994. At other locations, record mother-pup pairs and unusual events. At all locations except Laysan and Kure Atoll, the **X** code will be filled in back in Honolulu to indicate that standard association data was not recorded on Census or Atoll Count. **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 in straight line of sight, can be on opposite sides of a log.

Entry	Description
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. **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 **N**, **X**, and **O** should not appear together with other behaviors. Behaviors **B** and **M** require distance = **0**. With the exception of 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 (* = requires corresponding code—explained at end of this section) a) Active behavior **A** = approach/investigate/sniff/nudge **B** = Bite: **B1** = nip **B2** = draws blood/breaks skin **C** = Chase:* **C1** = ≤2 body lengths* **C2** = >2 body lengths* **D** = Seal displaces another (see CONTEST RULES)* **F** = Flee/move away: **F1** = ≤2 body lengths **F2** = >2 body lengths **J** = Joust/spar/fight:* **J1** = ≤30 s* **J2** = >30 s* **M** = Mount/attempted mount **M1** = ≤30 s **M2** = >30 s **P =** Play* **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.

Entry	Description

(**BEHAVIOR** *continued on following page*)

(**BEHAVIOR**, *continued*) (1) Individual seal, *continued*)

b) Spatial association
- **N** = Mother-pup pair (any distance). Does not imply nursing behavior. This is the only association recorded between mother-pup pairs.
- **L** = Association by location only (distance ≤10 m apart, for all except mother-pup pairs)

c) Optional codes
- **L1** = Pair association* A/S4 male paired with/defending an adult female or immature of either sex (actual sex may be unknown).

- **O** = Loser* ⎫ Codes used for A/S4 male-male
- **W** = Winner* ⎬ contests only (actual sexes may be
- **Y** = Tie* ⎭ unknown). 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.

Entry	Description
NOTES	There is room to code 2 different notes. Always use the first column first. Code and **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. However, the **D** code must appear on the original line. **A** = Artwork (scars drawn) **B** = Birth, first sighting post-partum (mom and pup) **D** = Seal is dead **G** = Seal is green with algae **H** = Handwritten notes **I** = First sighting after an interatoll movement **M** = Marked, bleach number first applied/reapplied post-molt **W** = Weaning, first sighting post-weaning (pup) **X** = Pup exchange, first sighting after a pup exchange
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

Entry		Description	
M = Mobbing/harassment		**1-3**	Mobbing/harassment number
N = Necropsy		**1-3**	Necropsy number
E = Entanglement		**1-3**	Entanglement number
		4	New/resight? **(N/R**)
W = Wound		**1-3**	Injury number
		4	New/resight? (**N/R**)
H = Animal handling		**1**	Handling type **T** = Tagging (w/restraint) **M** = Measuring (includes weighing) **A** = All (both tagging and measuring) **R** = Remote tagging **B** = Bleeding **O** = Other
P = Photo			**RECORD NON-SEAL PHOTOS IN THE HANDWRITTEN NOTES**
		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**

(**PHOTO** *continued on following page*)

Entry	Description

TYPE	CODES COLUMN	CONTENT
(**PHOTO**, *continued*)	**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/ **R** = Rearflipper / ventral in handwritten **NOTES** **O** = Overall view of a particular side **X** = Other, describe in handwritten **NOTES**
	8	Purpose **I** = Identification **W** = Wound (link with wound **EVENT** using continuation lines) **N** = Necropsy (link with necropsy **EVENT** using continuation lines) **E** = Entanglement (link with entanglement **EVENT** using continuation lines) **X** = Other, describe in handwritten **NOTES**
S = Specimen/sample		**DON'T RECORD SPECIMEN COLLECTION HERE IF YOU ARE CONDUCTING A NECROPSY--USE THE NECROPSY FORM.**
	1-2	Specimen type **SC** = Scat **SP** = Spew **T** = Tissue **M** = Molt **P** = Parasites **D** = Debris **Z** = Other

(*Next entry on following page*)

