



NOAA Technical Memorandum NMFS-PIFSC-28

October 2011

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## The Hawaiian Monk Seal in the Northwestern Hawaiian Islands, 2004



Compiled and Edited by

Thea C. Johanos and Jason D. Baker

Pacific Islands Fisheries Science Center  
National Marine Fisheries Service  
National Oceanic and Atmospheric Administration  
U.S. Department of Commerce

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Johanos, T. C., and J. D. Baker (compiled and edited).  
2011. The Hawaiian monk seal in the Northwestern Hawaiian Islands, 2004.  
U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-PIFSC-28,  
112 p. + Appendices.

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## EXECUTIVE SUMMARY

During 2004, field studies of the endangered Hawaiian monk seal (*Monachus schauinslandi*) were conducted at all of its main reproductive sites in the Northwestern Hawaiian Islands. These studies provide information necessary to identify and mitigate factors impeding the species recovery by evaluating (1) the status and trends of monk seal subpopulations, (2) natural history traits such as survival, reproduction, growth, behavior, and feeding habits, and (3) the success of various activities designed to facilitate population growth.

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

Since 1983, the number of pups born at the main reproductive sites has been highly variable. In 2004, 198 pups were counted at these sites, 61 of which were born at French Frigate Shoals (FFS). Although a record number of pups were born at Pearl and Hermes Reef and Midway Atoll, and pup numbers increased at all sites over the previous year, pup numbers at FFS remained well below historic levels. Mean beach counts, excluding pups, from the main reproductive sites totaled 361.4 seals. Although beach counts remained essentially unchanged from 1993 to 2000 and declined in 2001-2004, counts in 2004 were higher than those of the previous 3 years (Fig. 1b).

From the mid-1980s to the mid-1990s, adults and pups have comprised a growing portion of the animals counted while juveniles and subadults declined (Fig. 1c) and, in 2004, the composition of the counts again was dominated by adults and pups. This composition bodes poorly for reproduction in the near future if older adult females are not replaced by young females reaching reproductive age. High mortality of immature seals appears to have led to the shift in composition, particularly at FFS.

In 2004, the following activities were conducted by the Marine Mammal Research Program (Pacific Islands Fisheries Science Center, National Marine Fisheries Service) and cooperating scientists to enhance recovery of the species: (1) disentangling 11 seals and removing debris capable of entangling seals from all study sites; (2) moving 4 weaned pups stranded on the runway at FFS to the water's edge; (3) translocating 29 weaned pups between islets within FFS to decrease their risk of shark predation; (4) cutting the umbilical cords to remove placentas from 2 newborn pups at risk of drowning or attracting sharks at FFS; (5) performing 8 human-assisted pup exchanges and uniting an abandoned pup with a female that had lost a pup to increase pup survival at FFS; (6) interrupting two incidents of aggressive males mounting weaned pups at FFS and Kure Atoll; and (7) monitoring beaches at Midway Atoll for disturbance and mitigating human impacts through education.

This document describes these and other field studies conducted during 2004 and provides complete standardized summaries of the research activities and findings at each study site. The ready availability of such information is essential for ongoing efforts to stop the decline of this species and enhance its recovery.

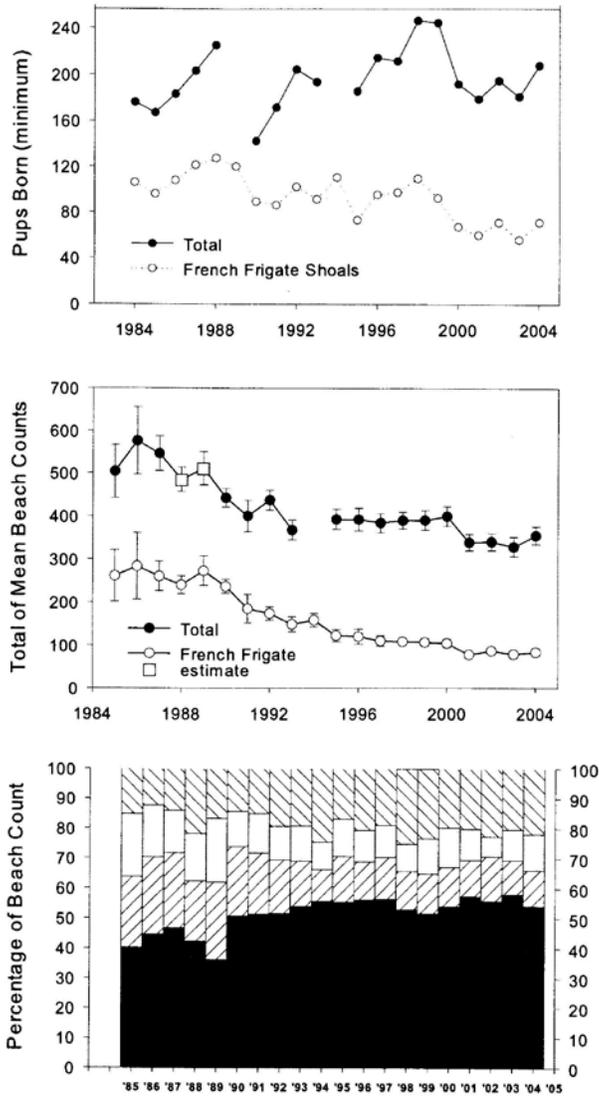


Figure 1.--Demographic trends of the Hawaiian monk seal, based on the main reproductive sites. (A) Number of pups born (minimum). (B) Total of mean beach counts, excluding pups, with 1 standard deviation. (C) Percentage of counts made up of adults, subadults, juveniles, and pups.

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## **CHAPTER 1. GENERAL INTRODUCTION**

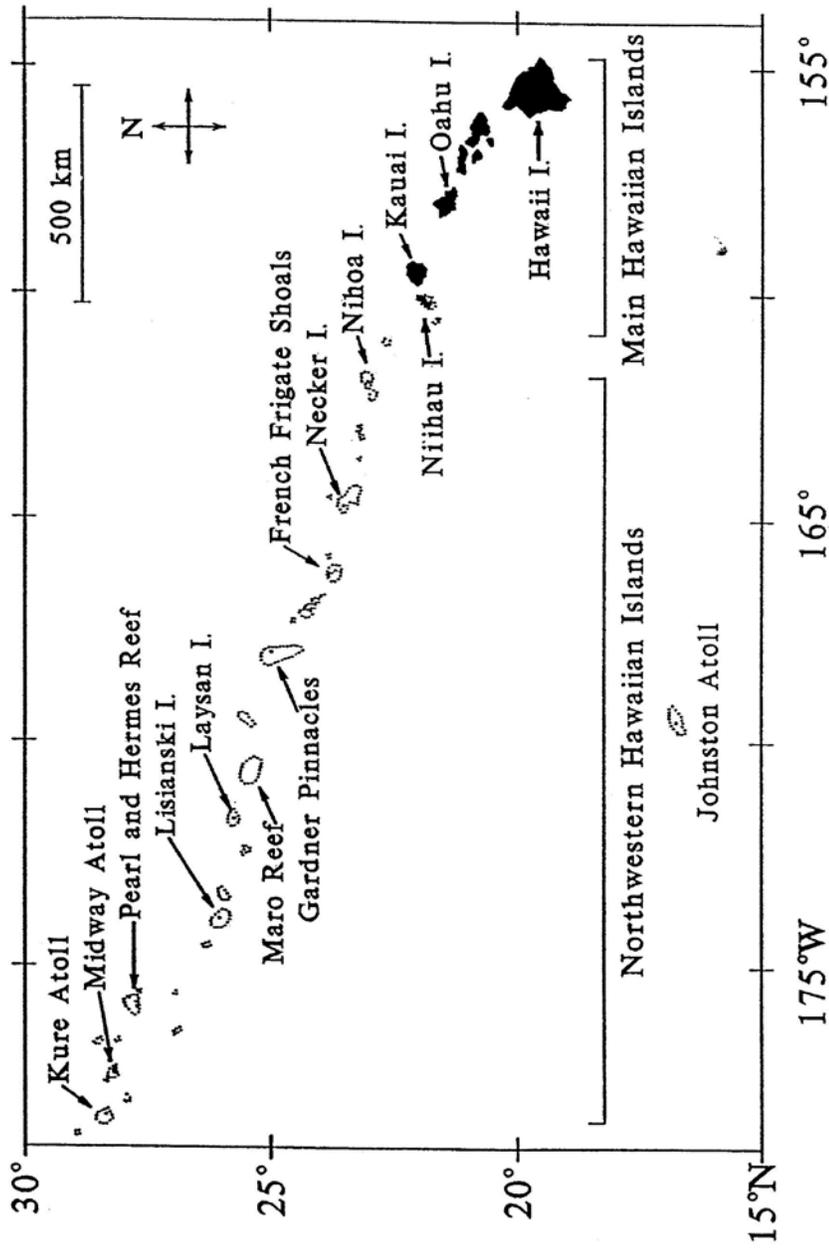


Fig. 1.1 The Hawaiian Archipelago.

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

The Marine Mammal Research Program began research on Hawaiian monk seals at most major reproductive sites in the NWHI during 1980 (Lisianski Island), 1981 (Laysan Island and Kure Atoll), 1982 (French Frigate Shoals (FFS) and Pearl and Hermes Reef), and 1983 (Midway Atoll). Nearly every year thereafter, field camps were established for periods of several days to 9 months to monitor and enhance the recovery of this species. Limited population monitoring has also been conducted at Nihoa and Necker Islands, where subpopulations appear to be limited to a small number of animals by availability of haulout area. Reports summarizing previous NMFS research are listed in Appendix A.

In 2004, Hawaiian monk seal research activities included (1) conducting beach counts (censuses); (2) tagging weaned pups and other seals for permanent identification and retagging animals to maintain identification; (3) identifying other seals by previously applied tags and by natural or applied markings; (4) monitoring reproduction, survival, injuries, entanglements, interatoll movements, disappearances, and deaths; (5) performing necropsies; (6) collecting scat and spew samples for food habits analysis; (7) collecting skin punches and shed molt samples for a DNA tissue bank; (8) collecting samples of placentas found with or from "aborted fetuses" or with deceased perinatal pups for histological and bacteriological examination; (9) disentangling seals; and (10) removing debris capable of entangling seals from beaches. Location-specific objectives and summaries of data collected during the 2004 field season are described in the following chapters. Much of the information presented in this memorandum is incorporated into larger data sets for additional analysis and publication elsewhere. Research was conducted under the authority of the following permits: Special Use Permits HWN-12521-0211, HWN-12521-0219, and SEPO-100102, and Marine Mammal Permit 848-1335.

## MATERIALS AND METHODS

### Censuses and Patrols

The primary means of data collection were censuses and patrols. Censuses consisted of timed, standardized beach counts during which an entire island or atoll was surveyed for seals. Although data were collected on all seals, those that were in the water, captive or dead were excluded from the beach count totals. Identified individuals were counted only once if they were resighted during the survey. The resulting counts did not reflect total population size but provided an index of population size for comparison among years and locations. Data collected on each seal observed during censuses included size class (ranging from pup, juvenile, subadult, and adult size as described in Stone, 1984 and Appendix B); sex; location on the island; beach position (indicating whether the seal was in the water or on land); body condition (a subjective estimate; e.g., fat, medium, or thin); identification information (permanent or temporary identification numbers and tag numbers); molting status (an estimate of the percentage completed); and disturbance index (the extent that the observer disturbed the seal). Further data were collected if any of the following events occurred: (1) factors affecting survival (e.g., entanglements, mobbings, or shark injuries), (2) animal handling, (3) photography, and (4) documentation of tag condition (e.g., good or broken). In addition, behavioral data (seal associations and interactions) were collected on Laysan and Lisianski Islands. A sample census form and guidelines for its completion are included in Appendix B. Censuses were conducted once at Nihoa Island and every 4 to 8 days at all other locations, starting at 1300 Hawaii Standard Time when possible, using census methods and criteria outlined in Johanos et al. (1987). Atoll-wide counts for locations with more than a single island (French Frigate Shoals, Pearl and Hermes Reef, Midway Atoll, and Kure Atoll) were completed within a 2-day period. The perimeter of each study area was divided into sectors to facilitate the analysis of data and detection of demographic trends in different geographic areas. Census methods specific to each location are detailed in the following chapters.

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

During all observation periods (i.e., censuses, patrols, and incidental sightings), observers attempted to minimize seal disturbance by walking above the beach crest and using vegetation as a visual barrier. On census days, activities which could disturb the animals and bias the count were not conducted until after the count was completed. Additionally, the following were recorded whenever observed: (1) births, pup exchanges, and weanings; (2) mating activities, adult male aggression, and post-mobbing aggregations (defined below); (3) entanglements in marine debris; (4) injuries; and (5) deaths.

## **Reproduction**

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

The average nursing period was calculated for some or all pups at each location. The average lactation period of parturient females was also calculated for seals at FFS because higher population density and frequent pup exchanges (Boness, 1990; Boness et al., 1998) made it difficult to track individual pups and determine their nursing period. Nursing or lactation periods were defined as the number of days from birth until the end of the last nursing relationship. Temporary breaks (e.g., if a mother and pup became separated and one or both seals subsequently obtained another nursing relationship) were not subtracted from the total. When the exact birth or weaning date was not known, but occurred within a range of 4 days or less, then the midpoint of that range was used as the start or end date for calculation of average nursing or lactation period. Nursing or lactation data were not used if the birth or weaning range exceeded 4 days, or if the pup died or disappeared before weaning. Prior to 2002, nursing or lactation periods of less than 20 days were also excluded from calculations.

## **Factors Affecting Survival**

The origins of a wide range of injuries were distinguished based on characteristic wound patterns described in Hiruki et al. (1993). Injuries were documented if they were related to attacks by large sharks, mounting attempts by male Hawaiian monk seals or entanglement in marine debris or if they were considered severe enough to possibly affect survival. Injuries were considered severe and were summarized if they consisted of (1) the total combined area of all abscesses or abscess-like raised areas was  $\geq 8$  cm diameter circle area (approximately  $50 \text{ cm}^2$ ); (2) an amputation of a minimum of half a flipper (either foreflipper or hindflipper); (3) the total combined exposed area of all punctures or gaping wounds is  $\geq 8$  cm diameter circle area; or (4) densely spaced (overlapping) scratches, abrasions, or lacerations covering an area equivalent to half the dorsum, or evidence of extensive underlying tissue damage (e.g., an uneven or darkened surface of the injured area, leaching fluids) or impaired seal movement. Major healed injuries that had been incurred since the previous season were documented but not included in summaries.

A seal was listed as dead if its death or carcass was observed. Deaths summarized here include carcasses found at the beginning of the field season if the seal had clearly died during the calendar year. A seal was listed as probably dead if it sustained severe injuries or was emaciated

(with skeletal structure clearly evident) and subsequently disappeared. In addition, one of the following conditions must have been satisfied to place a seal in the “probably dead” category: (1) the seal was lethargic, had difficulty moving or floated listlessly in the water, and disappeared more than a week before the end of data collection for the field season, or (2) the seal was in deteriorating condition (loss of weight, enlargement of abscesses, sloughing of skin) and disappeared a minimum of 10 surveys or 1 month before the end of data collection for the field season (whichever was longer). Nursing pups were listed as probably dead if they disappeared within 3 weeks of birth. Losses of apparently healthy older nursing pups (over 3 weeks of age) and newly weaned pups (within 2 weeks post-weaning) were listed as disappeared, suspected dead, if the pups were last seen at a minimum of 10 surveys or 1 month before the end of data collection.

Multiple male aggression (or “mobbing”) and other mating-related male aggression was observed and recorded. By definition, multiple male aggression occurred when more than one male 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). Single male aggression was defined as any incident where an adult or subadult male repeatedly bit the dorsum, attempted to mount, and tried to prevent the escape of another seal. These incidents were summarized in this report if they simultaneously involved more than one male aggressor or resulted in a minimum of one puncture or gaping wound (missing skin or extending into the blubber layer) or  $\geq 15$  scratches to the dorsum or flanks or if intervention was required to prevent drowning. Post-aggression aggregations were also summarized: these were groups of males congregated on the beach, attending a seal with new mounting injuries as described above.

### **Individual Identification**

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

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

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

In 2004, untagged immature and adult seals were opportunistically tagged with Temple Tags uniquely coded to indicate unknown ages and birth locations. These seals also received PIT tags. Seals with lost or broken tags were retagged to maintain their identities.

Seals were bleach-marked for individual identification (Stone, 1984) by using the solution described in Johanos et al. (1987), and applied bleach marks were photographed and sketched onto scar cards. Molting seals were re-marked with bleach to maintain their identities until the next molt. Some nursing pups were also bleach-marked prior to the post-natal molt to facilitate identification during the nursing period.

Digital photographs of scars and natural markings were added to individual identification folders throughout the field season to maintain a current description of the identifying marks of each seal.

Minimum subpopulation abundance and size-sex composition are presented. These statistics included all individuals observed alive at the location during the interval from March through August and all known parturient females and pups born anytime during the year.

