

Hawaiian Monk Seal Pupping Locations in the Northwestern Hawaiian Islands¹

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ABSTRACT: Most births of the endangered Hawaiian monk seal, *Monachus schauinslandi*, occur in specific beach areas in the Northwestern Hawaiian Islands. Data collected from 1981 to 1988 on the locations of monk seal births and of the first sightings of neonatal pups were summarized to identify preferred birth and nursery habitats. These areas are relatively short lengths of beach at the breeding islands and have some common characteristics, of which the primary feature is very shallow water adjacent to the shoreline. This feature, which limits access by large sharks to the water used by mother-pup pairs during the day, should enhance pup survival.

THE HAWAIIAN MONK SEAL, *Monachus schauinslandi*, is an endangered species that occurs primarily in the Northwestern Hawaiian Islands (NWHI) from Nihoa Island to Kure Atoll (Figure 1). The seals breed at these locations as well, with births mainly occurring from March through June and peaking in May. Sightings of monk seals are frequent around the main Hawaiian Islands and rare at Johnston Atoll, about 1300 km southwest of Honolulu (Schreiber and Kridler 1969). Recently, a tagged seal was observed near Wake Island, about 3650 km west of Honolulu (M. Pons, pers. comm.), and two monk seals were seen at Palmyra Island, 1670 km south of Honolulu (J. Hughes, pers. comm.).

In the late 1950s, about 1200 monk seals were counted on NWHI beaches, but by the mid-1970s, counts revealed less than half that number (Kenyon and Rice 1959, Johnson et al. 1982). Counts at some locations at the northwestern end of the Hawaiian Archipelago had declined by more than 90%, while the number of observed seals grew at least sixfold at French Frigate Shoals (FFS). These changes left very small breeding populations

at Kure Atoll, Midway Islands, and Pearl and Hermes Reef. Some of the reduced counts were reportedly due to human disturbance (Kenyon 1972). Depleted also, but less dramatically during that time, were the populations at Lisianski and Laysan islands. Although one could speculate that a net eastward movement of seals could account for the increase in seals at FFS along with the reductions at the western end, the available data on resightings of tagged individuals do not support such a conclusion (Johnson and Kridler 1983).

During the last decade, monk seal births were confirmed at all of the NWHI: Nihoa Island, Necker Island, FFS, Laysan Island, Lisianski Island, Pearl and Hermes Reef, Midway Islands, and Kure Atoll (Figure 1). In the main Hawaiian Islands, a single birth occurred in 1988 on the island of Kauai, and there have been unconfirmed reports of a few births per year on Niihau. Some females show high fidelity for previous parturition sites. Mother-pup pairs generally stay near the birth site in the early weeks of nursing, but some may slowly move along the beach, up to a few hundred meters away from the birth site, as the pup gets older and weaning time approaches (Alcorn 1984). Weaning occurs at 5 to 6 weeks of age.

Birth and nursing sites around the breeding islands tend to be concentrated at specific beach locations, based on several years of observations during the prolonged pupping

¹ Manuscript accepted 1 December 1989.

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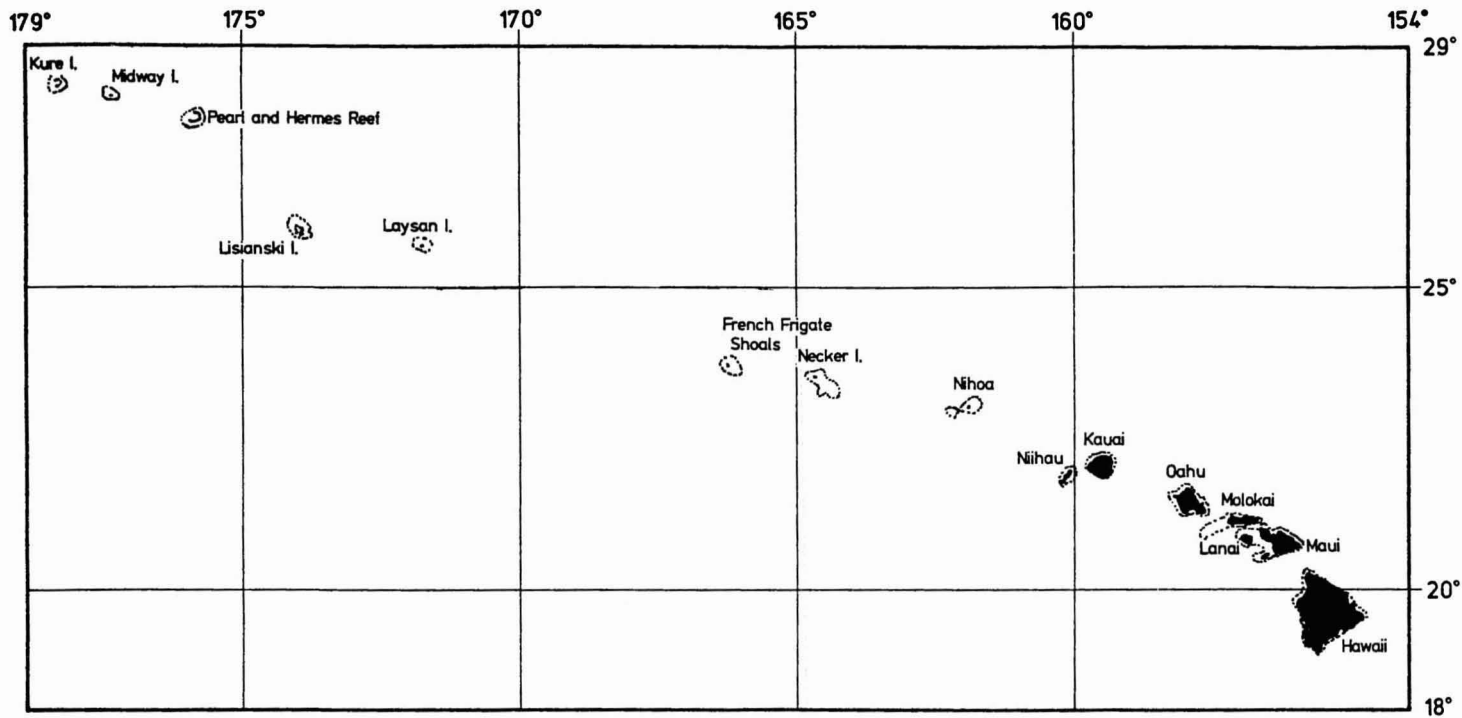