P = Posterior
U = Unknown

Entry	Description
TYPE	**CODES COLUMN** **CONTENT**
T = Tag condition	**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 Riese and 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
V = Vestibule	**3** Condition **B** = Broken **P** = Pulling out **F** = Faded color **R** = Recovered **G** = Good **U** = Unreadable **L** = Tag lost **V** = Tag side reversed **N** = No/partial resin **W** = No. worn/abraded **O** = Other **ONLY NOTE VESTIBULE STATUS AT LAYSAN AND LISIANSKI ISLANDS IN 1993**
	1 Vestibule code **0** = No swelling, normal **1** = Slight swelling, puffy **2** = Extensive swelling, dark protruding tissue

ADDITIONAL PROTOCOL

1. All original monk seal 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 and during entry. All field editing by the data collector should be in blue, and editing by others should be in red. As soon as you begin the entry 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. After completing the entry program, check off and initial the **ENTERED** box on the census form. All editing after this point should be in orange (for example, edits made in response to the census checking programs).

2. 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 formal patrol). In essence, on a census form with multiple headers, each header and its associated lines represents a separate data sheet.

3. 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).

4. 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.

5. 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. If the seal is identified, it will not be counted twice on census. To link two sightings of an unidentified seal (*i.e.*, a cruiser moving ahead of you on census), assign it a unique temporary number in a series reserved for unidentified seals.

6. 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.

7. Record all tag sightings explicitly (*i.e.*, both left and right tag numbers) at least once during your stay. When a pup is tagged, record the first occurrence of each tag on a census data sheet for that date as well as on a tagging 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 will be added by computer later.

8. 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 As
Temple Tags	
Light Tan (**A**, **T**, **K**, **L** series @ Laysan)	Gray, Light 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**, **O**, **Z** and later @ Kure)	Metal
Red	Orange
Yellow	White, Light Yellow
Green (dark forest)	Dark Blue, Navy
Blue (light)	—

Riese Tags (colors almost completely faded--just note presence if you can ID by other means):

White	Yellow
Red	Orange
Orange	Red
Yellow	White
Green	Blue
Blue	Green

9. On a census or atoll count, it is assumed that condition, molt and disturbance data will be taken. At locations other than Laysan and Lisianski Islands, it *is not* assumed that association data will be taken on census or atoll count in 1993. Thus, on a census or atoll count sheet from these other locations, no code in any of the association columns means that data was not taken, and an **X** code will be filled in by computer back in Honolulu. If you wish to indicate that a seal was alone, use the **O** behavior code. At Laysan and Lisianski Islands in 1993, it *is* assumed that behavioral data will be taken on census (and during behavior patrol). Thus, on a census data sheet from Laysan Island or Lisianski Island, no code in any of the association columns means that the seal was alone, whereas on a patrol data sheet from the same location, 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 back in Honolulu. If you are unable to record association data on a census or behavior patrol at Laysan or Lisianski Islands for any reason, indicate this with an **X** for the behavior code.

10. 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 record behaviors of an animal after it has been disturbed by the observer.

11. 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).

12. 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.

13. At Laysan and Lisianski Islands, note vestibule status for all S4 and adult females, except nursing moms, whenever you can get the information. Make a special effort to determine vestibule status for post-weaning moms.

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

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):