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

### **Measurements of Seals**

Pups were measured to provide information on condition. Measurements were taken as soon after weaning as possible, and measurements taken within 2 weeks after weaning were included in the summaries. Measurements included straight dorsal length (Winchell, 1990) and axillary girth (American Society of Mammalogists, 1967). Some older animals captured for retagging were also measured.

### **Collection of Samples**

Samples were collected for a DNA tissue bank, pathology analysis, investigation of food habits, and documentation of marine debris. Tissue punches for DNA were collected during tagging efforts for all newly tagged or retagged seals and during necropsies on seals that had died

recently. Samples of placentas found with or from aborted fetuses or deceased perinatal pups were also collected.

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

Scat and spew samples were collected opportunistically for analysis of food habits (Goodman-Lowe, 1998). These samples were collected from seals of known size and sex class, when possible.

Nets, lines, ropes, and other debris capable of entangling seals and turtles were removed from beaches. From 1982 to 1998, potentially entangling marine debris was incinerated on site at all locations, and debris incineration continued at Kure Atoll through 2001. More recently, marine debris was removed by ship.

**CHAPTER 2. THE HAWAIIAN MONK SEAL ON  
FRENCH FRIGATE SHOALS, 2004**

Suzanne M. Canja, Aaron Dietrich, Daniel F. Luers, Jean M. Higgins,  
Frans A. Juola, and Brenda Becker

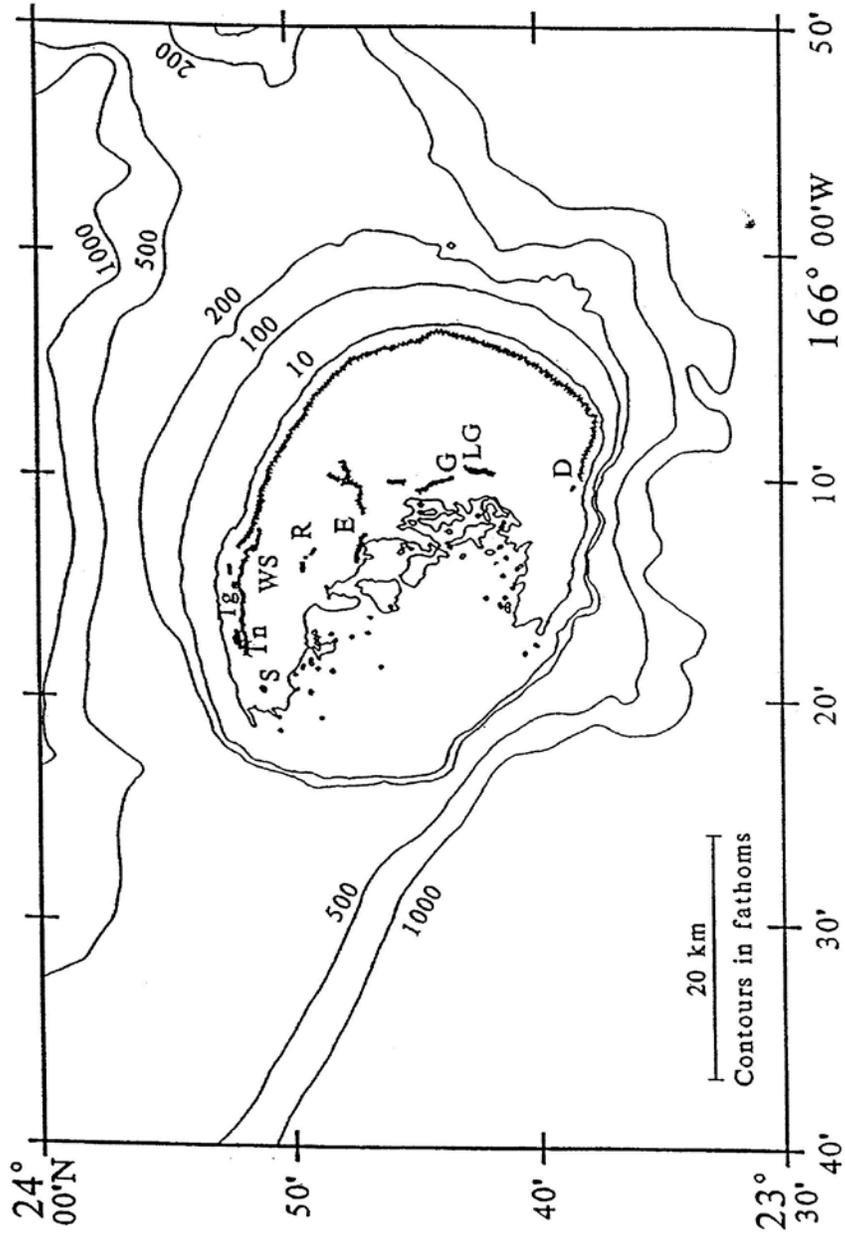


Fig. 2.1. French Frigate Shoals in the Northwestern Hawaiian Islands. Islands are: Disappearing (D), East (E), Gin (G), Little Gin (LG), Round (R), Shark (S), Tern (Tr), Trig (Tr), and Whaleskate (WS).

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

## RESEARCH

The National Marine Fisheries Service (NMFS) began research on Hawaiian monk seals at FFS in 1982. In 2004, research was conducted by NMFS from April 21–September 16 and October 17–December 28. The U.S. Fish and Wildlife Service (USFWS) also performed surveys exclusively on Tern Island during January 6– July 12 associated with a shoreline reconstruction project and conducted opportunistic observations throughout the atoll during the rest of the year. The perimeters of the five larger islets (East, Gin, Little Gin, Tern, and Trig) were divided into sectors using artificial or natural landmarks. In 2004, as part of the seal and turtle monitoring during the shoreline reconstruction project on Tern Island, additional sectors were created to record locations along the seawall and rock revetment areas. Research activities specific to this subpopulation in 2004 included (1) monitoring and removal of Galapagos sharks preying on monk seal pups throughout the atoll; (2) translocating newly weaned pups to reduce their risk of shark attack; (3) retagging or newly tagging seals; (4) rehabilitating juvenile seals in poor condition, referred to as the “Second Chance” Project; and (5) monitoring Hawaiian monk seals and green sea turtles during the Tern Island shoreline reconstruction project.

### Censuses and Patrols

Atoll-wide censuses ( $n = 14$ ) were conducted every 8 d, on average, from May 17 to August 30. Each atoll census required 1 to 2 days to complete. Disappearing, Round, Whaleskate, Bare, and Mullet Islets were surveyed either on foot or by boat; while the remaining islets (East, Gin, Little Gin, Shark, Tern, and Trig) were censused on foot by 1- 4 people. La Perouse Pinnacles were not routinely surveyed as there are no seal haulout sites available.

Bare Islet intermittently stayed above water during the season and Mullet completely submerged by July 20, 3 weeks sooner than in the 2003 season. Whaleskate Islet also went awash by August 26, after having been present throughout 2003, including the fall/winter months of 2003-04. Disappearing Islet remained present throughout the entire season and during the fall months, whereas in recent years it submerged by the end of the summer season. Both Trig and Round Islets had small spits adjacent to them by late April which lasted 2-3 months.

Individual islet censuses, patrols, and incidental surveys were scheduled to ensure monitoring of the entire atoll at least once each week during May 17–August 31. However, surveys at all islands except Disappearing commenced April 21. Surveys were more frequent at

islets where most pups were born and nearby sites, and sites of high shark activity: Trig and Round were monitored every 1–2 d on average; East every 1–3 d; Gin, Little Gin, and Mullet Islets every 2–4 d; Tern every 2–5 d; Shark and Whaleskate every 3–5 d; Disappearing every 6–7 d; and Bare averaged every 4–10 d.

From September 1 to 13, a combination of patrols and incidental surveys were conducted solely at Trig, Round, East, Gin, Little Gin and Tern Islets every 2–8 days to monitor nursing pairs and to document factors that may affect survival. During October 17–December 28, patrols and incidentals were conducted throughout the atoll primarily to monitor the condition of juvenile seals for potential inclusion in the Second Chance Project described in the following pages. Other activities included seal resights; monitoring mother/pup pairs, molting seals, and factors affecting survival; and seals were bleach marked post-molt.

### **Individual Identification**

A total of 298 individuals (237 excluding pups) were identified by existing or applied tags and bleach marks, scars, or natural markings. Bleach marks were applied to 127 seals, including 18 nursing pups. Forty-seven weaned pups were tagged with Temple Tags; 46 of which also received a passive integrated transponder (PIT) tag. Two weaned pups were not tagged; one disappeared shortly after weaning and the other died from a severe shark bite. Five pups were tagged post-summer field season (4 in October, 1 in November). Additionally, 5 other seals (including 3 after the summer field season) were either newly tagged or retagged with Temple Tags and 3 of these also received a PIT tag. These included 3 adults (2 male, 1 female), 1 subadult (female) and 1 weaned pup (male) who had lost a tag.

### **Collection of Samples**

Skin punches were collected from 58 seals; 51 during tagging (1 seal tagged on two occasions) and seven during necropsies. Full necropsies were performed and tissue samples collected from five dead seals found at the study site, and only skin and nail samples were collected from two other decomposed seal carcasses. Skeletal samples were collected from two carcasses; a mummified juvenile on East Islet and a highly decomposed fetus on Disappearing. Sixty-one scats, four spews, one shed molt, and four fresh placenta samples were also collected. One hundred dried ticks were collected for epidemiological studies. And finally, one entanglement sample was collected from an adult female green sea turtle and all other potentially entangling marine debris was cleared from beaches and stored in a secure location on Tern Island pending removal.

## **Special Studies**

### **Galapagos Shark Predation and Monitoring**

In contrast to the previous 3 years of this project, effort in 2004 focused on response to shark predatory events expanded to the full atoll using the same protocol and methodology used at Trig Island in previous seasons. Standardized observations (time/scan 15-min blocks) were conducted on 41 days (697 15-min time blocks) between May 16 and August 13 among Trig, Round, and Gin Islets. These observations were generally conducted during times of known or suspected shark activity (including full and new moon phases). In addition, researchers stayed overnight for 4 nights on Trig Island to increase observations during early morning and late afternoon hours.

In total, fishing/removal operations were conducted for 7 hours and 28 minutes over 3 days at Trig Island when a Galapagos shark exhibited predatory behavior towards a preweaned monk seal. Only one shark attempted to take the bait, and no sharks were culled. Detailed results are presented elsewhere.

### **Translocation of Weaned Pups**

To improve weaned pup survival, newly weaned pups were translocated to other islets within the atoll with lower evidence of shark activity. The majority of pups were moved on the day of or within 2 days of weaning, with four exceptions. One pup each from Gin and Little Gin were translocated 6–9 days postweaning after discovering a newly weaned pup had just disappeared from Gin. And two pups (1 Trig and 1 Gin) nursing at the end of the main field effort in September were translocated in October within 41 days postweaning. Of note, one Trig nursing pair disappeared for 1 day near weaning. The pup reappeared alone a day later and was then translocated.

Twenty-nine newly weaned pups from Trig (19), Gin (5), Round (4) and Little Gin (1) Islets were translocated. Eighteen were taken to Tern (15 from Trig and 3 from Round), 7 to East (5 from Gin, and 1 each from Little Gin and Trig), 3 to Whaleskate (all from Trig), and 1 to Shark (from Round). Additionally, 2 of 3 pups that were initially translocated from Trig to Whaleskate Islet 9 and 13 days earlier were then translocated a second time to East Islet after Whaleskate became mostly awash by the end of July. The remaining pup had been on Whaleskate for 38 days postweaning and appeared to have adapted to the recent ephemeral state of the island. One abandoned female nursing pup on East Islet was translocated and fostered to a parturient female on Trig Islet shortly after the disappearance of her pup. And finally, one Trig Islet pup swam to Tern Islet near the time of weaning.

### **Juvenile Nutritional Enhancement - Second Chance Project**

In efforts to improve survival of juveniles at FFS, seals in poor condition were to be captured and maintained in a shoreside pen on Tern Island where they would receive nutritional supplementation and then be released. A team of veterinarians, seal rehabilitation specialists, and

monk seal field staff was deployed from October 17 to the Spring of 2005. Body condition of all juveniles was photo documented over the the fall and winter to monitor any changes during this period. However, no juveniles were considered to be in such a compromised state that they warranted supplemental feeding.

### **Tern Island Seal Monitoring for Seawall Reconstruction Project**

To monitor the potential impacts on haulout patterns of monk seals prior to and during the Tern Island seawall reconstruction project which began in 2003, USFWS personnel continued conducting weekly “rapid assessment” seal censuses from January 6 to July 12. These data were provided to NMFS for analysis of the impacts of this construction project.

### **Noteworthy Events**

#### **Human Intervention**

Researchers cut the umbilical cords (and collected placentas) of two newborn pups (one each on Trig and Gin) because the attached placentas restricted movement and placed the pups in danger of drowning or attracting sharks. Four weaned pups on the runway at Tern Island were transported back to the beach by researchers. In addition, researchers intervened and halted an incident of adult male aggression towards a weaned pup on Trig Islet.

Eight human-assisted pup exchanges (five on Trig, two on East, and one on Gin) occurred when researchers intervened to improve the survival of a nursing pup. Researchers also successfully fostered a small weaned pup from East to an adult female on Trig who had lost her pup within the previous 2 days. One attempt to reunite a newly weaned pup to its birth mother who had weaned another pup was unsuccessful.

## **RESULTS**

### **Population Abundance and Composition**

The mean of 14 atoll censuses was 113.9 seals (15.1 SD) including pups, and 86.6 seals (10.3 SD) excluding pups (Table 2.1). The total number of seals identified as part of the spring-summer subpopulation was 284 individuals, 223 excluding pups (Table 2.2). This number is a subset of the total identified in the calendar year, and is an unknown proportion of the total subpopulation as many of the older, untagged seals couldn't be uniquely identified. The numbers of tagged known-age seals born at FFS during the 1984 to 2003 period and resighted at any location in 2004 are summarized in Table 2.3.

## **Reproduction**

A minimum of 61 pups were born at FFS in 2004: 49 successfully weaned (including five nursing at the end of the NMFS summer field season and one born in late September), 9 died or probably died prior to weaning, 2 pups older than 21 days suspiciously disappeared prior to weaning, and the weaning status is unknown for one 9-11-day-old pup which was still nursing in September when the field team departed and was not seen when field personnel returned in October 40 days later (Table 2.4a). The following were birth locations for these pups: 25 born at Trig, 17 at East, 10 at Gin, 6 at Round, 2 at Little Gin, and 1 at Whaleskate. This is the first year since 1988 that no pups were born at Tern Island. One decomposed fetus was found on Disappearing Islet and was not included in the pup total. Nursing periods and measurements of weaned pups are summarized in Table 2.4b. The mean lactation period for 37 females was 38.1 d (5.9 SD). One parturient female had an unusually long lactation period of 50–55 days and began molting during the final days before weaning.

Thirty pup exchanges (22 Trig, 6 East, 2 Gin) were documented among 21 adult females and 21 pups; 7 of these events were observed and 8 others (5 on Trig, 2 on East, and 1 on Gin) involved human assistance to improve pup survival. These intervention events culminated in 11 nursing pups (one pup twice) being reunited to a mother and 4 older pups were weaned by human assistance. This includes a pup abandoned at 27 days old on East Islet that was translocated and fostered to a parturient female on Trig whose pup had disappeared within the previous 48 hours. This female pup received an additional 15 days of nursing and successfully weaned. In addition (not included in the intervention total), researchers unsuccessfully attempted to reunite a smaller, unmolted newly weaned pup with its birth mom who had weaned a different pup 6 days previously and was still in good condition. One birth and one weaning were observed, both on Trig Islet.

## **Interatoll Movement**

Interatoll movement was documented for two seals that completed a total of two movements between FFS and either Laysan or Lisianski Islands (Tables 2.5a and b).

## **Factors Affecting Survival**

Attacks by large sharks, mounting attempts by male Hawaiian monk seals, emaciation, and unknown factors resulted in 41 life-threatening conditions, which resulted in the confirmed deaths of 8 seals and the probable deaths of 6 seals (these 14 deaths/probable deaths include 9 nursing and 1 weaned pups). In addition, 6 pups suspiciously disappeared and are likely dead (2 nursing pups more than 3 weeks old, 3 pups 3–9 days postweaning, and 1 pup 10–51 days old that disappeared when field effort was temporarily discontinued) (Table 2.6).

Of 61 pups born at FFS this year, 7 pups (3 weaned and 4 nursing) were seriously bitten by sharks: 4 died (2 at Trig, and one each at Gin and Round) and 1 disappeared (at Trig). Eleven additional pups (9 weaned, including one injured twice, and 2 nursing) received very minor shark injuries, not serious enough to include in Table 2.6. Two of these minor injuries occurred at East (one each to a weaned and nursing pup), one at Round (to a nursing pup) and two (both to weaned pups) at Gin. The islet where the other 7 minor injuries occurred could not be ascertained because they were inflicted on older weaned pups (more than 30 days postweaning) and these older pups move throughout the atoll. In one East Islet case, fresh shark injuries were documented on a female as well as her pup, with the mother incurring more severe injuries than the pup. She was at the end of her nursing period, in thin condition, and weaned her pup 1-3 days after getting injured.