FIGURE 1. The Hawaiian Archipelago.

TABLE 1
DATA SOURCES ON RESEARCH CONDUCTED ON HAWAIIAN MONK SEALS IN THE NORTHWESTERN HAWAIIAN ISLANDS, 1982-1987

LOCATION	1982	1983	1984	1985	1986	1987
Necker Island	Conant (1985)	Morrow and Buelna (1985)	NMFS (unpubl. data)	NMFS (unpubl. data)	NMFS (unpubl. data)	NMFS (unpubl. data)
French Frigate Shoals	NMFS (unpubl. data)	NMFS (unpubl. data)	NMFS (unpubl. data)	NMFS (unpubl. data)	NMFS (unpubl. data)	NMFS (unpubl. data)
Laysan Island	Alcorn (1984)	Alcorn and Buelna (1989)	Johanos et al. (1987)	Johanos and Austin (1988)	NMFS (unpubl. data)	Becker et al. (1989)
Lisianski Island	Johanos and Henderson (1986)	Johanos and Kam (1986)	Alcorn et al. (1988)	Alcorn et al. (1988)	Westlake and Siepmann (1988)	—
Pearl and Hermes Reef	—	NMFS (unpubl. data)	NMFS (unpubl. data)	NMFS (unpubl. data)	Forsyth et al. (1988)	NMFS (unpubl. data)
Kure Atoll*	NMFS (unpubl. data)	NMFS (unpubl. data)	NMFS (unpubl. data)	Reddy and Griffith (1988)	NMFS (unpubl. data)	Reddy (1989)

* Kure Atoll: 1981 data are from Gilmartin et al. (1986) and 1988 data are from NMFS (unpubl. data).

season. This report summarizes the current information on the "preferred" birth and postnatal nursing sites of Hawaiian monk seals in the NWHI and identifies the apparent characteristics of this preferred pupping habitat.

MATERIALS AND METHODS

The information used to identify the birth and nursing sites of monk seals from 1981 to 1988 in the NWHI was obtained from published reports and unpublished National Marine Fisheries Service (NMFS) data listed in Table 1. The descriptions of the sites were prepared from a combination of published and unpublished information, including photographs, maps, and charts; interviews with individuals familiar with the sites; and the authors' observations of these locations in recent years.

Much of the information on beach use by monk seals before 1981 does not contain details on birth sites. With few exceptions, field time was very short relative to the extended pupping season of monk seals. From 1977 to 1981, the entire pupping season or most of it was monitored at Laysan Island (Johnson and Johnson 1984). Beginning in 1981 at Kure Atoll and expanding to all other major breeding islands in the following years, the NMFS identified all observed birth sites and nursing locations by recording the appropriate sectors of the various islands. The sectors include all of the potential haul-out areas (places where seals come out of the water to rest, molt, give birth, etc.) on the permanent islands in the NWHI. Sectors are delineated by natural or man-made markings and may vary in size within and among the NWHI. The small, semipermanent sand-spit islets are not similarly partitioned; seals on these islets are simply noted as being present, without more specific information on location.