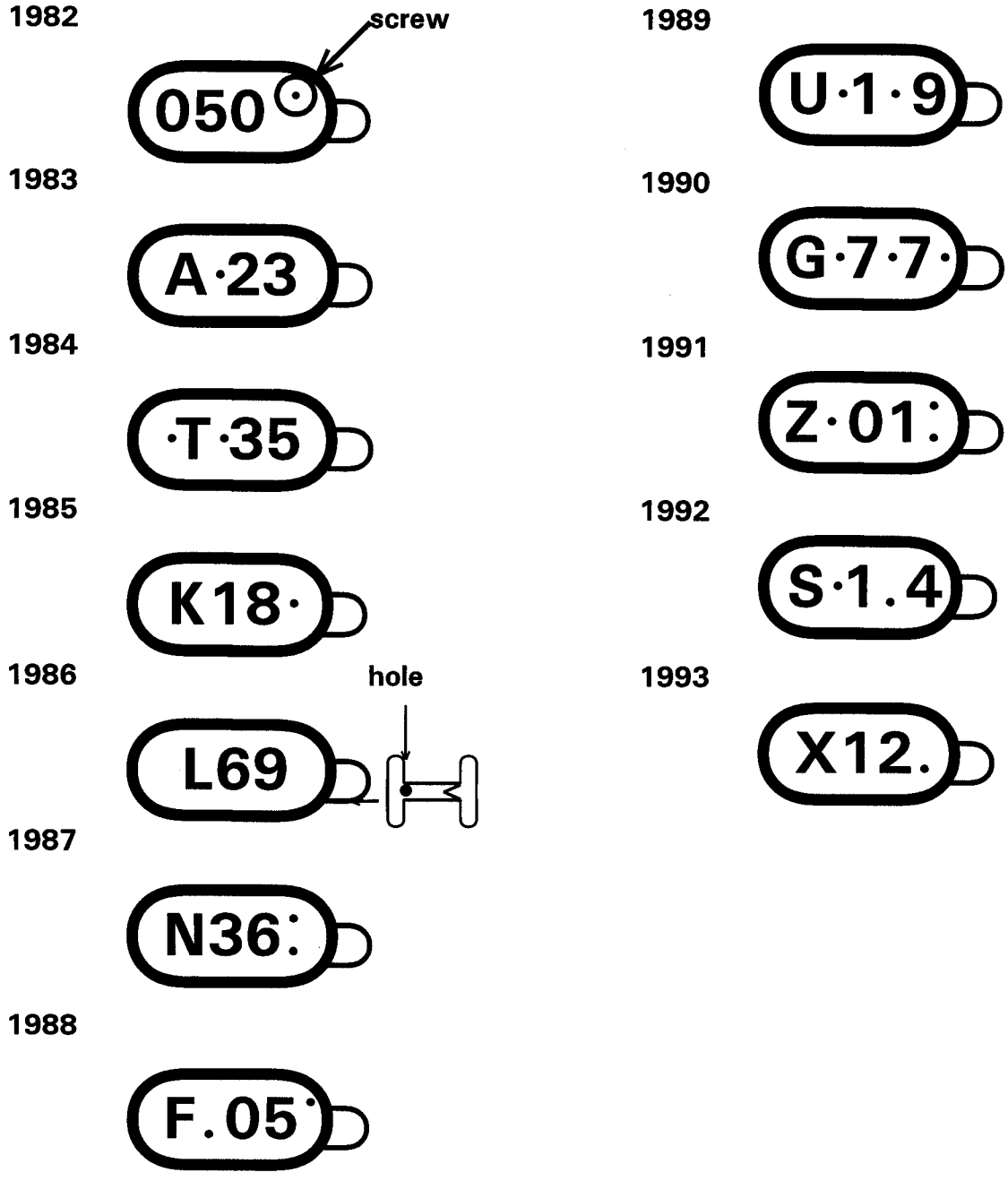
   - Distance between males = 0
   - Either adult male vocalizes (**V**) or performs a **C**, **D**, or **J**
   - If cruiser approaches to beach position ≥ 1, regardless of other behaviors

4. Definition of winner or loser adult male:

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** ii) Original Male Paired with Adult Female otherwise	Has **F**	No Ties No Ties
Paired Male *vs*. Paired Male where both pairs are same type: (**#1** *vs*. **#1** or **#2** *vs*. **#2**)	Has **D**	Has **F**	Tie if no **D**
Single Male *vs*. Single Male: (**#3** *vs*. **#3**)	Has **D** or **C**	Has **F**	Tie if no **D** or **C**

HAWAIIAN MONK SEAL TEMPLE TAGS
NUMBERING SCHEME AND HOLE DRILLING SEQUENCE FOR WEANED PUPS



Beginning in 1988, we will be using Riese tags on adults at Laysan. The tags will have letters on them, but the combination of multiple tag colors, flipper position, and presence or absence of holes in the tags will also enable a seal to be individually identified. To record this information on the census form requires some modification of our method of recording tags. The rules for recording Riese tags are:

1. The *color* of a Riese tag is **P** (plastic).

2. The tag position of a Riese tag is either **L** or **R** (not **B**).

3. The *number* of a Riese tag may be *either*:

   a. the 2 letters printed on the tag; or

   b. a combination of 3 letters which indicate presence or absence of a hole in the tag and colors of the 2 halves of the Riese tag. Codes for hole condition are:

H	=	Hole present
N	=	No hole present

   Codes for colors are:

B	=	Blue
G	=	Green
O	=	Orange
R	=	Red
W	=	White
Y	=	Yellow

   Hole condition is coded first, then 2 colors. Example of recording a red and green Riese tag, with hole, on the left flipper:

		H	**R**	**G**	**L**	**P**

4. For each sighting, use either method **a** with 2 letters, or **b** with 3 letters, *but not both*. The computer will know the difference according to whether you enter 2 letters or 3. In method **a**, the combination of 2 letters printed on each tag is unique, so tag position and color merely provide a check for consistency. Tags are printed on only one side, however. In method **b**, the combination of 2 colors, hole condition, and tag position also identifies an individual seal. The order in which the 2 colors are recorded does not matter. In the example above, **HRG** and **HGR** would mean the same. Hole condition (**H**) or **N**) and tag position (**L** or **R**) *do* matter, however, so these must be seen and recorded correctly.

RECENT TECHNICAL MEMORANDUMS

Copies of this and other NOAA Technical Memorandums are available from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22167. Paper copies vary in price. Microfiche copies cost $9.00. Recent issues of NOAA Technical Memorandums from the NMFS Southwest Fisheries Science Center are listed below:

NOAA-TM-NMFS-SWFSC- 217 Report of 1993-1994 marine mammal aerial surveys conducted within the U.S. Navy outer sea trust range off southern California.
J.V. CARRETTA, K.A. FORNEY, and J. BARLOW
(March 1995)

218 The effectiveness of California's commercial rockfish port sampling program
D.E. PEARSON and G. ALMANY
(June 1995)

219 U.S. pacific marine mammal stock assessments.
J. BARLOW, R.L. BROWNELL, JR., D.P. DeMASTER, K.A. FORNEY, M.S. LOWRY, S. OSMEK, T. RAGEN, R.R. REEVES, and R.J. SMALL
(July 1995)

220 The physical oceanography off the central California coast during February and May-June, 1991: A summary of CTD data from larval and pelagic juvenile rockfish surveys.
K.M. SAKUMA, F.B. SCHWING, H.A. PARKER, and S. RALSTON
(September 1995)

221 The physical oceanography off the central California coast during March and May-June, 1994: A summary of CTD data from larval and pelagic juvenile rockfish surveys.
K.M. SAKUMA, F.B. SCHWING, H.A. PARKER, K. BALTZ and S. RALSTON
(September 1995)

222 Guidelines for handling marine turtles hooked or entangled in the Hawaiian longline fishery: Results of an expert workshop held in Honolulu, Hawaii March 15-17, 1995.
G.H. BALAZS, S.G. POOLEY, and S.K. MURAKAWA, (Eds.)
(November 1995)

223 Age determination in Pacific sardine, *Sardinops sagax*.
M.L. YAREMKO
(January 1996)

224 Report of a cetacean, seabird, marine turtle and flying fish survey of the western tropical Indian ocean aboard the research vessel *Malcolm Baldrige*, March 21 - July 26, 1995.
L.T. BALLANCE, R.L. PITMAN, S.B. REILLY, and M.P. FORCE
(January 1996)

225 Catch and effort from Hawaii's longline fishery summarized by quarters and five degree squares.
D.S. CURRAN, C.H. BOGGS, and X. HE
(January 1996)

226 Calibration of radar altimeter readings used in aerial photogrammetry of eastern tropical Pacific dolphins - 1992 and 1993.
J.W. GILPATRICK, JR.
(February 1996)