Shark attack also likely caused the disappearances of four other nursing pups; including the probable deaths of 2 young nursing pups and the suspicious disappearances of 2 older nursing pups. Two of these disappearances occurred at Gin, one at Little Gin, and one at Trig. Shark attack was suspected because the pups appeared healthy and normal when last seen. Additionally, in three of these four cases, the parturient female was present and actively searching for her missing pup, confirming that the pups had not been weaned. Another pup disappeared for unknown reasons; it was 9–11 days old and nursing on Trig at the end of the summer field camp in mid-September and was no longer present when researchers returned 40 days later on October 19. In addition, 3 apparently healthy weaned pups disappeared within 3–9 days of weaning.

An adult female sustained moderate male mounting injuries, resulting in an abscess that almost completely healed during the season, and two incidents of adult male aggression towards weaned pups were witnessed (one on Tern and the other on Trig). Researchers intervened and halted the incident on Trig, and neither event resulted in obvious injuries. No seals were seen entangled this season, however researchers freed 1 adult green sea turtle from an aggregate of line wrapped tightly around its neck and right foreflipper. The turtle incurred very minor injuries where the line had cut into its skin.

In addition to the incidents presented in Table 2.6, a fetus was found on Disappearing Islet and seven seals were observed with healed moderate to severe shark injuries inflicted since the previous field season (1 adult male, 4 adult females, and a juvenile male and female). One nursing pup was observed with an eye opacity; there was no obvious trauma to the eye region and it is unknown if the pup's vision was impaired.

## ACKNOWLEDGMENTS

We acknowledge the support of the USFWS, Hawaiian Islands National Wildlife Refuge staff and volunteers. Special thanks to Dominique Horvarth and Joe Wiggins for logistical support, always there to help get our equipment and supplies out to Tern Island. We also are grateful to USFWS Chris and Carrie Eggleston, Jennifer Tietjen, Steve Barclay, Heidi Hoffman, Todd Marse, Joe Spring, other staff and volunteers for conducting weekly Tern Island seal counts to monitor seal haulouts during the seawall project and providing additional observations and assistance with field work. We also thank contract veterinarian Dr. Robert Braun, and The Marine Mammal Center staff and volunteers, Tracey Goldstein, Dr. Frances Gulland, Jamie King, Cullen Meade, and Elizabeth Wheeler, for assistance with the Second Chance Project. We thank the captains, officers, and crew of the NOAA Ships *Oscar Sette* and *Hi'ialakai*, Coast Guard Cutter *Kukui*, and M/V *Casitas*, and the pilots of Pearl Pacific Enterprises.

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**TABLES**  
**for French Frigate Shoals**



Table 2.1.--Summary statistics for atoll censuses ( $n = 14$ ) of Hawaiian monk seals at French Frigate Shoals from May 17 to August 30, 2004.

Size/Sex	Mean number of individuals	Standard deviation
Adults	58.5	8.5
Male	18.7	3.2
Female	36.1	7.8
Unknown	3.7	3.1
Subadults	12.4	4.1
Male	6.0	2.1
Female	5.1	2.6
Unknown	1.3	1.6
Juveniles	15.4	2.6
Male	5.3	1.1
Female	8.9	2.3
Unknown	1.2	1.1
Pups	27.2	8.5
Male	13.3	3.7
Female	11.5	5.4
Unknown	2.4	1.7
Non-pup Total	86.6*	10.3
Grand Total	113.9*	15.1

\* Includes some seals not placed in any size class.

Table 2.2.--Composition of the Hawaiian monk seal subpopulation at French Frigate Shoals during the spring and summer of 2004. These numbers are an unknown proportion of the entire subpopulation as many untagged adults could not be uniquely identified. All known parturient females and pups born during the calendar year are included.

Size	Number of seals				Sex ratio male:female
	Male	Female	Unknown	Total	
Adults	63	93	0	156	0.7:1
Subadults	14	15	0	29	0.9:1
Juveniles	16	22	0	38	0.7:1
Pups	29*	29	3*	61*	1.0:1
Non-pup Total	93	130	0	223	0.7:1
Grand Total	122	159	3	284	0.8:1

\* Includes perinatal pups (two male and one of unknown sex) that weren't seen alive.

Table 2.3.--Summary of tagged known-age seals born at French Frigate Shoals and resighted at any location in 2004.

Cohort Year	Age (years)	Sex	Number originally tagged	Number resighted in 2004
1984	20	Male	49	4*
		Female	43	7*
1985	19	Male	48	2
		Female	38	7
1986	18	Male	52	6*
		Female	48	15*
1987	17	Male	55	5
		Female	51	5
1988	16	Male	52	4
		Female	62	3
1989	15	Male	51	5
		Female	50	4
1990	14	Male	38	1
		Female	41	6*
1991	13	Male	24	1
		Female	44	4*
1992	12	Male	36	2
		Female	55	9*
1993	11	Male	40	3
		Female	39	2
1994	10	Male	47	1
		Female	48	7*
1995	9	Male	29	2
		Female	26	10*
1996	8	Male	39	3
		Female	30	3
1997	7	Male	32	1
		Female	19	0
1998	6	Male	49	4
		Female	39	4

Cohort Year	Age (years)	Sex	Number originally tagged	Number resighted in 2004
1999	5	Male	30	7
		Female	30	4
2000	4	Male	27	3
		Female	30	4
2001	3	Male	21	2
		Female	19	4
2002	2	Male	25	11
		Female	28	16
2003	1	Male	12	8
		Female	25	7

\*Cohort survivors include seals removed from French Frigate Shoals for rehabilitation or direct translocation. These seals were either released at Kure or Midway Atoll ( $n = 13$ ) or remain in permanent captivity ( $n = 11$ ).

Table 2.4a.--Summary of Hawaiian monk seals born at French Frigate Shoals in 2004.

Event	Number of pups			
	Male	Female	Unknown	Total
Born	29 <sup>a</sup>	29	3 <sup>b</sup>	61
Died/probably died prior to weaning	4 <sup>c</sup>	2	3 <sup>b</sup>	9
Suspicious Disappearance prior to weaning	1	1	0	2
Suspicious disappearance weaning status unknown	1 <sup>d</sup>	0	0	1
Weaned	23 <sup>e</sup>	26	0	49 <sup>e</sup>
Tagged	21 <sup>f</sup>	26 <sup>f</sup>	0	47

<sup>a</sup> One male pup was born after the NMFS summer field camp on Round Islet.

<sup>b</sup> One newborn pup never seen (alive or dead) at Gin, known gone because 2 females subsequently nursed 1 pup for 3 weeks.

<sup>c</sup> Includes 2 newborn pups found dead unknown cause (1 Trig, 1 Whaleskate).

<sup>d</sup> One male pup was nursing on Trig at the end of the NMFS summer field camp and was not seen again.

<sup>e</sup> Two weaned pups were not tagged. One disappeared shortly after weaning and the other died from a severe shark bite.

<sup>f</sup> Four females and 1 male tagged in October and November, respectively (includes 4 of the 5 pups that were still nursing at the end of the season and 1 pup born after the NMFS summer field camp).

Table 2.4b.--Summary of nursing periods and measurements of weaned pups at French Frigate Shoals in 2004. Nursing periods were calculated where birth and weaning dates were both known or occurred within a range of 4 days or less. All measurements were taken within 2 weeks after weaning.

---

	Nursing period (d)	Axillary girth (cm)	Straight dorsal length (cm)
Mean	38.8	107.6	125.0
Standard Deviation	5.5	8.3	6.5
<i>n</i>	30	44	44

---

Table 2.5a.--Documented movement of Hawaiian monk seals to French Frigate Shoals from other locations in 2004, summarized by movements between two locations.

---

Original location	Number of trips, size, and sex class
Lisianski Island	1 adult male

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Table 2.5b.--Documented movement of Hawaiian monk seals from French Frigate Shoals to other locations in 2004, summarized by movements between two locations.

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Destination	Number of trips, size, and sex class
Laysan Island	1 adult female

---

Table 2.6.--Factors affecting Hawaiian monk seal survival at French Frigate Shoals in 2004.

Size	Sex	Total	Outcome			
			Injured	Died	Probably died	Suspicious Disappearance <sup>e</sup>
<b>Attack by Large Shark</b>						
Adult	Male	7 <sup>a</sup>	7	0	0	0
	Female	6	6	0	0	0
Juvenile	Female	1	1	0	0	0
Weaned pup	Male	3	2	1	0	0
Nursing pup	Male	1	0	1	0	0
	Female	2	0	2	0	0
	Unknown	1	0	0	1	0
<b>Mounting by Males</b>						
Adult	Female	1	1	0	0	0
Weaned pup	Male	1 <sup>b</sup>	0	0	0	0
	Female	1 <sup>c</sup>	0	0	0	0
<b>Entanglement (none observed)</b>						
<b>Emaciation</b>						
Juvenile	Male	1	0	1 <sup>d</sup>	0	0
	Female	2	0	0	2	0
<b>Unknown</b>						
Adult	Female	1	1	0	0	0
Juvenile	Male	1	0	1 <sup>e</sup>	0	0
Weaned pup	Male	2	1	0	0	1
	Female	2	0	0	0	2
Nursing pup	Male	5	0	2 <sup>f</sup>	1	2 <sup>g</sup>
	Female	1	0	0	0	1
	Unknown	2	0	0	2 <sup>h</sup>	0

- <sup>a</sup> One adult male was injured twice, first by March 22 and again November 24.
- <sup>b</sup> Observed incident on Tern Island where an adult male harassed a weaned pup for 23 minutes. This pup sustained no obvious injuries.
- <sup>c</sup> Observed incident on Trig Islet where an adult male harassed a pup that weaned 1–2 days previously. Although not overly aggressive, researchers intervened after 12 minutes of observation. The pup sustained no obvious injuries.
- <sup>d</sup> Juvenile found dead on Tern islet by USFWS personnel February 22. Seal was last seen alive February 17 as emaciated and very green with algae on fur.
- <sup>e</sup> Mummified carcass found on East Islet by USFWS personnel April 18.
- <sup>f</sup> Two newborn pups were not seen alive; 1 at Whaleskate on April 30, and 1 at Trig on July 2.
- <sup>g</sup> One pup disappeared from Trig between September 10 and October 19, when field effort was temporarily discontinued. The cause of the disappearance and weaning status is unknown.
- <sup>h</sup> One newborn pup was never seen but was assumed born and lost between May 25–31, as 2 females nursed a single pup for 3 weeks on Gin Islet.

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**CHAPTER 3. THE HAWAIIAN MONK SEAL ON  
LAYSAN ISLAND, 2004**

**Karen Holman, Melinda Fowler, Catherine Gunther-Murphy**

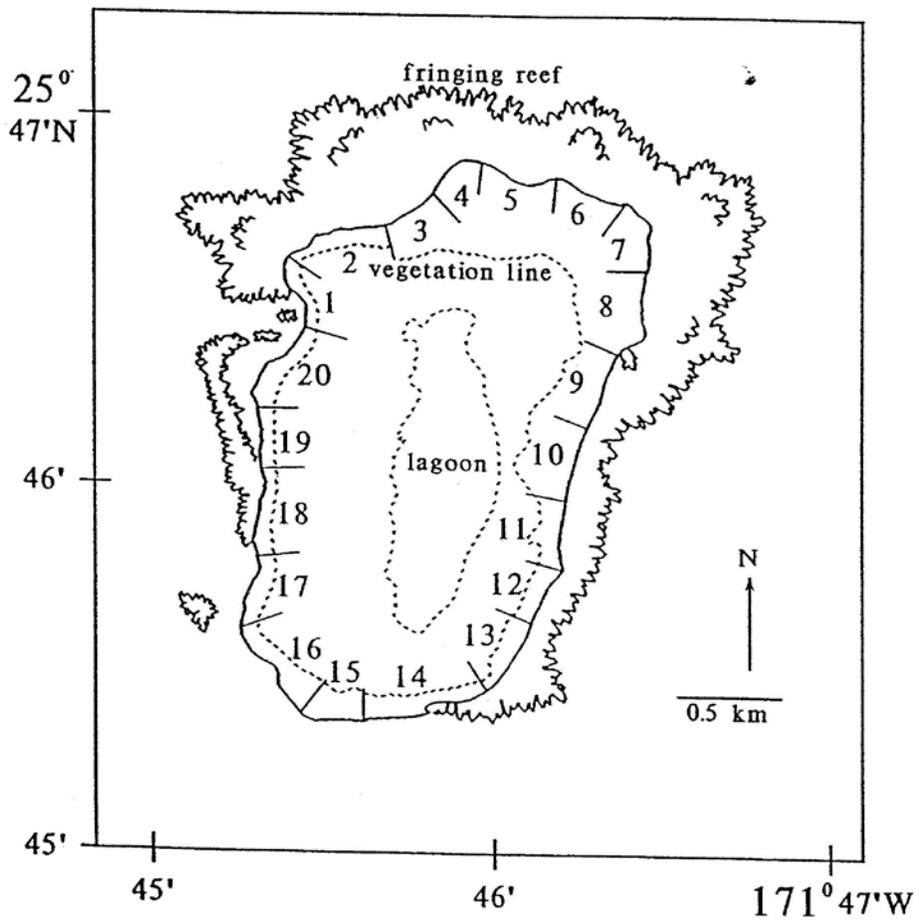


Fig. 3.1 Laysan Island in the Northwestern Hawaiian Islands.

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 the Papahānaumokuākea Marine National Monument, and is one of the six primary haulout and pupping locations of the Hawaiian monk seal (Fig. 3.1).

## **RESEARCH**

The National Marine Fisheries Service (NMFS) began research on Hawaiian monk seals at Laysan Island in 1981. In 2004, research was conducted by NMFS during April 24–August 5 and September 30–October 2, and incidental observations were recorded by U.S. Fish and Wildlife Service (USFWS) personnel during the remainder of the year. The perimeter of the island (ca. 11 km) was divided into 20 sectors using artificial or natural landmarks (Fig. 3.1). Research objectives specific to this subpopulation in 2004 included (1) assessment of maternity and pup exchanges; and (2) documentation of male behavior, including aggression.

### **Censuses and Patrols**

Censuses and patrols were scheduled to ensure that the entire island perimeter was monitored at least once daily during April 26–August 3. Censuses ( $n = 21$ ) were conducted by two observers every fourth day from May 10 to August 1, beginning at 1300 Hawaii Standard Time and continuing for 2.3 to 3.5 h.

Standardized behavior patrols were conducted on noncensus days from May 12 to July 26 to assess activity patterns of adults and large subadults and document male aggression. During these patrols ( $n = 18$ ), observer attention was directed out to sea as much as possible, since multiple male aggression has been observed most frequently in the water. Full-island standardized incidental surveys ( $n = 60$ ) were conducted on noncensus and nonbehavior patrol days to record female and pup pairs, factors affecting survival, weaned pups, and molting animals. Additional partial island surveys were conducted as needed.

### **Individual Identification**

A total of 273 individuals (237 excluding pups) were identified by existing or applied tags, bleach marks, scars or natural markings. Bleach marks were applied to 220 seals, including 30 nursing pups. Most weaned pups ( $n = 33$ ) were tagged with Temple Tags and 26 of these pups received PIT tags. In addition, 2 yearlings were newly tagged and 1 yearling was retagged with temple tags to replace a lost tag.

## **Collection of Samples**

Sixty-two scat and 11 spew samples were collected. Skin punches were collected from 31 weaned pups and 3 yearlings. Shed molt samples were collected from 26 individuals. Placentas were collected from 2 females. Necropsies were performed, and tissue samples collected from 1 recently dead pup, and skulls from 1 adult and 1 yearling carcass were also collected. Potentially entangling debris were collected from beaches and stored at secure sites around the island pending removal. Two pieces of debris were removed and collected from entangled animals (1 from a seal and 1 from a seabird).

## **RESULTS**

### **Subpopulation Abundance and Composition**

The mean of 21 censuses was 103.4 seals (8.8 SD) including pups, and 81 seals (8.6 SD) excluding pups (Table 3.1). The total spring-summer subpopulation was 270 individuals, 234 excluding pups (Table 3.2). This number is a subset of the total identified in the calendar year. The overall adult sex ratio was 0.9:1 (63 males: 70 females). The numbers of tagged known-age seals born at Laysan Island during the 1983–2003 period and resighted at any location in 2004 are summarized in Table 3.3.

### **Reproduction**

At least 36 pups were born at Laysan Island in 2004: 34 were successfully weaned and 2 died prior to weaning (Table 3.4a). Although 3 pups were still nursing at the end of camp, they all successfully weaned and were marked by USFWS personnel. Two of the 3 late-weaned pups were subsequently tagged (one in October 2004 and the other in April 2005). Nursing periods and measurements of weaned pups are summarized in Table 3.4b. The birth rate measured as the number of pups born divided by the number of adult-sized females in the subpopulation  $\times 100$  was 51.4%  $((36/70) \times 100)$ . A minimum of 13 pup exchanges occurred among 14 nursing females; one of these incidents was observed. One birth was also observed.