RESULTS AND DISCUSSION

The volume of data available on birth sites of monk seals in the NWHI varies among the island locations and years. These data

were reported inconsistently by observers of Hawaiian monk seals from the late 1950s until 1977 at Laysan Island and 1981–1982 at other islands. Although all birth sites observed since 1981 have been documented, the pattern of field effort of the NMFS on the breeding islands has varied. Determination of pupping sites has been incidental to other NMFS monk seal research and recovery activities. Despite these limitations, all of the major breeding islands (with the exception of Pearl and Hermes Reef) since 1981 have had nearly full coverage of at least two pupping seasons in which dates and locations of all observed births were recorded. The available data from the late 1950s to the present do not indicate that these observed patterns have varied, except at Kure Atoll, where human disturbance has been an important factor (unpubl. data).

Locations of birth sites and first sightings of nursing mother-pup pairs (where pups were less than 1 week old), along with descriptions of these sites, are presented below, beginning at the eastern end of the NWHI.

Nihoa

The easternmost island of the NWHI is Nihoa Island, a 63-ha remnant of a precipitous volcanic peak with a maximum elevation of 273 m (Clapp et al. 1977). With few exceptions, the island's shoreline perimeter is steep lava cliffs. The west side has a large lava bench, and the westernmost cove on the south side has a small, sandy beach, known as Derby's Landing, that monk seals use as a haul-out and pupping area (Figure 2, *top*). Two other coves on the south side have small, rock terraces whose accessibility to the seals is dependent on tide and sea conditions. The cliffs along the north and east sides of Nihoa Island rise straight from the ocean, and only a few rocky outcroppings potentially can be used by the seals. The bottom along the entire shoreline drops off quickly.

Up to two weaned pups per year were sighted at Derby's Landing during brief visits from 1981 to 1986 (S. Conant, unpublished data). Observers have been on Nihoa Island for only 5 days or less in each of the last 5 yr, making it impossible to document well

the number of births or birth locations. One mother-pup pair was seen each year in 1986 and 1987 at Derby's Landing (T. Gerrodette, pers. comm.). The very limited haul-out areas at Nihoa Island will keep this seal population small.

Necker Island

Necker Island also is a small (17 ha) remnant of volcanic rock with high, steep slopes (maximum elevation of 84 m) and has only a few rocky ledges that can be used by monk seals. The bottom along the entire perimeter of the island drops quickly to at least several meters deep.

Data on nursing pups at Necker Island were collected intermittently during 1982–1987, with coverage ranging from 1 day to 2 weeks each year (Table 2). Most mother-pup pairs were on the west side of Shark Bay in sector 5 (Figure 2, *bottom*). A basalt ledge with a few small tide pools at the shoreline, sector 5a appears to be the primary rookery and haul-out area, although no births have been witnessed. The water beyond the tide pools off sector 5a is at least 2 m deep, enough to allow sharks along the ledge. Although this area normally receives little wave action during the pupping season, waves can wash completely over this ledge during summer storms (WGG, personal observation). The few other haul-out sites for seals at Necker Island are much smaller and are predominantly used by adult males, which may discourage use of these areas for pupping. Ten of 11 mother-pup pairs were sighted in sector 5a during 6 yr of observations; the other pair was sighted in sector 8 in 1982 (Conant 1985). No nursing or weaned pups were seen during short trips to Necker Island in May of 1986 and 1987 (T. Gerrodette, pers. comm.). As at Nihoa Island, the limited haul-out space prevents Necker Island from becoming a major breeding site.

French Frigate Shoals

French Frigate Shoals, located about 930 km northwest of Honolulu, is a low-lying, multi-island coral atoll, which currently has the largest population of Hawaiian monk