### **Interatoll Movement**

Interatoll movement was documented for 13 seals that completed a total of 17 movements between Laysan Island and either French Frigate Shoals or Lisianski Island (Tables 3.5a and b).

## **Factors Affecting Survival**

Attacks by large sharks, entanglement, emaciation, and other/unknown factors led to 14 life-threatening conditions, which resulted in the death of 5 seals and the disappearance of 2 other seals (Table 3.6). Three deaths were reported pre-season by the FWS crew; a pup, a yearling, and an emaciated adult female. One neonate death occurred during the data collection period and a prematurely weaned pup died in December, after the field season. Three seals were entangled: 1 escaped unaided and 2 were released by observers. In addition to the incidents presented in Table 3.6, one probable large shark injury occurred between seasons and was observed as healed at the beginning of the season. Five 2-year-old seals were observed with an unusual fur condition that persisted throughout the season. The abnormality was characterized by matted, discolored fur mostly on the crown of the head and the dorsal posterior region. These animals did not appear otherwise compromised.

## **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 *The Oscar Elton Sette*.

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**TABLES**  
**for Laysan Island**



Table 3.1.--Summary statistics for censuses ( $n = 21$ ) of Hawaiian monk seals at Laysan Island from May 10 to August 1, 2004.

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Size/Sex	Mean number of individuals	Standard deviation
Adults	46.9	4.4
Male	18.8	3.7
Female	26.6	2.9
Unknown	1.5	2.1
Subadults	19.3	5.9
Male	8.9	2.5
Female	9.8	4.7
Unknown	0.7	1.0
Juveniles	14.7	4.6
Male	7.1	2.6
Female	7.3	2.7
Unknown	0.2	0.5
Pups	22.4	2.5
Male	8.7	2.0
Female	13.1	1.9
Unknown	0.7	1.0
Non-pup total	81.0	8.6
Grand total	103.4	8.8

---

Table 3.2.--Composition of the Hawaiian monk seal subpopulation at Laysan Island during the spring and summer of 2004. Includes all known parturient females and pups born during the calendar year.

Size	Number of seals			Total	Sex ratio male:female
	Male	Female	Unknown		
Adults	63	70	0	133	0.9:1
Subadults	24	27	0	51	0.9:1
Juveniles	26	24	0	50	1.1:1
Pups	13	22	1	36	0.6:1
Non-pup total	113	121	0	234	0.9:1
Grand total	126	143	1	270	0.9:1

Table 3.3.--Summary of tagged known-age seals born at Laysan Island and resighted at any location in 2004.

Cohort year	Age (years)	Sex	Number originally tagged	Number resighted in 2004
1983	21	Male	10	1
		Female	10	4
1984	20	Male	16	2*
		Female	13	2
1985	19	Male	16	2
		Female	14	2
1986	18	Male	15	0
		Female	17	1
1987	17	Male	13	3
		Female	15	3
1988	16	Male	23	5*
		Female	17	2
1989	15	Male	16	2
		Female	13	1
1990	14	Male	7	2
		Female	9	2
1991	13	Male	18	7
		Female	13	3
1992	12	Male	18	2
		Female	14	3
1993	11	Male	23	3
		Female	14	4
1994	10	Male	18	7
		Female	29	7
1995	9	Male	16	7
		Female	21	8
1996	8	Male	23	7
		Female	21	8
1997	7	Male	19	5
		Female	16	5

Cohort year	Age (years)	Sex	Number originally tagged	Number resighted in 2004
1998	6	Male	24	12
		Female	20	9
		Unknown	1	0
1999	5	Male	20	8
		Female	34	18
2000	4	Male	14	2
		Female	20	2
2001	3	Male	16	7
		Female	17	9
2002	2	Male	21	17
		Female	16	10
2003	1	Male	10	9
		Female	18	12

\*Cohort survivors include 2 seals removed from Laysan Island and translocated to the main Hawaiian Islands.

Table 3.4a.--Summary of Hawaiian monk seals born at Laysan Island in 2004.

Event	Number of pups			
	Male	Female	Unknown	Total
Born	13	22	1	36
Died prior to weaning	0	1	1	2
Weaned	13 <sup>a</sup>	21 <sup>b</sup>	0	34 <sup>a,b</sup>
Tagged	13 <sup>a</sup>	20 <sup>b</sup>	0	33 <sup>a,b</sup>

<sup>a</sup> One male pup weaned after the end of the season and was tagged in October 2004.

<sup>b</sup> Two female pups weaned after the end of the season and were bleached by FWS. One of these 2 pups was resighted and tagged in April 2005.

Table 3.4b.--Summary of nursing periods and measurements of weaned pups at Laysan Island in 2004. Nursing periods were calculated where birth and weaning dates were both known or occurred within a range of 4 days or less. All measurements were taken within 2 weeks after weaning.

	Nursing period (d)	Axillary girth (cm)	Straight dorsal length (cm)
Mean	36.2	106.0	123.7
Standard deviation	4.4	8.4	5.9
<i>n</i>	30	30	30

Table 3.5a.--Documented movement of Hawaiian monk seals to Laysan Island from other locations in 2004, summarized by movements between two locations. No seals made more than one observed trip.

Original location	Number of trips, size, and sex class
French Frigate Shoals	1 adult female
Lisianski Island	3 adult male 2 adult female

Table 3.5b.--Documented movement of Hawaiian monk seals from Laysan Island to other locations in 2004, summarized by movements between two locations. No seals made more than one observed trip.

Destination	Number of trips, size, and sex class
Lisianski Island	3 adult male 6 adult female 1 subadult male 1 subadult female

Table 3.6.--Factors affecting Hawaiian monk seal survival at Laysan Island in 2004.

Size	Sex	Total	Outcome		
			Injured	Died	Probably died
<b>Attack by Large Shark</b>					
Adult	Male	1	1	0	0
Juvenile	Male	1	1	0	0
<b>Mounting by Males</b>					
(none observed)					
<b>Entanglement</b>					
Subadult	Male	1 <sup>a</sup>	0	0	0
Weaned pup	Male	1 <sup>b</sup>	0	0	0
	Female	1 <sup>b</sup>	0	0	0
<b>Emaciation</b>					
Adult	Female	1	0	1 <sup>c</sup>	0
Prematurely weaned pup	Female	1	0	1 <sup>c</sup>	0
<b>Other/Unknown</b>					
Adult	Female	1	0	0	1 <sup>d</sup>
Subadult	Male	1	1	0	0
	Female	1	1	0	0
Juvenile	Male	1	0	1	0
Weaned pup	Male	1	0	0	1 <sup>e</sup>
Nursing Pup	Female	1	0	1 <sup>f</sup>	0
	Unknown	1	0	1 <sup>g</sup>	0

<sup>a</sup>Seal disentangled itself and sustained no injuries from the entanglement.

<sup>b</sup>Seal was released by researchers and sustained no injuries from the entanglement.

<sup>c</sup>Both seals found dead and emaciated by FWS, the adult female had an estimated age of 19 years, the prematurely weaned female pup also had seal-inflicted injuries.

<sup>d</sup>A 21-year-old seal in extremely poor and deteriorating condition disappeared. This seal also suffered a partially severed hind flipper and a reopened mounting injury.

<sup>e</sup>Severely injured, possibly by boat propeller, in December 2004, seal disappeared by 1/3/2005.

<sup>f</sup>Perinatal pup death.

<sup>g</sup>Pup found dead by FWS within 4 days of birth, never confirmed to be alive.

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**CHAPTER 4. THE HAWAIIAN MONK SEAL ON  
LISIANSKI ISLAND, 2004**

Ryan Jenkinson and Elizabeth Jenkinson

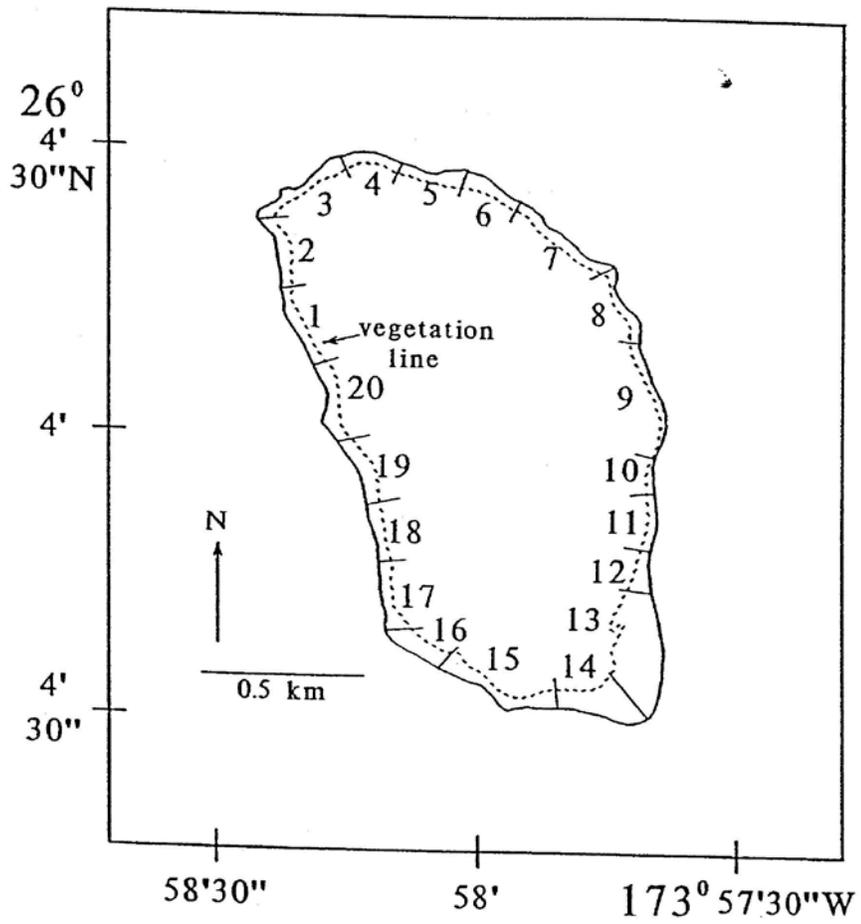


Fig. 4.1 Lisianski Island in the Northwestern Hawaiian Islands.

Lisianski Island (lat. 26°02'N, long. 174°00'W) is one of the primary haulout and pupping locations of the Hawaiian monk seal. The island is located ca. 1760 km northwest of Oahu (Fig. 1.1) and is surrounded by Neva Shoal, a shallow reef bank within the Hawaiian Islands National Wildlife Refuge and the Papahānaumokuākea Marine National Monument (Fig. 4.1).

## **RESEARCH**

The National Marine Fisheries Service (NMFS) began research on Hawaiian monk seals at Lisianski Island in 1980. In 2004, research was conducted by NMFS during April 24–August 1, and incidental pelagic seal observations were recorded by fisheries observers near Lisianski Island on November 7–9. The perimeter of the island was divided into 20 sectors using artificial or natural landmarks (Fig. 4.1). Research activities specific to this subpopulation in 2004 included (1) assessment of maternity and pup exchanges; and (2) documentation of adult male behavior and aggression.

### **Censuses and Patrols**

Censuses and patrols were scheduled to ensure that the entire island was monitored at least once daily during April 24–August 1. Censuses ( $n = 24$ ) were conducted by two observers every fourth day from April 30 to July 31, beginning at 1300 Hawaii Standard Time and continuing from 1.3 to 2.3 h.

Standardized behavior patrols were conducted on noncensus days to assess activity patterns of adults and large subadults and document male aggression. During these patrols ( $n = 23$ ), attention was directed out to sea as much as possible since multiple male aggression has been observed most frequently in the water. Full island standardized incidental surveys ( $n = 52$ ) were conducted on non-census and nonbehavior patrol days from April 24 to July 30 to record female and pup pairs, factors affecting survival, weaned pups and molting animals. Additional partial island surveys were conducted as needed.

### **Individual Identification**

A total of 191 individuals (162 excluding pups) were identified by existing or applied tags, bleach marks, scars, or natural markings. All weaned pups ( $n = 29$ ) were tagged with Temple Tags and 28 of these pups received PIT tags.

## **Collection of Samples**

One-hundred one scats and 1 spew sample were collected. Skin punches were collected from 29 seals during tagging. One skull was collected from the mummified carcass of a fetus. Forty-two shed molt samples were collected from 42 individuals. Potentially entangling marine debris was collected from beaches and stored in a secure location pending removal. Four debris items were removed from entangled seals, collected, and brought back to Honolulu.

## **RESULTS**

### **Subpopulation Abundance and Composition**

The mean of 24 censuses was 82.8 seals (10.3 SD) including pups, and 61.8 seals (8.5 SD) excluding pups (Table 4.1). The total spring-summer subpopulation was 189 individuals, 160 excluding pups (Table 4.2). This number is a subset of the total identified during the calendar year. The overall adult sex ratio was 1.2:1 (65 males:52 females). The numbers of tagged known-age seals born at Lisianski Island during the 1982–2003 period, and resighted at any location in 2004, are summarized in Table 4.3.

### **Reproduction**

A minimum of 29 pups were born at Lisianski Island in 2004 and all 29 were successfully weaned (Table 4.4a). One mummified fetus was found at the beginning of the field season and was not included in the pup total. Nursing periods and measurements of weaned pups are summarized in Table 4.4b. The birth rate, measured as the number of pups born divided by the number of adult-sized females in the subpopulation  $\times 100$  was 55.8%  $((29/52) \times 100)$ . A minimum of 6 pup exchanges occurred among 7 nursing females.

### **Interatoll Movement**

Interatoll movement was documented for 13 seals that completed a total of 19 movements between Lisianski Island and either FFS, Laysan Island or Pearl and Hermes Reef (Tables 4.5a and b).

### **Factors Affecting Survival**

Attacks by large sharks, mounting attempts by male Hawaiian monk seals, entanglement in marine debris, and emaciation factors led to 10 life-threatening conditions, which resulted in the disappearance and probable death of one seal (Table 4.6). Five seals were observed entangled in marine debris: 1 escaped unaided and 4 were released by observers.

In addition to the cases summarized in Table 4.6, several other cases are noteworthy. Male harassment of weaned pups/juveniles was observed on 8 occasions. A minimum of 2 other weaned pups sustained minor dorsal scratches probably inflicted by other seals during unobserved incidents. One adult female seal displayed healed large shark bite scars on her left head and muzzle area that were not present on the animal in 2003. A mummified carcass of a seal fetus was found during the first full island patrol by which time the mother and date of death could not be determined.

### **ACKNOWLEDGMENTS**

We thank the captain, officers, and crew of the NOAA Ship *Oscar Elton Sette* for logistical assistance. We acknowledge the support of the U.S. Fish and Wildlife Service, Hawaiian Islands National Wildlife Refuge staff.

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**TABLES**  
**for Lisianski Island**



Table 4.1.--Summary statistics for censuses ( $n = 24$ ) of Hawaiian monk seals at Lisianski Island from April 30 to July 31, 2004.

Size/Sex	Mean number of individuals	Standard deviation
Adults	45.8	7.7
Male	22.5	5.0
Female	21.8	3.9
Unknown	1.5	1.7
Subadults	8.1	2.7
Male	4.3	1.8
Female	3.8	1.5
Unknown	0.0	0.2
Juveniles	7.8	2.0
Male	4.8	1.5
Female	3.1	1.4
Unknown	0.0	0.0
Pups	21.0	2.9
Male	12.6	2.1
Female	8.4	1.7
Unknown	0.0	0.2
Non-pup total	61.8	8.5
Grand total	82.8	10.3

Table 4.2.--Composition of the Hawaiian monk seal subpopulation at Lisianski Island during the spring and summer of 2004. Includes all known parturient females and all pups born during the calendar year.

Size	Number of seals			Sex ratio male:female
	Male	Female	Total	
Adults	65	52	117	1.2:1
Subadults	9	10	19	0.9:1
Juveniles	11	13	24	0.8:1
Pups	17	12	29	1.4:1
Non-pup total	85	75	160	1.1:1
Grand total	102	87	189	1.2:1

Table 4.3.--Summary of tagged known-age seals born at Lisianski Island and resighted at any location in 2004.

Cohort year	Age (years)	Sex	Number originally tagged	Number resighted in 2004
1982	22	Male	7	2
		Female	6	0
1983	21	Male	6	1
		Female	18	7
1984	20	Male	10	4
		Female	5	1
1985	19	Male	5	1
		Female	9	0
1986	18	Male	11	4
		Female	9	2
1987	17	Male	12	1
		Female	6	1
1988	16	Male	10	5
		Female	8	6
1989	15	Male	--	--
		Female	--	--
1990	14	Male	8	3
		Female	9	2
1991	13	Male	9	4
		Female	6	2
1992	12	Male	13	6
		Female	8	3
1993	11	Male	4	2
		Female	9	2
1994	10	Male	4	1
		Female	5	0
1995	9	Male	7	2
		Female	10	2
1996	8	Male	9	2
		Female	13	1

Cohort year	Age (years)	Sex	Number originally tagged	Number resighted in 2004
1997	7	Male	10	4
		Female	9	3
1998	6	Male	10	3
		Female	11	4
1999	5	Male	16	3
		Female	11	2
2000	4	Male	9	1
		Female	9	1
2001	3	Male	5	1
		Female	9	1
2002	2	Male	12	4
		Female	11	4
2003	1	Male	12	9
		Female	14	11

Table 4.4a.--Summary of Hawaiian monk seals born at Lisianski Island in 2004.

Event	Number of pups		
	Male	Female	Total
Born	17	12	29
Died/Probably died prior to weaning	0	0	0
Weaned	17	12	29
Tagged	17	12	29

Table 4.4b.--Summary of nursing periods and measurements of weaned pups at Lisianski Island in 2004. Nursing periods were calculated where birth and weaning dates were both known or occurred within a range of 4 days or less. All measurements were taken within 2 weeks after weaning.

	Nursing period (d)	Axillary girth (cm)	Straight dorsal length (cm)
Mean	39.1	108.2	123.0
Standard deviation	4.2	10.5	7.1
<i>n</i>	13	23	23

Table 4.5a.--Documented movement of Hawaiian monk seals to Lisianski Island from other locations in 2004, summarized by movements between two locations. No seals made more than one observed trip.

Original location	Number of trips, size, and sex class
Laysan Island	3 adult male 6 adult female 1 subadult male 1 subadult female
Pearl and Hermes Reef	1 subadult male

Table 4.5b.--Documented movement of Hawaiian monk seals from Lisianski Island to other locations in 2004, summarized by movements between two locations. No seals made more than one observed trip.

Destination	Number of trips, size, and sex class
FFS	1 adult male
Laysan Island	3 adult male 2 adult female
Pearl and Hermes Reef	1 subadult male

Table 4.6.--Factors affecting Hawaiian monk seal survival at Lisianski Island in 2004.

Size	Sex	Total	Outcome		
			Injured	Died	Probably died
<b>Attack by Large Shark</b>					
Juvenile	Female	1	1 <sup>a</sup>	0	0
Weaned pup	Female	1	1 <sup>b</sup>	0	0
<b>Mounting by Male</b>					
Adult	Female	1	1 <sup>c</sup>	0	0
Weaned pup	Male	1 <sup>d</sup>	0	0	0
<b>Entanglement</b>					
Adult	Female	2 <sup>e</sup>	0	0	0
Weaned pup	Male	2 <sup>f</sup>	0	0	0
	Female	1 <sup>g</sup>	0	0	0
<b>Emaciation</b>					
Juvenile	Female	1 <sup>h</sup>	0	0	1 <sup>j</sup>

<sup>a</sup>Includes a seal with extensive yet almost healed injury. Injury occurred in early 2004.

<sup>b</sup>Weaned pup sustained a shark bite injury and was not observed as healed by the end of field data collection 2004.

<sup>c</sup>Adult female observed with post-mounting injuries covering half the dorsum.

<sup>d</sup>Adult male was observed mounting weaned male pup in shallow water. Intervention by another adult male prevented the pup's imminent drowning.

<sup>e</sup>One seal offshore, wrapped in floating debris, released self and the other seal, entangled with rope and floats, was released by observers.

<sup>f</sup>Both seals were entangled around the neck, one with a plastic ring and the other with a strap. Both were released by observers.

<sup>g</sup>Seal entangled with rope and line, released by observer.

<sup>h</sup>Juvenile seal disappeared after it was observed as lethargic and emaciated.

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**CHAPTER 5. THE HAWAIIAN MONK SEAL ON  
PEARL AND HERMES REEF, 2004**

Maire K. Cahoon, Jonathan C. Sprague, and Nicole M. Teeples

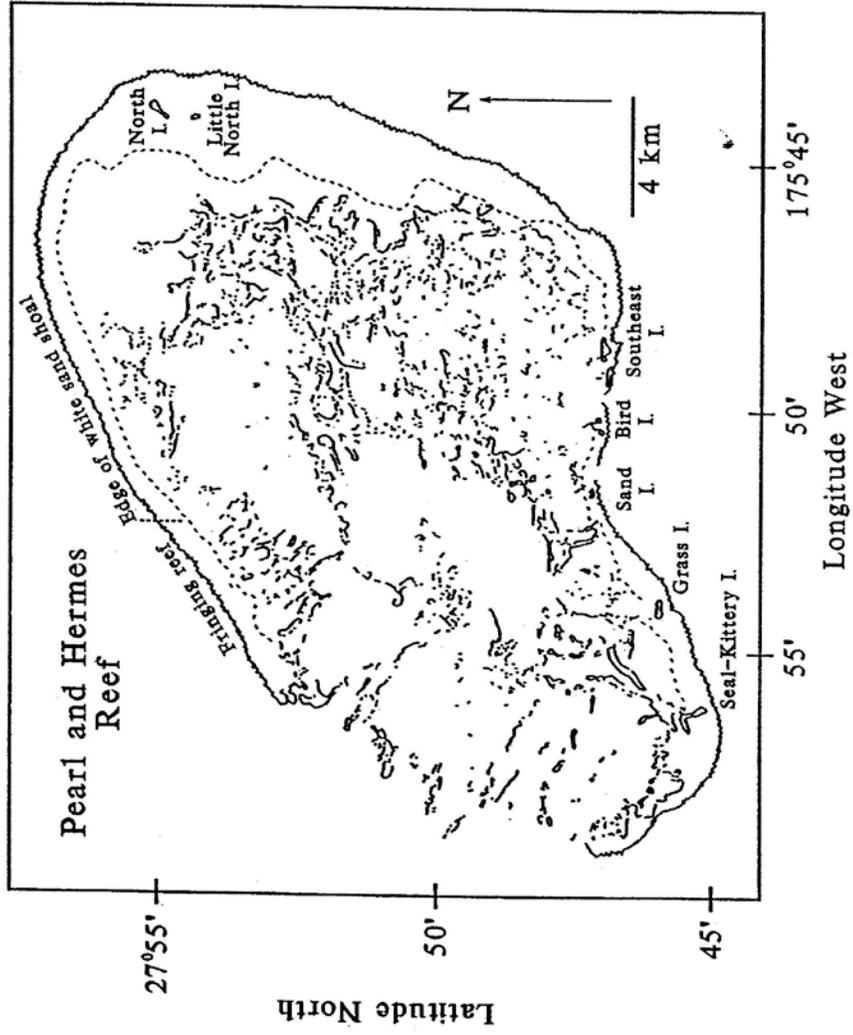


Fig. 5.1 Pearl and Hermes Reef in the Northwestern Hawaiian Islands.

Pearl and Hermes Reef (lat. 27°55'N, long. 175°45'W) is one of the primary haulout and pupping locations of the Hawaiian monk seal. This atoll is located ca. 1900 km northwest of Oahu in the Northwestern Hawaiian Islands and is part of the Hawaiian Islands National Wildlife Refuge and the Papahānaumokuākea Marine National Monument (Fig. 1.1). Pearl and Hermes is composed of four vegetated and three nonvegetated sand islets enclosed in a fringing reef (Fig. 5.1).

## **RESEARCH**

The National Marine Fisheries Service (NMFS) began research on Hawaiian monk seals at Pearl and Hermes Reef in 1982. In 2004, research was conducted by NMFS on April 23 and during June 6–August 4. The perimeters of the four larger vegetated islets were divided into sectors using natural landmarks.

### **Censuses and Patrols**

Atoll censuses ( $n = 10$ ) were conducted every fourth day, on average, from June 18 to August 4. All islets were censused on foot by one or two persons. In addition, incidental surveys were conducted opportunistically on noncensus days to resight seals tagged in previous years and to identify and bleach-mark all animals in the subpopulation.

### **Individual Identification**

A total of 231 individuals (196 excluding pups) were identified by existing or applied tags, scars or natural markings. Bleach marks were applied to 122 seals, including 1 nursing pup. Most weaned pups ( $n = 28$ ) were tagged with Temple Tags and 27 of these pups received PIT tags. Six unknown adult seals (3 male, 3 female) were tagged with Temple Tags. One unknown adult female and 2 unknown subadults (1 male, 1 female) were tagged with Temple Tags and PIT tags. Twenty-two known adult seals (16 male, 6 female) and 1 known subadult male were retagged with Temple Tags. Ten known adult seals (7 males, 3 females) and 1 known subadult male were retagged with both Temple tags and PIT tags.

### **Collection of Samples**

Seventy-one scat and five spew samples were collected. Skin punches were collected from 77 seals during tagging. Necropsies were performed and tissue and skeletal samples were collected from two dead seals. Shed molt samples were collected from 11 individuals. Potentially entangling marine debris was collected from beaches and stored in a secure location pending removal.

## RESULTS

### Subpopulation Abundance and Composition

The mean of 10 atoll censuses was 90.0 seals (10.4 SD) including pups and 72.9 seals (8.5 SD) excluding pups (Table 5.1). The total summer subpopulation was 227 individuals, 192 excluding pups (Table 5.2). This number is a subset of the total identified during the calendar year. The numbers of tagged known-age seals born at Pearl and Hermes Reef during the 1983–2003 period, and resighted at any location in 2004, are summarized in Table 5.3.

### Reproduction

At least 35 pups were born at Pearl and Hermes Reef in 2004: 29 were successfully weaned, 4 were still nursing at the end of the research period, and 2 died before weaning (Table 5.4). Nursing periods and measurements of weaned pups are summarized in Table 5.4. No pup switches were observed.

### Interatoll Movement

Interatoll movement was documented for 13 seals that completed a total of 20 movements between Pearl and Hermes Reef and either Lisianski Island, Midway Atoll, or Kure Atoll (Tables 5.5a and b).

### Factors Affecting Survival

Entanglement in marine debris and unknown factors resulted in seven life-threatening conditions (Table 5.6). One adult and two subadult seals were disentangled from debris. A possibly pregnant female was seen with a thin piece of line firmly secured around its neck. Attached to the line was a small bundle (12 in × 6 in) of debris consisting of various pieces of net and line. We were unable to remove the line and did not resight this individual during the field season. In addition to incidents presented in Table 5.6, a prematurely weaned female pup was last observed on July 9 and likely did not survive.

## ACKNOWLEDGMENTS

We thank the captain, officers, and crew of the NOAA Ship *Oscar Elton Sette*. We also acknowledge the support of the U.S. Fish and Wildlife Service, Hawaiian Islands National Wildlife Refuge staff. Many thanks to PIFSC Coral Reef Ecosystem Division and the *F/V Casitas* for assistance in removal of debris on islands.

**TABLES**  
**for Pearl and Hermes Reef**



Table 5.1.--Summary statistics for atoll censuses ( $n = 10$ ) of the Hawaiian monk seal at Pearl and Hermes Reef from June 18 to August 4, 2004.

Size/Sex	Mean number of individuals	Standard deviation
Adults	49.4	5.1
Male	20.7	3.4
Female	22.8	4.3
Unknown	5.9	2.0
Subadults	14.1	2.6
Male	6.2	2.1
Female	6.3	1.6
Unknown	1.6	1.0
Juveniles	9.4	3.0
Male	4.8	2.1
Female	4.0	1.2
Unknown	0.6	1.0
Pups	17.1	3.1
Male	7.6	2.5
Female	6.8	2.8
Unknown	2.7	2.1
Non-pup total	72.9	8.5
Grand total	90.0	10.4

Table 5.2.--Composition of the Hawaiian monk seal subpopulation at Pearl and Hermes Reef during the spring and summer of 2004. Includes all known parturient females and pups born during the calendar year.

Size	Number of seals				Sex ratio male:female
	Male	Female	Unknown	Total	
Adults	68	69	2	139	1.0:1
Subadults	15	16	0	31	0.9:1
Juveniles	11	11	0	22	1.0:1
Pups	16	15	4	35	1.1:1
Non-pup total	94	96	2	192	1.0:1
Grand total	110	111	6	227	1.0:1

Table 5.3.--Summary of tagged known-age seals born at Pearl and Hermes Reef and resighted at any location in 2004.

Cohort year	Age (years)	Sex	Number originally tagged	Number resighted in 2004
1983	21	Male	8	0
		Female	2	1
1984	20	Male	5	1
		Female	8	2
1985	19	Male	9	2
		Female	6	3
1986	18	Male	10	2
		Female	7	2
		Unknown	1	0
1987	17	Male	14	3
		Female	7	2
1988	16	Male	12	7
		Female	6	3
1989	15	Male	8	1
		Female	6	0
1990	14	Male	5	3
		Female	1	0
1991	13	Male	10	5
		Female	11	3
1992	12	Male	13	5
		Female	10	7
1993	11	Male	14	3
		Female	7	3
1994	10	Male	--	--
		Female	--	--
1995	9	Male	15	7
		Female	12	4
1996	8	Male	11	2
		Female	12	3
1997	7	Male	16	6
		Female	11	3

Cohort year	Age (years)	Sex	Number originally tagged	Number resighted in 2004
1998	6	Male	8	4
		Female	21	12
1999	5	Male	11	3
		Female	15	5
2000	4	Male	12	5
		Female	10	3
2001	3	Male	16	2
		Female	9	2
2002	2	Male	16	2
		Female	6	2
2003	1	Male	14	8
		Female	10	7

Table 5.4a.--Summary of Hawaiian monk seals born at Pearl and Hermes Reef in 2004.

Event	Number of pups			
	Male	Female	Unknown	Total
Born	16	15	4	35
Died prior to weaning	0	2	0	2
Still nursing	0	0	4	4
Weaned	16	13	0	29
Tagged	16	12*	0	28*

\*A prematurely weaned female pup was last seen on July 9 and disappeared before tagging.

Table 5.4b.--Summary of nursing periods and measurements of weaned pups at Pearl and Hermes Reef in 2004. All measurements were taken within 2 weeks after weaning.

	Nursing period (d)	Axillary girth (cm)	Straight dorsal length (cm)
Mean	36.5	100.1	124.2
Standard deviation	7.1	10.0	6.1
<i>n</i>	2	12	12

Table 5.5a.--Documented movement of Hawaiian monk seals to Pearl and Hermes Reef from other locations in 2004, summarized by movements between two locations. No seals made more than one observed trip.

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

Table 5.5b.--Documented movement of Hawaiian monk seals from Pearl and Hermes Reef to other locations in 2004, summarized by movements between two locations. One seal made more than one observed trip.

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

Table 5.6.--Factors affecting Hawaiian monk seal survival at Pearl and Hermes Reef in 2004.

Size	Sex	Total	Outcome		
			Injured	Died	Probably died
<b>Attack by Large Shark</b>					
(none observed)					
<b>Mounting by Males</b>					
(none observed)					
<b>Entanglement</b>					
Adult	Female	2 <sup>ab</sup>	0	0	0
Subadult	Male	1 <sup>a</sup>	0	0	0
Juvenile	Male	1 <sup>a</sup>	0	0	0
<b>Unknown</b>					
Adult	Female	1	0	1	0
Nursing pup	Female	2	0	2	0

<sup>a</sup>Seal released by observers.

<sup>b</sup>Observers unable to remove entanglement; seal was not resighted.

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**CHAPTER 6. THE HAWAIIAN MONK SEAL ON  
MIDWAY ATOLL, 2004**

Leona Laniawe and Albert L. Harting

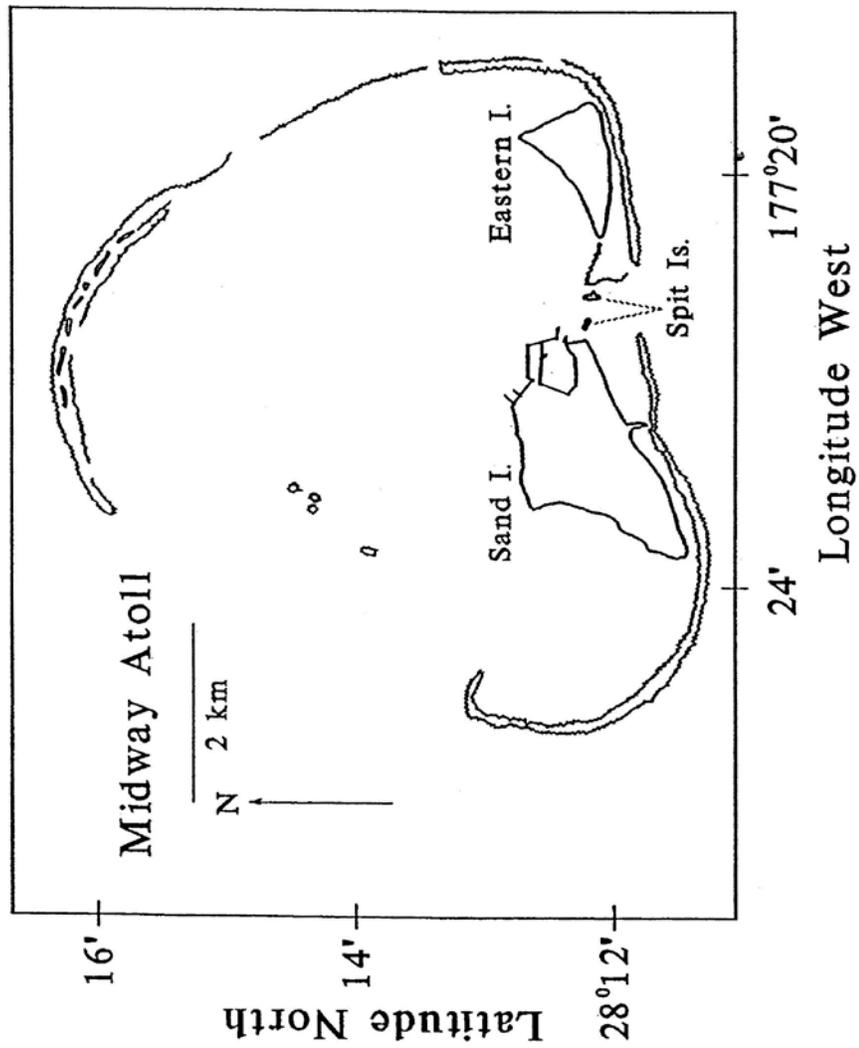


Fig. 6.1 Midway Atoll in the Northwestern Hawaiian Islands.