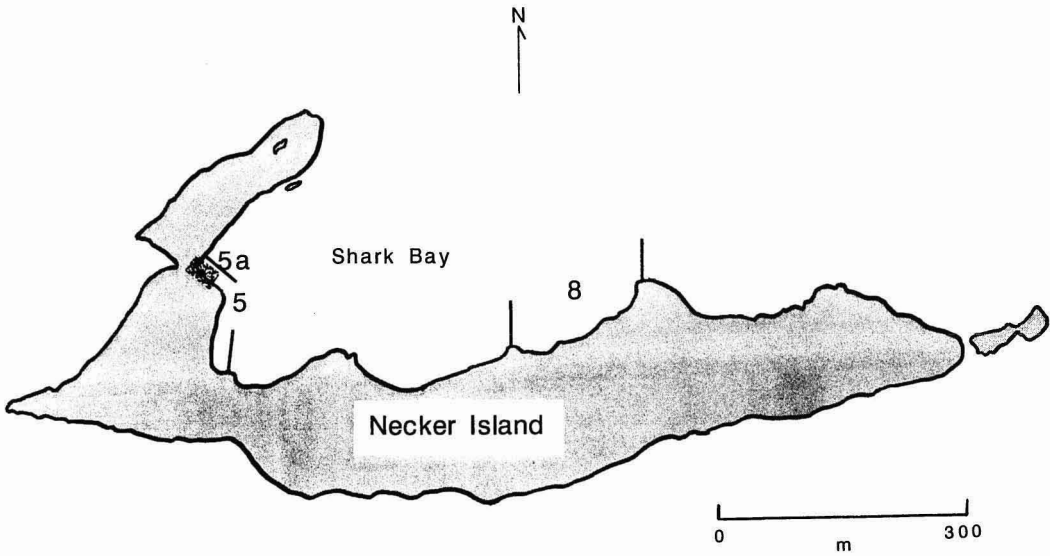
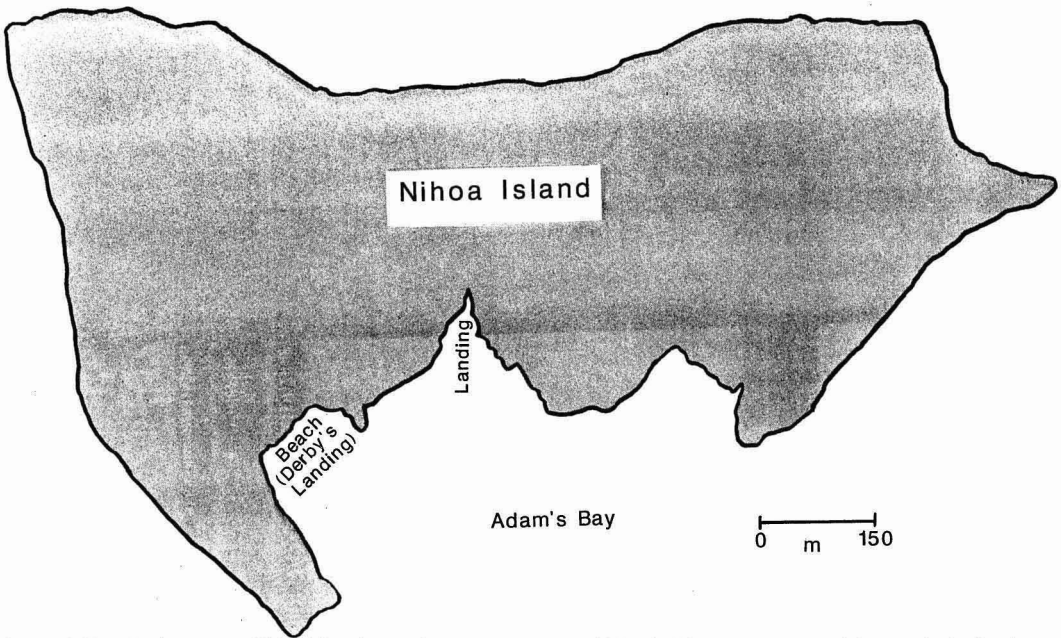


FIGURE 2. *Top*, Nihoa Island; *bottom*, Necker Island (section 5a is darkened area).

TABLE 2

NECKER ISLAND MONK SEAL BIRTH LOCATIONS

SECTOR	1982	1983	1984	1985	1986	1987	TOTAL
5	3	2	3	2			10
8	1						1
Total							11

NOTE: See Figure 2, bottom, for sector locations.

seals in the NWHI (Figure 3). The atoll is approximately 28 km across its longest axis and consists of 10 permanent or semipermanent islands and at least three small, sand-spit islets that are present intermittently, depending on weather and tide conditions. Pupping activity within the shoals occurs primarily on East, Whale-Skate, and Round islands, although some births are known to have occurred at most of the other islands as well.