Midway Atoll (lat. 28°14'N, long. 177°22'W) is one of the primary haulout and pupping locations of the endangered Hawaiian monk seal. This atoll is located ca. 2100 km northwest of Oahu in the Northwestern Hawaiian Islands within the Midway Atoll National Wildlife Refuge and the Papahānaumokuākea Marine National Monument (Fig. 1.1) and comprises a circular atoll approximately 9 km in diameter, enclosing a lagoon and three permanent islets (Fig. 6.1). Eastern and Spit are uninhabited. Sand Island was the site of a U.S. Naval Air base from ca. 1939 until 1993. The U.S. Fish and Wildlife Service (USFWS) maintained an overlay refuge at the site since 1988, until full authority was transferred to the USFWS in October 1996.

## **RESEARCH**

The National Marine Fisheries Service (NMFS) began limited monitoring of Hawaiian monk seals at Midway Atoll in 1983. This effort was increased to year-round monitoring in 1997–1999 by collaborating researchers from Oceanic Society (OS) and Hawaii Wildlife Fund. In 2004, research was conducted by NMFS during January 29–August 5. Incidental observations were recorded by USFWS personnel during the rest of the year. Perimeters of the three permanent islets were divided into sectors using artificial or natural landmarks. Research objectives specific to this subpopulation in 2004 included (1) assessment of maternity and pup exchanges; and (2) monitoring human impacts on seals to quantify occurrence and potential effects on monk seal habitat usage.

### **Censuses and Patrols**

Atoll censuses ( $n = 26$ ) were conducted every seventh day, on average, from January 29 to August 2. All islets were censused on foot by one or two persons. Patrols of Sand Island ( $n = 15$ ), Eastern ( $n = 15$ ), or Spit ( $n = 15$ ) were conducted on non-atoll census days during January 29–August 5.

### **Individual Identification**

A total of 76 individuals (57 excluding pups) were identified by existing or applied tags, bleach marks, scars or natural markings. Most weaned pups ( $n = 13$ ) were tagged with Temple tags and PIT tags. One prematurely weaned pup was not tagged and later disappeared.

### **Collection of Samples**

Skin punches were collected from 13 weaned pups during tagging. Three scats and 3 shed molt samples were collected. One necropsy was performed and tissue samples were collected. Potentially entangling marine debris were collected from beaches and either destroyed at Midway or stored in a secure location pending removal.

## **Noteworthy Events**

### **Beach Monitoring and Public Education**

From January to August 2004, Sand Island beaches were monitored to limit human impacts and disturbance on seals. Monk seal natural history was shared opportunistically with visitors and residents. On three occasions, NMFS observer intervention prevented the probable disturbance of resting monk seals; one involved persons violating refuge rules in the presence of a mother/pup pair. Other actions taken to mitigate disturbance to seals included the posting of seal signs approximately 50 yards away from seals informing people of the animal's presence in public access areas. On Sand Island, through cooperation with the USFWS, a section of a public beach was temporarily closed to limit disturbance to a mother and pup pair. In addition, FWS orientation presentations for new personnel and visitors include seal natural history, NMFS recovery efforts, and address refuge rules governing seal viewings and beach closures.

## **RESULTS**

### **Subpopulation Abundance and Composition**

The mean of 26 atoll censuses was 24.8 seals (5.9 SD) including pups, and 19.3 seals (5.2 SD) excluding pups (Table 6.1). The total spring-summer subpopulation was 62 seals, 45 excluding pups (Table 6.2). This number is a subset of the total identified in the calendar year. The numbers of tagged known-age seals born at Midway Atoll during the 1988–2003 period, and resighted at any location in 2004, are summarized in Table 6.3.

### **Reproduction**

A minimum of 17 pups were born at Midway Atoll in 2004; 14 were successfully weaned (Table 6.4a), 2 were found dead, and 1 was still nursing at the end of the field season. The birth rate, measured as the number of pups born divided by the number of adult-sized females in the subpopulation  $\times 100$  was 73.9%  $((17/23) \times 100)$ . A minimum of one pup exchange occurred between nursing females, resulting in one prematurely weaned pup. Nursing periods and measurements of weaned pups are summarized in Table 6.4b.

### **Interatoll Movement**

Interatoll movement was documented for 19 seals that completed a total of 31 movements between Midway Atoll and either Pearl and Hermes Reef or Kure Atoll (Tables 6.5a and b).

## **Factors Affecting Survival**

Other/unknown causes led to 7 life-threatening conditions (Table 6.6). Two pups were found dead early in the season. One pup carcass was found on Eastern Island and the other was found floating in shallow water off of Spit Island. Both carcasses were in fresh to semi-fresh condition (one was necropsied at Midway and the other in Honolulu). In addition, a third pup disappeared and probably died after she was prematurely weaned due to a pup exchange. Another pup was injured, possibly by a shark, and was thin and in deteriorating condition when last seen in November.

## **ACKNOWLEDGMENTS**

We acknowledge the support of the U.S. Fish and Wildlife Service. Special thanks are extended to John Klavitter, Refuge Biologist; Mike Johnson, Assistant Refuge Manager; and Island residents that expressed interest and cooperation in Midway Atoll Hawaiian monk seal recovery efforts. We also thank the officers and crew of the NOAA Ship *Oscar Elton Sette* for logistical assistance.

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**TABLES  
for Midway Atoll**



Table 6.1.--Summary statistics for atoll censuses ( $n = 26$ ) of Hawaiian monk seals at Midway Atoll from January 29 to August 2, 2004.

Size/Sex	Mean number of individuals	Standard deviation
Adults	15.3	4.2
Male	5.4	2.5
Female	8.8	2.8
Unknown	1.2	1.3
Subadults	1.8	0.9
Male	1.0	0.6
Female	0.7	0.5
Unknown	0.0	0.2
Juveniles	2.2	1.3
Male	0.9	0.8
Female	1.2	0.8
Unknown	0.1	0.3
Pups	5.5	4.7
Male	1.0	1.3
Female	1.7	2.2
Unknown	2.8	2.7
Non-pup total	19.3	5.2
Grand total	24.8	5.9

Table 6.2.--Composition of the Hawaiian monk seal subpopulation at Midway Atoll during the spring and summer of 2004. Includes all known parturient females and pups born during the calendar year.

Size	Number of seals				Sex ratio male:female
	Male	Female	Unknown	Total	
Adults	15	23	0	38	0.6:1
Subadults	2	1	0	3	2.0:1
Juveniles	2	2	0	4	1.0:1
Pups	5	11	1*	17*	0.5:1
Non-pup total	18	27	0	45	0.7:1
Grand total	24	37	1	62	0.6:1

\*Includes a pup that was still nursing when the field camp ended.

Table 6.3.--Summary of tagged known-age seals born at Midway Atoll and resighted at any location in 2004.

Cohort year	Age (years)	Sex	Number originally tagged	Number resighted in 2004
1988	16	Male	0	NA
		Female	1	1
1989	15	Male	0	NA
		Female	0	NA
1990	14	Male	0	NA
		Female	0	NA
1991	13	Male	1	1
		Female	1	1
1992	12	Male	0	NA
		Female	1	1
1993	11	Male	1	0
		Female	0	NA
1994	10	Male	0	NA
		Female	0	NA
1995	9	Male	1	0
		Female	6	1
		Unknown	1	0
1996	8	Male	1	0
		Female	4	0
1997	7	Male	3	1
		Female	6	2
1998	6	Male	8	3
		Female	2	1
1999	5	Male	7	2
		Female	4	1
2000	4	Male	5	1
		Female	9	0
2001	3	Male	6	1
		Female	5	2
2002	2	Male	7	1
		Female	4	2
2003	1	Male	5	1
		Female	9	3

Table 6.4a.--Summary of Hawaiian monk seals born at Midway Atoll in 2004.

Event	Number of pups			
	Male	Female	Unknown	Total
Born	5	11	1	17
Died prior to weaning	0	2	0	2
Still nursing	0	0	1	1
Weaned	5	9	0	14
Tagged	5	8*	0	13

\*A prematurely weaned female pup was not tagged. This pup later disappeared.

Table 6.4b.--Summary of nursing periods and measurements of weaned pups at Midway Atoll in 2004. Nursing periods were calculated where birth and weaning dates were both known or occurred within a range of 4 days or less. All measurements were taken within 2 weeks after weaning.

	Nursing period (d)	Axillary girth (cm)	Straight dorsal length (cm)
Mean	39.0	110.6	128.0
Standard deviation	--	5.9	7.5
<i>n</i>	1	12	12

Table 6.5a.--Documented movement of Hawaiian monk seals to Midway Atoll from other locations in 2004, summarized by movements between two locations. Three seals made more than one observed trip.

Destination	Number of trips, size, and sex class
Pearl and Hermes Reef	5 adult male 3 adult female 1 juvenile male
Kure Atoll	2 adult male 6 adult female 1 weaned male pup 1 weaned female pup

Table 6.5b.--Documented movement of Hawaiian monk seals from Midway Atoll to other locations in 2004, summarized by movements between two locations. No seals made more than one observed trip.

Destination	Number of trips, size, and sex class
Pearl and Hermes Reef	3 adult male 3 adult female
Kure Atoll	2 adult male 3 adult female 1 juvenile female

Table 6.6.--Factors affecting Hawaiian monk seal survival at Midway Atoll in 2004.

Size	Sex	Total	Outcome		
			Injured	Died	Probably died
<b>Attack by Large Shark</b>					
(none observed)					
<b>Mounting by Males</b>					
(none observed)					
<b>Entanglement</b>					
(none observed)					
<b>Other/Unknown</b>					
Adult	Female	3	3	0	0
Weaned pup	Female	1	1 <sup>a</sup>	0	0
Prematurely weaned pup	Female	1 <sup>b</sup>	0	0	1
Nursing pup	Female	2	0	2	0

<sup>a</sup> The pup was injured, possibly by a shark, and was thin and in deteriorating condition when last seen in November.

<sup>b</sup> The pup disappeared and probably died after she was prematurely weaned due to a pup exchange.

**CHAPTER 7. THE HAWAIIAN MONK SEAL AT  
KURE ATOLL, 2004**

Tracy A. Wurth and Robert D. Marshall

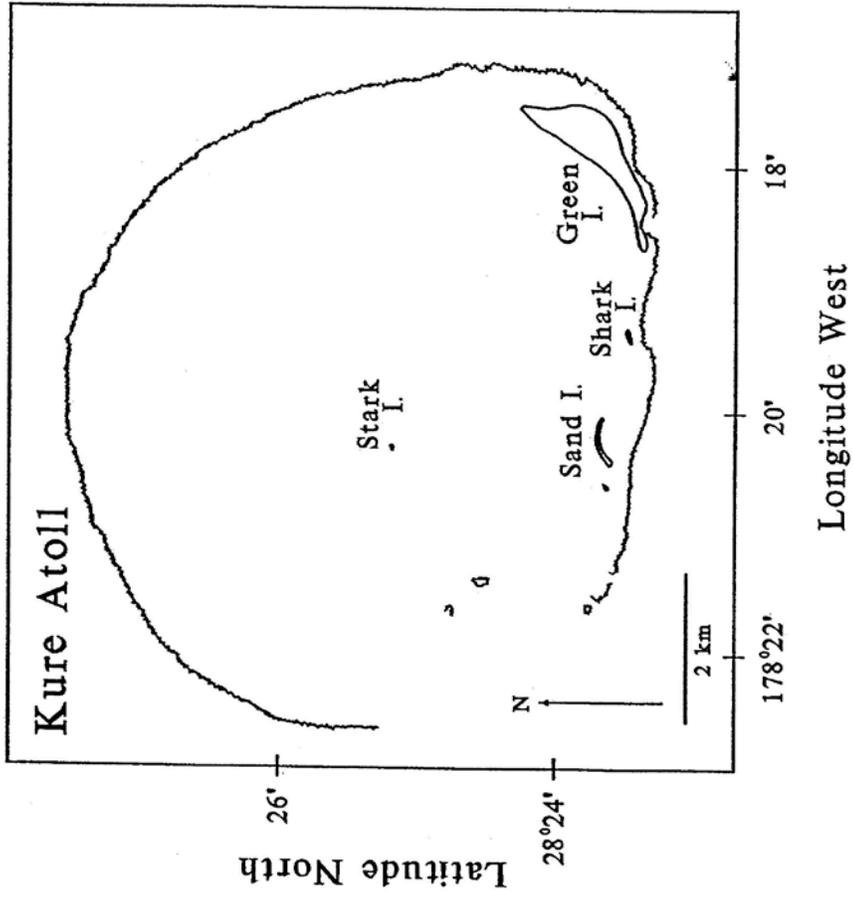


Fig. 7.1 Kure Atoll in the Northwestern Hawaiian Islands.

Kure Atoll (lat. 28°25'N, long. 178°10'W) is one of the primary haulout and pupping locations of the Hawaiian monk seal. The atoll is located ca. 2300 km northwest of Oahu in the Northwestern Hawaiian Islands (Fig. 1.1) and is a seabird sanctuary of the State of Hawaii within the Papahānaumokuākea Marine National Monument. The atoll consists of a circular fringing reef approximately 9 km in diameter, the enclosed lagoon, one permanent vegetated island (Green Island), two sand islets (Sand and Shark), and an ephemerally emergent area known locally as Stark Reef (Fig. 7.1). From 1960 to 1992, Green Island was the site of a U.S. Coast Guard (USCG) LORAN station, staffed by 20-30 USCG personnel. In July 1992, this station was closed and vacated by the USCG, leaving the atoll uninhabited. In 1993, the USCG completed the removal of most of the infrastructure on Green Island.

## **RESEARCH**

NMFS began research on the Hawaiian monk seal at Kure Atoll in 1981. In 2004, research was conducted by NMFS from June 9 to August 2, and additional incidental observations were recorded by State of Hawaii personnel until August 30. The perimeter of Green Island was divided into eight sectors using artificial or natural landmarks.

### **Censuses and Patrols**

Atoll censuses ( $n = 11$ ) were conducted every fourth day on average, from June 17 to July 29. All islets were censused on foot by one or two persons. Shark Islet and Stark Reef were not emergent during the 2004 field season. Patrols were conducted on non-atoll census days to identify seals and monitor locations used by parturient females. In total, 31 patrols of Green Island and 1 patrol of Sand Islet were conducted. Full island standardized incidental surveys of Green Island ( $n = 7$ ) were conducted on non-atoll and non-patrol days between June 10 and August 2 to record females with nursing pups, weaned pups, juveniles, molting animals, and sick or injured seals. Additional partial island surveys of Green Island were conducted as needed.

### **Individual Identification**

A total of 108 individuals (88 excluding pups) were identified by existing or applied tags, bleach marks, scars or natural markings. All weaned pups ( $n = 20$ ) were tagged with Temple Tags, and 18 of these pups received PIT tags.

### **Collection of Samples**

Forty-one scat, 2 spew, and 27 molt samples were collected. Skin punches were collected from 18 seals during tagging. Potentially entangling marine debris was collected from the beaches on Green and Sand Islands and stored in a secure location pending removal. A large

conglomerate of buried net remains at the site of the *Paradise Queen II* wheel house, the remains of a wreck on the east shore of Green Island.

## **Noteworthy Events**

### **Aggression Towards Weaned Pups**

One incident of targeted, male aggression towards weaned pups was observed in 2004. Two female weaned pups and 1 juvenile male were observed interacting together in shallow water. Two of the 3 seals (1 weaned pup and 1 juvenile) were harassed, bitten, and held underwater by an adult male that swam into the area. The incident was eventually disrupted by researchers. The event did not result in obvious injuries to any of the animals involved and no further aggression was observed.

## **RESULTS**

### **Subpopulation Abundance and Composition**

The mean of 11 atoll censuses was 50.1 seals (11.3 SD) including pups, and 39.8 seals (9.0 SD) excluding pups (Table 7.1). The total spring-summer subpopulation was 106 individuals, 86 excluding pups (Table 7.2). This number is a subset of the total identified in the calendar year. The numbers of tagged known-age seals born at Kure Atoll during the 1981–2003 period, and resighted at any location in 2004, are summarized in Table 7.3.

### **Reproduction**

At least 20 pups were born at Kure Atoll in 2004, and all successfully weaned (Table 7.4a). All 20 pups were born prior to the time NMFS research began on June 9. Measurements of weaned pups are summarized in Table 7.4b. The birth rate, measured as the number of pups born divided by the number of adult-sized females in the subpopulation  $\times 100$  was 50.0% (20/40  $\times 100$ ). Six of the 8 identified parturient females (75%) had been temporarily maintained as pups in the Kure Atoll Head Start Project between the years of 1984 and 1991. Three documented pup exchanges occurred in the 2004 season.

### **Interatoll Movement**

Interatoll movement was documented for 15 seals that completed a total of 19 movements between Kure Atoll and either Pearl and Hermes or Midway Atolls (Tables 7.5a and b).

## **Factors Affecting Survival**

Attacks by large sharks, mounting attempts by male Hawaiian monk seals, and entanglement in marine debris resulted in 6 life-threatening conditions, which lead to the probable death of 1 seal (Table 7.6). Three seals were observed entangled in marine debris. Two of the seals were disentangled by researchers with no evident complications. Two attempts were made to disentangle the third seal, but with only partial success, and the seal ultimately freed itself from the debris. One large shark bite was observed on a weaned pup. The seal suffered a large and severe bite to the top of the head and neck, and subsequently disappeared and probably died. In addition to the incidents in Table 7.6, an emaciated adult female was observed in late July on Sand Islet. No other obvious injuries were evident and the seal was not seen again before the end of the field season on August 5, but was resighted alive the following year.

## **ACKNOWLEDGMENTS**

We acknowledge the support of the State of Hawaii, Department of Land and Natural Resources and Division of Forestry and Wildlife. Special thanks are extended to Cynthia Vanderlip, DNLR staff. We thank the captain and crew of the NOAA Ship *Oscar Elton Sette* for logistical support. We also thank the NMFS Coral Reef Ecosystem Division marine debris team for their hard work and assistance in removing derelict fishing gear from Green Island and within Kure Atoll.

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**TABLES**  
**for Kure Atoll**



Table 7.1.--Summary statistics for atoll censuses ( $n = 11$ ) of Hawaiian monk seals at Kure Atoll from June 17 to July 29, 2004.

Size/Sex	Mean number of individuals	Standard deviation
Adults	32.0	7.2
Male	11.3	3.1
Female	16.9	4.2
Unknown	3.8	2.5
Subadults	3.2	1.5
Male	2.4	0.9
Female	0.3	0.5
Unknown	0.5	0.8
Juveniles	4.6	1.4
Male	3.2	1.2
Female	1.5	0.9
Unknown	0.0	0.0
Pups	10.3	3.3
Male	4.9	1.5
Female	5.0	2.3
Unknown	0.4	0.5
Non-pup total	39.8	9.0
Grand total	50.1	11.3

Table 7.2.--Composition of the Hawaiian monk seal subpopulation at Kure Atoll during the spring and summer of 2004. Includes all known parturient females and pups born during the calendar year.

Size	Number of seals			Sex ratio male:female
	Male	Female	Total	
Adults	33	40	73	0.8:1
Subadults	3	1	4	3.0:1
Juveniles	6	3	9	2.0:1
Pups	9	11	20	0.8:1
Non-pup total	42	44	86	1.0:1
Grand total	51	55	106	0.9:1

Table 7.3.--Summary of tagged known-age seals born at Kure Atoll and resighted at any location in 2004.

Cohort year	Age (years)	Sex	Number originally tagged	Number resighted in 2004
1981	23	Male	3	0
		Female	5	0
1982	22	Male	1	0
		Female	3	1
1983	21	Male	4	2
		Female	0	NA
1984	20	Male	4	0
		Female	2	2
1985	19	Male	2	0
		Female	3	1
1986	18	Male	1	0
		Female	0	NA
1987	17	Male	1	1
		Female	3	2*
1988	16	Male	2	2
		Female	5	2
1989	15	Male	5	1
		Female	4	1
1990	14	Male	3	0
		Female	3	1
1991	13	Male	7	4
		Female	6	3*
1992	12	Male	5	3
		Female	8	5
1993	11	Male	9	5
		Female	4	2
1994	10	Male	3	0
		Female	0	NA
1995	9	Male	6	3
		Female	5	2

Cohort year	Age (years)	Sex	Number originally tagged	Number resighted in 2004
1996	8	Male	10	3
		Female	6	0
1997	7	Male	9	1
		Female	7	2
1998	6	Male	17	5
		Female	6	2
1999	5	Male	8	2
		Female	13	2
2000	4	Male	5	1
		Female	8	0
2001	3	Male	4	0
		Female	13	0
2002	2	Male	11	3
		Female	7	0
2003	1	Male	8	4
		Female	10	2

\*Cohort survivors include two seals removed from Kure Atoll for rehabilitation and released at either Kure or Midway Atoll.

Table 7.4a.--Summary of Hawaiian monk seals born at Kure Atoll in 2004.

Event	Number of pups		
	Male	Female	Total
Born	9	11	20
Died prior to weaning	0	0	0
Weaned	9	11	20
Tagged	9	11	20

Table 7.4b.--Summary of nursing periods and measurements of weaned pups at Kure Atoll in 2004. Nursing periods were calculated where both birth and weaning date ranges were  $\leq 4$  d. All measurements were taken within 2 weeks after weaning. All pups were born prior to researchers' arrival on island.

	Nursing period (d)	Axillary girth (cm)	Straight dorsal length (cm)
Mean	-	114.9	135.9
Standard deviation	-	13.3	8.6
<i>n</i>	-	8	8

Table 7.5a.--Documented movement of Hawaiian monk seals to Kure Atoll from other locations in 2004, summarized by movements between two locations. No seals made more than one observed trip.

Original location	Number, size, and sex class
Midway Atoll	2 adult male 3 adult female 1 juvenile male
Pearl and Hermes Reef	1 adult female 1 adult male

Table 7.5b.--Documented movement of Hawaiian monk seals from Kure Atoll to other locations in 2004, summarized by movements between two locations. No seals made more than one observed trip.

Destination	Number, size, and sex class
Pearl and Hermes Reef	1 adult female
Midway Atoll	2 adult male 6 adult female 1 male weaned pup 1 female weaned pup

Table 7.6.--Factors affecting Hawaiian monk seal survival at Kure Atoll in 2004.

Size	Sex	Total	Outcome		
			Injured	Died	Probably died
Attack by Large Shark					
Weaned pup	Female	1 <sup>a</sup>	0	0	1
Mounting by Males					
Weaned pup	Female	1 <sup>b</sup>	0	0	0
Juvenile	Male	1 <sup>b</sup>	0	0	0
Entanglement					
Weaned pup	Male	2 <sup>c,d</sup>	0	0	0
Adult	Female	1 <sup>e</sup>	0	0	0

<sup>a</sup> Large shark bite to the top of head and neck. Seal disappeared.

<sup>b</sup> Adult male aggressor harassed, bit, and held the two seals underwater. The incident was disrupted by observers.

<sup>c</sup> Seal released by observers.

<sup>d</sup> Seal found with eel cone stuck on muzzle. Seal was released by observers.

<sup>e</sup> Seal had piece of net entangled around its neck. Several attempts were made to disentangle the seal. The seal eventually disentangled itself.

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**CHAPTER 8. THE HAWAIIAN MONK SEAL ON  
NIHOA ISLAND, 2004**

Maire Cahoon, Charles Littnan, and Thea Johanos

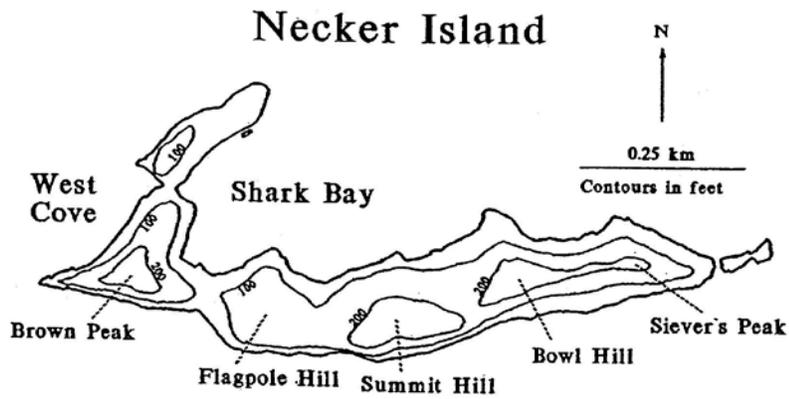
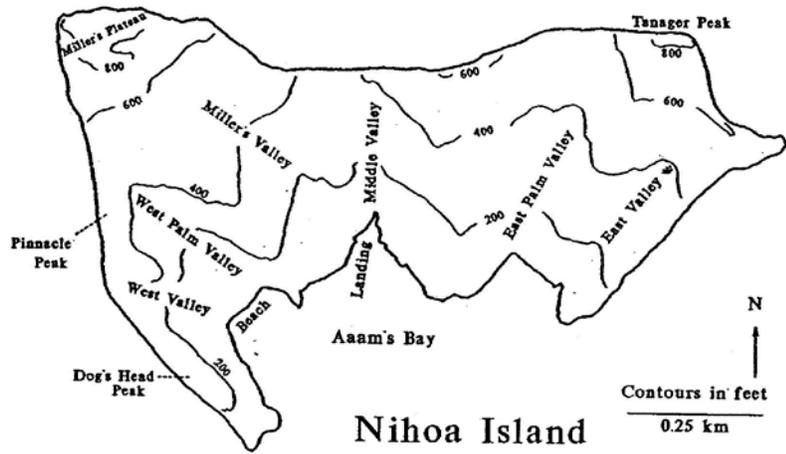


Fig. 8.1 Nihoa and Necker Islands in the Northwestern Hawaiian Islands.

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

## **RESEARCH**

In 2004, the National Marine Fisheries Service collected data at Nihoa Island on August 13. Necker was not visited in 2004. The perimeter of Nihoa Island was divided into 3 sectors using natural landmarks (Fig. 8.1). In 2004, research objectives specific to the Nihoa Island included assessment of pup production and the extent of migration between French Frigate Shoals and this location.

### **Censuses and Patrols**

One entire island survey was conducted at Nihoa in 2004; a beach count of all haulout sites was conducted by two observers on August 13, beginning at 0930 Hawaii Standard Time and continuing for approximately 4.5 h.

### **Individual Identification**

On Nihoa Island, one seal was identified by tag as a 5-year-old male born at Nihoa Island in 1999. In total, 3 tagged seals were noted; 2 seals were observed with 1 red tag each (1 identified and 1 unidentified), and 1 unidentified seal was observed with a broken yellow tag, indicating that it was originally tagged at FFS.

### **Collection of Samples**

No samples were collected at Nihoa Island in 2004.

## **RESULTS**

### **Subpopulation Abundance and Composition**

The census total for counts conducted on Nihoa Island was 34 seals (28 excluding pups) on August 13. Because of limited effort, the composition of the spring-summer subpopulation was not determined.

### **Reproduction**

At least 6 pups (all of unknown sex) were born at Nihoa Island in 2004; 4 nursing pups and 2 weaned pups were observed at Nihoa Island on August 13.

### **Interatoll Movement**

Interatoll movement was not documented for seals observed at Nihoa Island in 2004.

### **Factors Affecting Survival**

Factors affecting survival were not observed at Nihoa Island in 2004.

### **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 *Oscar Elton Sette* for logistical assistance.

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Appendix B.—Hawaiian monk seal census form and 2004 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 Post Condition	ID	TAG				MOLT			ASSOCIATION			EVENT		
							No.	?	No.	L/R	Col	?	%	?	Disturb	Line No.	Dist	Behavior	Notes
1																			
2																			
3																			
4																			
5																			
6																			
7																			
8																			
9																			
10																			
11																			
12																			
13																			
14																			

NOTES:

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**2004**  
**CENSUS FORM DIRECTIONS**  
(Unabridged - Laysan and Lisianski Islands)

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

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

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

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

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

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

## **PAGE HEADER**

### **DATA TYPE**

C = Census: A complete, timed count on an island begun around 1300. Census is conducted as quickly as possible (while gathering all information). Data collected on all seals and turtles. Complete data are recorded, including size, sex, condition, ID, and disturbance. Associations are assumed to be coded for all seals. In 2004 at Laysan and Lisianski Islands, record spatial and pair associations and paired male-male contests involving adult and S4 seals, otherwise code behavior X (data not taken).

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

B = Behavior patrol: A complete, untimed count where size, sex, ID and disturbance are recorded. Associations are assumed to be coded for all seals. In 2004 at Laysan and Lisianski Islands, record spatial and pair associations and paired male-male contests involving adult and S4 seals, otherwise code behavior X (data not taken). Record turtles only if noteworthy observation.

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

I = Incidental observation. In this data type, null fields are interpreted as "data not recorded", so code data explicitly. If numbered, this indicates a full island incidental with year-specific goals. At Laysan and Lisianski Islands in 2004, these surveys will record mother-pup pairs, weaned pups, molters, survival factors (including severe harassments and mobbings) and other noteworthy observations.

T = Tag status entry (to record that a given tag is now inactive/not on a seal). Record tag status (found or recovered) in notes columns.

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

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

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

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

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

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

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

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

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

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

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

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

## LINES

**CONTINUE** If the same seal sighting is recorded on several lines for any reason (e.g., additional tag or association, behavior at a later time, change of beach position, or photos), put the original line number you are continuing from here. Lines may be continued only within the same page. Fill in the original line as completely as possible. During entry, the data in all fields from TIME through MOLT must be copied from the original line if left blank on the continuation line. Do **not** copy other fields after MOLT (see entry directions for more information). Several lines can have the same continuation line number.

**Make a new original line (i.e. do not use continuation lines) for a seal each time that you come abreast of it** on census or patrol. This is important because beach position on the original line determines if a seal is counted on census (if the seal is ashore it will be counted). When recording paired male-male contests (at Laysan and Lisianski Islands in 2004), record contests as you see them ahead of you (within 30 m). When you come abreast of the seal, record the beach position and time and make this your original line. All previously recorded lines for this sighting will be reverse continuation lines.

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

**SECTOR** Location on island (e.g., 1-20 on Laysan)  
Special codes as follows:  
00 = unknown sector (use also for areas without sectors, i.e. middle of the lagoon)  
77 = pen  
88 = offshore spit/emergent reef  
99 = island not present

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

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

Juvenile	Short, slight seals from the length of a weaned pup (about 138 cm) to 20-30 cm longer; includes yearlings, and other young seals up to 3 years. Distinguished from pups by thinness and yellowish color.
Subadults	Seals perceptibly longer than juveniles up to breeding size; less robust than adults, generally with lighter pelage. Immature seals ca. 3 to 5 or 6 years old.
Adult	Reproductively active or breeding size seals at least as long as known breeders. Mature or probably mature seals. Adult females often have extensive back scars or wounds; adult males usually dark, including ventrum, and extensively scarred.

Code size as follows:

Pups of the year

P0 = Fetus/premature pup (<75cm dorsal straight length; pelage, whiskers, nails, or oral cavity not fully developed).

P = Nursing pup

P1 = Nursing pup, wrinkles. Full term ( $\geq 75$ cm DSL, fully developed pelage, whiskers, nails, and oral cavity).

P2 = Nursing pup, no wrinkles

P3 = Nursing pup, blimp, black

P4 = Nursing pup, molting

P5 = Nursing pup, molted

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

W = Weaned pup

Immatures

I = Immature

J = Juvenile

J1 = Juvenile I

J2 = Juvenile II

S = Subadult

S3 = Subadult III

S4 = Subadult IV

Adults

A = Adult

Unknowns

U = Seal of unknown size

Turtles

T = Turtle (lengths from anterior to posterior tip of carapace)

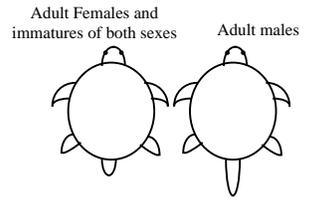
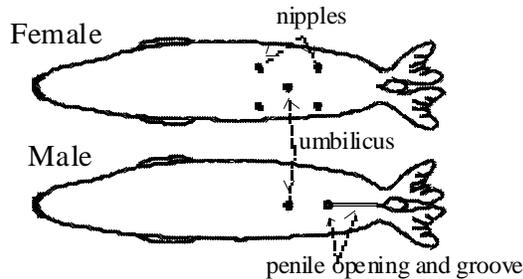
T1 = Turtle, juvenile (<65 cm straight carapace length)

T2 = Turtle, subadult (65 - 80 cm)

T3 = Turtle, adult (>80 cm)

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

**SEX** M = Male  
F = Female  
U = Unknown



**BEACH POS.** Location of seal or turtle when observer comes abreast of animal (e.g., if seal is seen in the water from a distance and yet is on the beach when the observer come abreast, the seal is recorded as being on the beach). When recording paired male-male contests (at Laysan and Lisianski Islands in 2004), record contests as you see them ahead of you (within 30 m). When you come abreast of the seal, record the beach position and time and make this your original line. All previously recorded lines for this sighting will be reverse continuation lines.