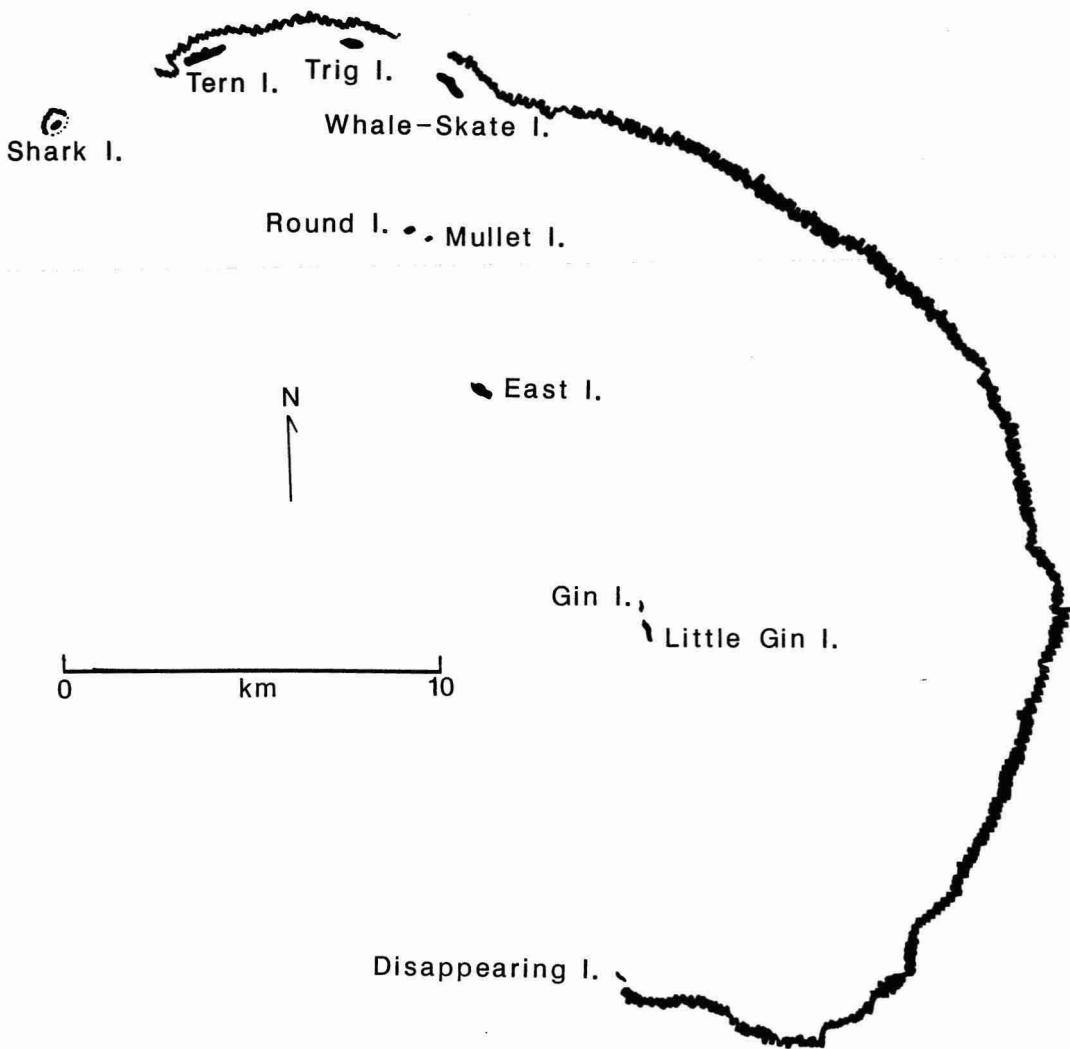


FIGURE 3. French Frigate Shoals.