- 0 = animal floating or swimming in water (not included in census tally but may be used for behavioral data or other analysis).
- 1 = on the beach (or regularly surveyed areas on the fringing reef for **Midway Reef Surveys**)
- 9 = on an offshore rock/reef with no connections to the island. Separated from shore by a deep channel or substantial distance, and not regularly surveyed (not included in census tally). For **Midway Reef Surveys**, use beach position **9** for the back side of the reef and other areas that are not regularly surveyed. For Laysan, use beach position **9** for the offshore rocks in sector 11/12.
- X = data not taken

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

Condition codes:

M = medium

P = probably pregnant

F = fat

T = thin, includes emaciated (ribs visible, neck obvious, concave dorsal musculature)

X = data not taken

Codes F and T indicate extreme conditions, seals that are medium-fat, or medium-thin should be coded as medium. **Always code condition explicitly.**

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

**ID DATA** These fields can be used to record either a temporary or permanent ID number. Although the paper form only has one ID field, the database actually has two ID fields. Thus, you can record both a temporary and a permanent ID number on a seal's original line (to do this on the form, split the ID field horizontally and write both numbers on a single line, or expand the original line by sacrificing the subsequent line). Use continuation lines to record two or more temporary numbers. If the seal is identified, it will not be counted twice on census. To link two sightings of an unidentified seal during a survey (i.e. for a cruiser moving ahead of you), assign it a temporary number in a series reserved for unidentified seals, and code a 6 in the temp ? field.

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

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

**? column:**

- 0 = seal is definitely unmarked; can coexist with a non-bleach 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 recorded bleach number is questionable, **and the seal is not identifiable** from other information
- 4 = partially read bleach number completed from other data
- 5 = incompletely read bleach number, there isn't enough information to identify the seal but the partial data are certain, **the seal is not identifiable** from other information
- 6 = temporary number valid for this survey only (for unident. cruisers moving ahead of you on census, etc.). Use a special number series so these numbers are not confused with real temporary ID numbers. Numbers may be reused on the next survey for different seals.
- blank = number is certain and complete if present

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

**? column:**

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

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

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

**L/R: Tag position**

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

**COL:**

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

Temple tags

Y = yellow (FFS)  
T = tan/brown (Laysan)  
G = green (Lisianski)  
B = blue (Pearl & Hermes)  
P = pink (Midway, starting in 2004)  
K = silver/gray (Kure)  
R = red (Necker, Nihoa, Main Islands, Midway prior to 2004)

Other tag types

M = metal, Monel  
C = clear, PIT tag

**? column:**

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

**MOLT**

Percentage of old pelage lost, optional for pups. However, for weaned pups, record the % molt at time of tagging. Record molt as 100% for at least 1 month post-molt. Code the full percentage (1 to 100%) in the single box provided.

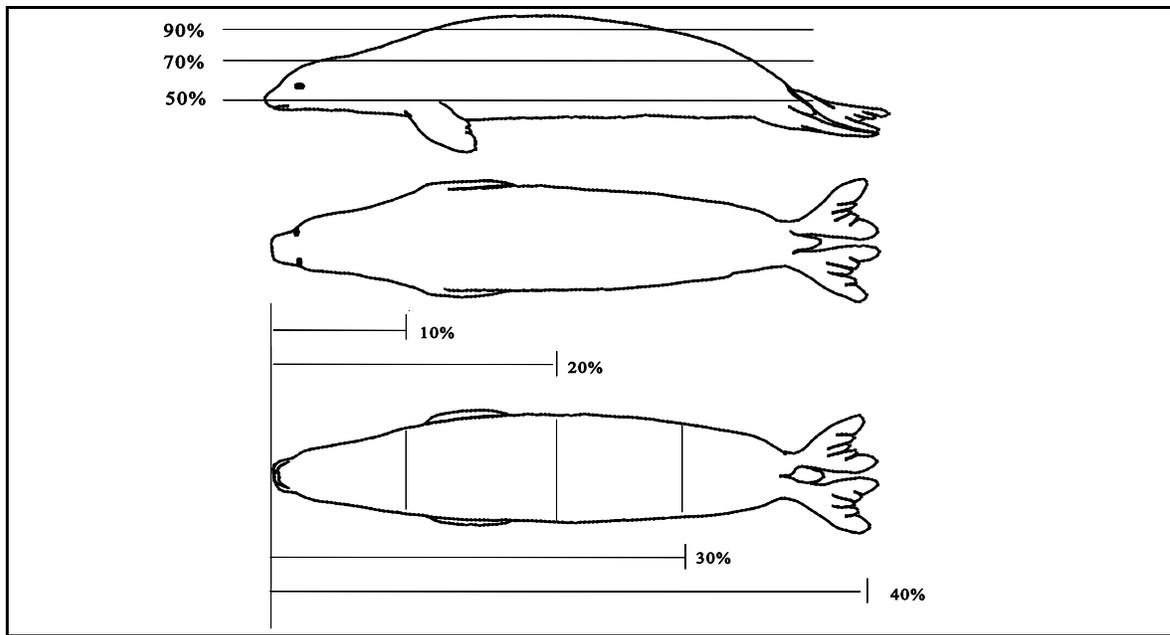
- blank = no molting evident
- 1 to 99 = 1 to 99% molted. The first signs of molt usually occur around the eyes, nose, flippers, and scars. **The first record of >10% of the old pelage molted off is considered the first day of true molt.**
- 100 = 100% molted, freshly molted, **required for the first month after molt.** Put all 3 digits of the 100 in the single box provided.

**? column:**

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

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

- 2 = seal in molt
- 3 = seal pre-molt
- 4 = seal post-molt



**DISTURB**

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

- 0 = no disturbance, or seal merely raised its head or looked at observer - If column **blank**, 0 is assumed
- 1 = seal vocalized, gestured, or moved  $\leq 2$  body lengths
- 2 = seal alerted to observer and moved  $> 2$  body lengths
- 3 = seal alerted to observer and fled into water

## ASSOCIATION DATA

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

Record spatial and pair associations involving adult and S4 seals at Laysan and Lisianski Islands in 2004. Don't record associations that only involve S3 or smaller sized seals or associations that involve turtles. If you wish to indicate that a seal was alone, use the Q (this code is alpha, not zero!) behavior code. If you do not record association data on a census or behavior patrol at Laysan or Lisianski Island for any reason, indicate this with an X for the behavior code. **Always explicitly record whether the seal is unassociated or association data is not recorded.** Use continuation lines to record more than one association.

An association should either be all blank or have the Q, Z, or X behavior only (with no line number or distance), or have a line number, a distance, and some behavior code (other than Q or X) all present.

**All associations should be recorded in pairs**, i.e., between animals on two different lines. You should fill in the line numbers, distances, and behavior codes for both animals involved in each association. The association line number should refer directly to the line where the corresponding behavior is coded (i.e. if the corresponding code is on a continuation line, refer to that particular line, not to the original line or a different continuation line). If two seals are associated, the time recorded on their lines doesn't need to match, but should be within 30 minutes of each other.

Active associations will not be recorded in 2004. However, if a **paired male-male** contest occurs write a brief summary in **Notes** and code the contest outcome (see the attached **CONTEST RULES**).

### Spatial associations

- 1) noted as observer comes abreast of the subject.
- 2) individual seals
  - mother-pup pair (N): any distance
  - Adult or S4 seals (L): distances  $\leq 10$  m away, record two nearest neighbors in a straight line of sight. Seals can be on opposite sides of a log, etc. Only record the L associations of seals in their original configuration (don't re-code if seals shift positions).

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

**DIST.** Closest distance during behavior - both associated lines must have the same minimum distance.  
0 = body contact  
1 =  $< 2$  m  
2 = 2-5 m  
3 =  $> 5$  m ( $> 5$  m but  $\leq 10$  m in the case of L behavior code)

**BEHAVIOR** Up to four behaviors may be recorded for each association, but L, N, X, and O should not appear together with other behaviors. If there is a **paired male-male** contest write a brief summary in **Notes. Focus on the major points**, such as the seals involved, pairings before and after the interaction, the contest winner/loser, and the most intense behaviors (joust, bite, mount, chase, displace).

1) individual seal

a) spatial association

N = mother-pup pair (any distance), does not imply actual nursing behavior. This is the only association recorded between mother-pup pairs, and the N code must be on the original line for each pair member. If there is an unusual event (i.e., birth, weaning, or pup switch) write a brief summary in Notes and use the appropriate Notes Code.

L = association by location only (distance  $\leq 10$  m apart, for all except mother-pup pairs).

Z = cruising (**OPTIONAL CODE**). A/S4 only behavior (actual sex may be unknown).

Does not require a line number reference to another seal, but may have one.

b) additional codes (Laysan and Lisianski 2004)

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

\*Q = loser (quitter)

\*W = winner

\*Y = tie

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

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

Code Corresponding code

N.....N

L.....L

L1.....L1

Q.....W

W.....Q

Y.....Y

2) nothing nearby

O = no behavior or association

3) no data

X = no association data recorded on Census or Atoll Count

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

- A = artwork (scars drawn) - attach drawing, labeled with date, island, observer, data type, page number, and line number
- B = birth, 1st sighting postpartum (mom and pup)
- G = seal is green with algae
- H = handwritten notes
- M = marked, indicate each time a seal is bleached (includes attempts to bleach)
- W = weaning, 1st sighting post-weaning (pup or mom, whichever sighting confirms weaning or end of nursing (i.e., mom alone after pup disappearance).
- X = pup exchange, 1st sighting after exchange (mom and pup)
- Y = disturbance is to "bystander" seal during non-survey activity such as tagging, bleaching, instrumenting, disentangling, etc. This includes all animal handlings/"hands on" research, even if the attempt was unsuccessful (i.e., removing dead pups, cutting umbilical cords, or reuniting pups with their mothers).

**FOR DATA TYPE "T" (TO RECORD THAT A GIVEN TAG IS NOW INACTIVE/NOT ON A SEAL):**

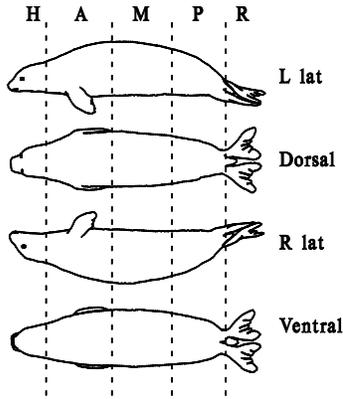
- F = tag found
- R = tag recovered from seal in hand

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

TYPE	CODES COLUMN	CONTENT
F = survival factor	ONLY RECORD RESIGHT OF A SURVIVAL FACTOR AS AN EVENT IF THERE ARE IMPORTANT CHANGES TO DOCUMENT, SUCH AS A NEW WOUND, HEALING, DEATH, ETC., TRANSCRIBE NOTES TO SURVIVAL FACTOR FORM. For turtles, use a different survival factor number series (i.e., begin at 500), fill out a survival factor form (or use an alternate format if specified by mtrp), but do not enter the data into the seal survival factor database.	
	1-3 4	Survival Factor number Factor Type. If seal dead, always record factor type "D" on ORIGINAL LINE. For mobbings/ harassments, always code a census entry with factor type "M" for the victim at the beginning and end of the incident. Otherwise, you only need to record the most appropriate factor type if more than one applies. D = death W = wound (includes abscess/raised area) E = entanglement V = very thin (emaciated) I = illness/abnormal (includes eye disease) M = mobbing/harassment/post-mobbing aggregation O = other
	5	Participant type (for mobbings/ harassments/post-mobbing aggreg. only) V = victim/subject M = male aggressor



7 Part



- H = head
- A = anterior body (neck and shoulders)
- M = midbody (behind fore-flippers and before posterior)
- P = posterior body (behind midbody and before rear flippers)
- F = foreflipper; write whether dorsal/ventral in comments
- R = rearflipper; write whether dorsal/ventral in comments
- O = overall view of a particular side
- \X = other, describe in comments

8 Purpose

- I = identification
- F = survival factor (link with survival factor EVENT using continuation lines)
- X = other, describe in comments

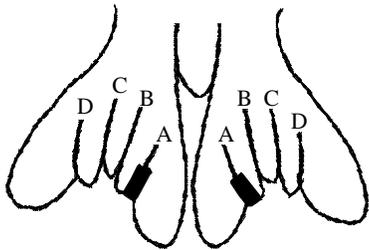
**TYPE**

**CODES COLUMN CONTENT**

T = tag condition

RECORD TAG CONDITION FOR BOTH SIDES OF EACH TAG AT LEAST ONCE DURING THE SEASON. If tag condition is recorded for an incompletely read tag, complete the tag number (with appropriate tag? Code) prior to computer entry.

1 Web



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

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

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

3

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

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

## CONTEST RULES

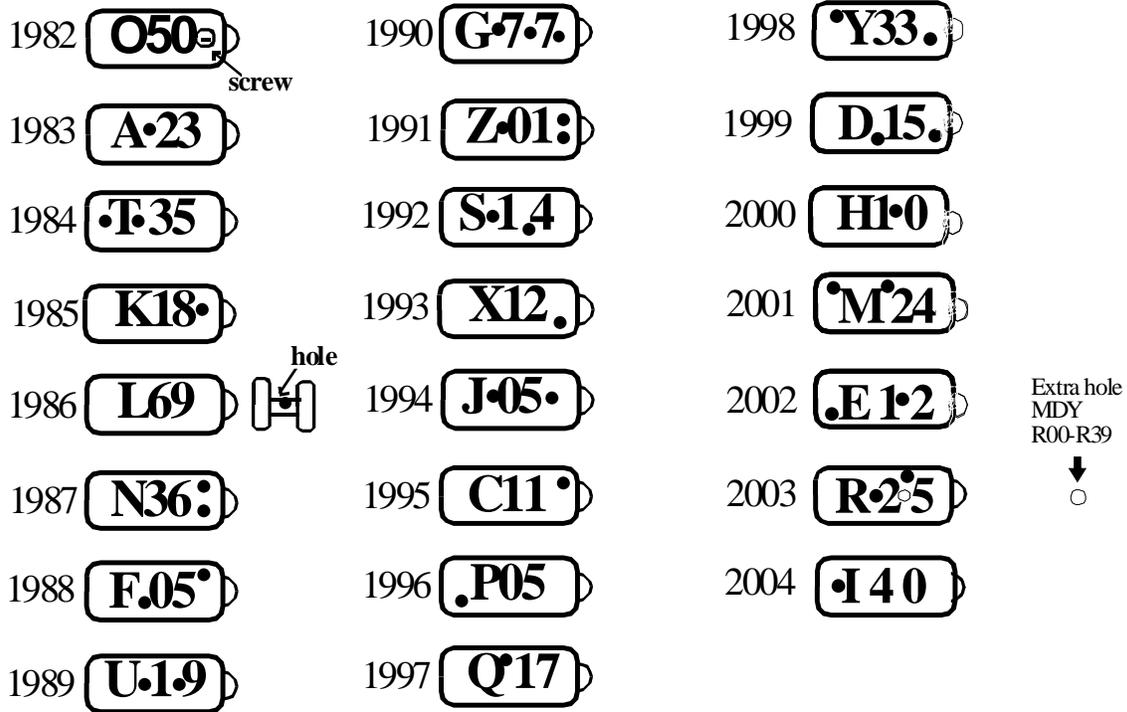
1. **Male-male contest definition** (must conform to at least one condition below):
  - a. Distance between adult males = 0
  - b. Either adult male vocalizes, chases, displaces or jousts with the other male
  
2. **The contest outcome depends upon pair type** (what size/sex seal the adult male is paired with)
  - a. For contest rules, size S4 seals are considered to be adults (both sexes), seals size S3 or smaller are considered to be immature
  - b. Definition of (**L1**) pair type:
    - i. Pair type **#1**: adult male paired with (actively defending) an adult female
    - ii. Pair type **#2**: adult male paired with (actively defending) an immature seal of either sex
  
3. **Contest outcomes** (definition of winner or loser adult male):

Case	Winner (W)	Loser (Q)	Tie (Y)
Paired Male vs. Single Male:	i) The paired male wins if he is not displaced	Unsuccessful single male	No Ties
	ii) The single male wins if he displaces the original paired male	Displaced originally paired male	No Ties
Male Paired with Adult Female vs. Male Paired with Immature Seal: (#1 vs. #2)	i) The male paired with the adult female wins if he is not displaced	Unsuccessful male paired with immature	No Ties
	ii) The male paired with the immature seal if he displaces the male originally paired with the adult female	Displaced originally paired male	No Ties
Paired Male vs. Paired Male of equal pair type: (#1 vs. #1 or #2 vs. #2)	Displaces the other seal	Is displaced	Tie if neither seal is displaced

### 1. Generalizations:

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

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



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

**Original tag color:**  
**Temple Tags:**

**Faded tag may appear:**

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

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Copies of this and other documents in the NOAA Technical Memorandum NMFS series issued by the Pacific Islands Fisheries Science Center are available online at the PIFSC Web site <http://www.pifsc.noaa.gov> in PDF format. In addition, this series and a wide range of other NOAA documents are available in various formats from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161, U.S.A. [Tel: (703)-605-6000]; URL: <http://www.ntis.gov>. A fee may be charged.

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