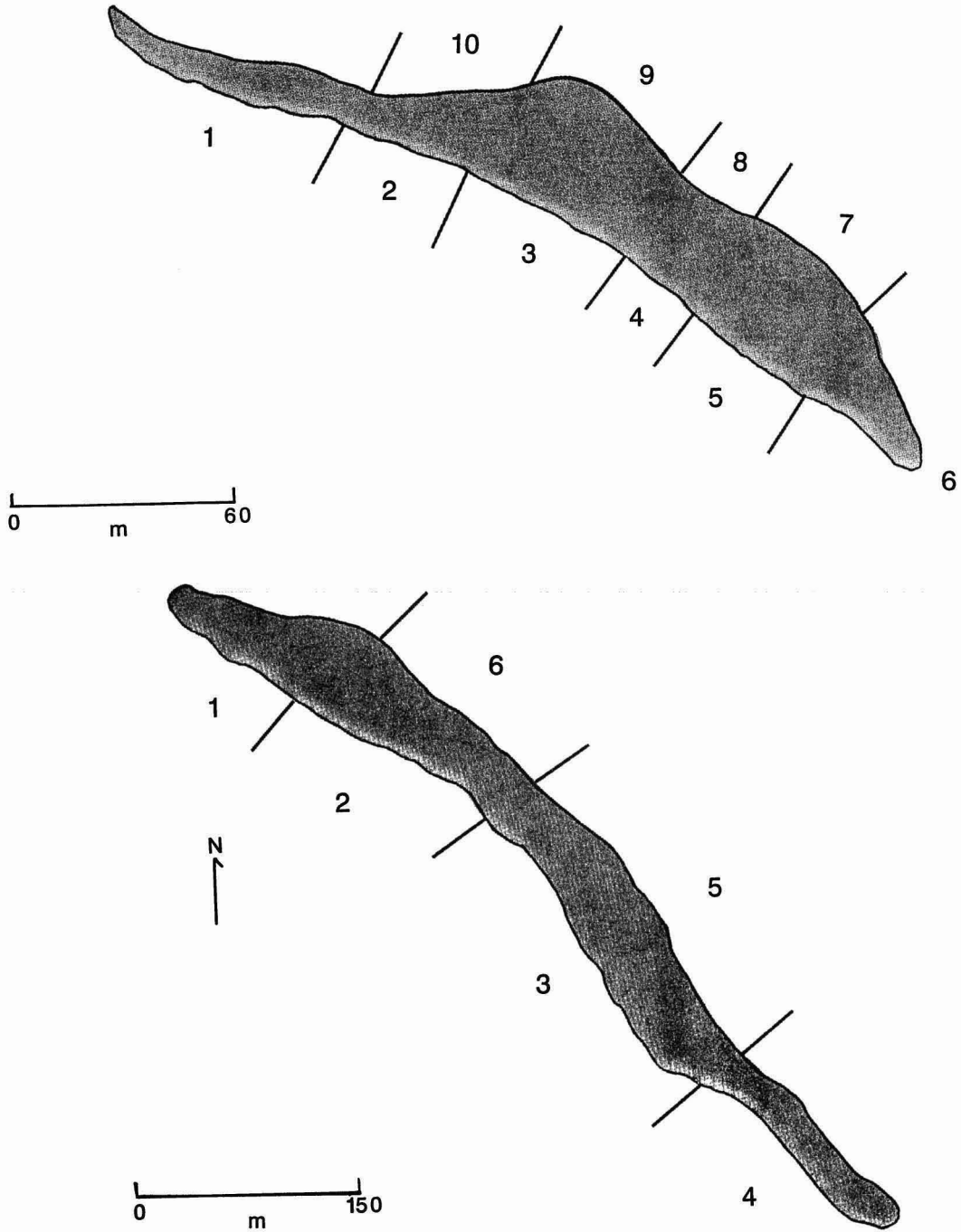


FIGURE 4. French Frigate Shoals: *top*, East Island; *bottom*, Whale-Skate Island.

East Island, near the center of the atoll, is the main pupping island of the monk seals (Figure 4, top; Table 3). It is an elongated island, 4.5 ha in size with an elevation of about 2 m, and lies within the inner crescent-shaped reef. It has a low vegetation cover consisting of grasses, vines, and shrubs. Some ruins of a U.S. Coast Guard (USCG) loran station, built in 1944 and abandoned in 1952, are scattered about the island.

After the USCG left East Island, mother-pup pairs were frequently sighted on its southwest beach, increasing in numbers during the rapid growth of the FFS population in the 1960s (Amerson 1971). Beginning in 1983, births have been monitored closely at East Island by NMFS. Data since 1983 show that about one-half of the births at FFS and at least one-fourth of the births in the entire NWHI occur at East Island.

East Island is divided into 10 sectors: sectors 1 and 6 on the west and east tips of the

island, respectively; sectors 2–5 on the southwest side (leeward); and sectors 6–10 on the northeast (windward) side (Figure 4A). Almost all mothers with newborn nursing pups on East Island (96% of 177 sightings) were found on the beaches at the east or west tip of the island, sectors 1 and 6, and along the south shore, sectors 2–5 (Table 3). The south side of the island is paralleled by a very shallow, wide reef flat. The shallow water offers protection from shark intrusion into the swimming area of the mother-pup pairs. Only a small portion of the north side of East Island is similarly abutted by shallow reef. Most of the sandy shoreline on the north side drops off quickly and is patrolled regularly by large tiger sharks, *Galeocerdo cuvieri*, during the early summer months.

East Island also has relatively few adult male seals during the breeding season. Adult males in search of females in estrus can be a continuing disturbance to mother-pup pairs, as some posturing and vocalizing on the part of the female is necessary to cause the male to stop pursuit. Absence of this disturbance may also contribute to making East Island a preferred pupping island.

The other frequently used pupping islands at FFS are Whale-Skate and Round islands. If combined, the births at these two islands equal about 60% of those at East Island. Whale-Skate Island is 6.8 ha of coral rubble and sand, with vegetation similar to that at East Island. Whale-Skate Island lies along the northern shelf of the reef; is long, narrow, and slightly curved; and has an elevation maximum of about 2 m (Figure 4, bottom).

From 1983 to 1987, 107 sightings of births and newborn pups on Whale-Skate Island were made; the distribution clearly favored sectors 1, 2, 3, and 6 (Table 3), the northwest end and southwest beach (Figure 4, bottom). Many large coral heads are scattered near shore around the northwest half (sectors 1 and 6) of the island. The water over the reef is very shallow, and throughout the area is a maze of narrow channels of water 2–3 m deep. The beach at the northwest end is 10–15 m wide and has vegetation behind the berm. Sectors 2 and 3, also frequently used for pupping, are on the south side (leeward) of the island. This

TABLE 3

FRENCH FRIGATE SHOALS MONK SEAL BIRTH LOCATIONS

SECTOR	1983	1984	1985	1986	1987	TOTAL
East Island						
1	2	8	4	6	5	25
2	2	7	5	3	5	22
3	3	5	7	6	13	34
4	3	6	2	13	8	32
5	1	2	8	7	8	26
6	6	7	5	7	6	31
8		1				1
9	1	1		1	1	4
10				2		2
Total						177
Whale-Skate Island						
1	5	5	8		5	23
2	2	4	5		10	21
3	3	5	5	4	6	23
4		2	2	1	2	7
5	1	4	1	2	1	9
6	5	8	4	3	4	24
Total						107
Round Island		25	21	14	21	81
Little Gin Island		7	3	3	6	19
Trig Island		3	1		1	5
Tern Island		1*	1*	2*	2*	6
Other islands: Mullet, Disappearing, Gin		4	1	5	12	22

NOTE: See Figures 3–4 for island and sector locations.

*Premature or stillbirths.

latter area has a narrow channel about 1 m deep along the beach with a shallow reef 30 m wide adjacent to it. Females giving birth in sectors 2 and 3 selected sites with the shallowest water. Sectors 4 and 5 on the opposite side of the narrow island have deeper water and less reef protection along the shore.

The third major pupping site is Round Island, a small, sandy, nonvegetated islet with a maximum area of about 0.1 ha and an elevation that does not exceed about 1.5 m. It is almost completely surrounded by very shallow water and reef. Numerous mother-pup pairs have been observed at Round Island since 1956 (Amerson 1971; Table 3). It is much smaller than East and Whale-Skate islands, and it has the highest density of mother-pup pairs. But despite the high density at Round Island during the pupping season, adult females prefer to use it rather than other small sand-spit islets that lack its protective reef, shallow-water perimeter, and stability (Round Island rarely disappears).

A small number of mother-pup pairs have been recorded on other islands within FFS (Table 3), most of which have little or no vegetation because they are periodically awash in the winter. Little Gin Island (Figure 3) lies southeast of East Island in the crescent-shaped reef and is about 2 ha of sand with a very small area of vegetation. The water along the shoreline is at least 1 m deep. Mother-pup pairs have been sighted on Little Gin Island since the late 1950s, but in relatively few numbers compared with these on East, Whale-Skate, and Round islands (Amerson 1971). Births continue to be observed here, averaging five per year. A few other small sand islets, Mullet, Disappearing, Trig, and Gin Islands (Figure 3), combined contribute about seven pups per year. These locations have water at least 1 m deep along the shoreline and may disappear easily with changes in weather, tide, and current patterns.

The largest land mass in the shoals is Tern Island (Figure 3), a 14-ha man-made island completed in 1942 as an aircraft refueling site (Amerson 1971), with an elevation of 2 m. It has been nearly continuously occupied by humans, but an important change for monk seals occurred in 1979: the USCG Ioran station, which had been relocated from East

Island to Tern Island in 1952, was closed, and the U.S. Fish and Wildlife Service (USFWS) began occupation of the island. Before this change, Tern Island was used only occasionally by monk seals, but since 1979 the annual mean beach counts have risen dramatically, to 80–90 seals in recent years. This increase occurred because of a change in beach use: access by station personnel is now highly restricted, and no dogs are present on the island.

The entire south beach of Tern Island is suitable for hauling out and is heavily used by seals for resting and molting, but observers have recorded only a few stillbirths and premature births on Tern Island between 1979 and 1987 (Table 3). Some readily identifiable adult female seals have used Tern Island regularly for hauling out and then, within a few days of a Tern Island sighting, appeared on East Island with a newborn pup. Tern Island provides a haul-out beach near the windward atoll slope and fringing reef, which is probably good foraging habitat at FFS. The cause of the premature and stillbirth incidents that occur on Tern Island is not understood, but may be related to these females not receiving sufficient physiological warning of the imminent births and, therefore, not seeking a more appropriate parturition site.

Tern Island will probably not become a major pupping island for monk seals because of the surrounding water habitat. The water along the beach becomes deep quickly, and the offshore reef does not provide a sufficient barrier to dissipate waves from the south nor prevent the access of large sharks to the near-shore area. Large sharks have been observed swimming close to this shoreline, making it incompatible with high pup survival (K. W. Kenyon and M. J. Rauzon, unpubl. data, 1977).

Laysan Island

The largest island in the NWHI is Laysan Island, about 365 ha, which contains a large hypersaline lake in its central depression (Figure 5, *left*). The highest elevation is just over 12 m. Laysan Island is divided into 20 sectors, is well vegetated with a variety of plant life, and has some wide (200–400 m), sandy

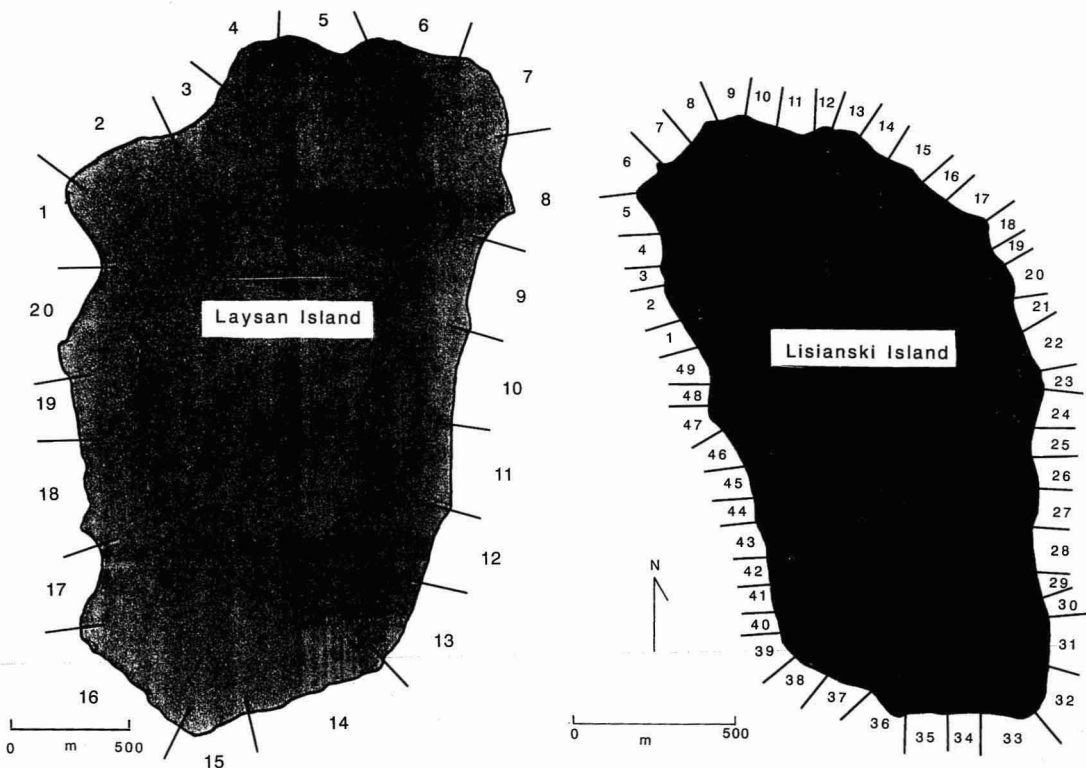


FIGURE 5. *Left*, Laysan Island; *right*, Lisianski Island.

beaches on the north side (sectors 4–10) (Ely and Clapp 1973). The beaches on the northwest and west sides of the island, sectors 1–3 and 17–20, are narrower (50–200 m) and steeper and have vegetation at the berm. The nearshore areas on the west and northwest sides (sectors 18–20 and 2–3) consist of extensive reef flats, which are exposed most of the time. Present along this shoreline are rocky ledges that provide small pools of shallow water. Large waves break up on the fringing reef, 100 m or more from the beach.

During 1977–1980, most of the pupping (76%) occurred at the northwest quarter of the island (Johnson and Johnson 1984). This pattern continued during 1982–1987, based on information on the birth locations of 104 pups at Laysan Island. About 55% of the births occurred in sectors 2–3 and 19–20, and 66% of the total number occurred in the northwest quarter (Table 4).

Sectors 10–13 on the east side of the island were the site of 17 (16%) of the known births

at Laysan Island in 1982–1987. This area is very calm and shallow (1.0–1.5 m), with a prominently exposed coral-rock border that parallels the shoreline and is, on average, about 100 m offshore. Few adult males searching for females frequent this area, so mother-pup pairs remain relatively undisturbed while swimming near the beach. The beach is very wide here, up to 75 m, and mother-pup pairs have not been seen using the inland vegetation.

Not commonly used for pupping are those areas along the south shore and northeast side of the island. A large coral shelf drops into deep, choppy water on the south side in sectors 15 and 16. Along the northeast shore (sectors 6–8), tradewinds can create extremely rough surf on the beaches and can cause sand storms. Also, the very wide northeast beach requires a mother-pup pair to travel up to 400 m to reach vegetation for protection from inclement weather.

Most pupping activity at Laysan Island co-

TABLE 4
LAYSAN ISLAND MONK SEAL BIRTH LOCATIONS

SECTOR	1982	1983	1984	1985	1986	1987	TOTAL
1			1	1		2	4
2	5	3	4	6	1	2	21
3	1		1	4	1	2	9
4	1		1		1		3
5	1		1	1		2	5
6			1	1	1	1	4
7			1				1
8			1	1			2
10	1		1		1		3
11	1	2	2	3		1	9
12				1		1	2
13	1					2	3
18			1	1	3	1	6
19	2	2	1				5
20	9	2	2	6	2	6	27
Total	22	9	18	25	10	20	104

NOTE: See Figure 5, *top*, for sector locations.

incides temporally with the seasonal, non-aggressive aggregations of gray reef sharks, *Carcharhinus amblyrhynchos*, in the shallow waters off sectors 2 and 3. Seals have been seen swimming through these large aggregations without incident (Alcorn and Buelna 1989).

Lisianski Island

Lisianski Island is a low coral and sand island situated at the northern edge of Neva Shoal (Clapp and Wirtz 1975). It is 182 ha, with a maximum elevation of just over 6 m. The top of the island is densely covered with shrubs and grasses. Most beach areas around the island (except the southeast) are sloped, relatively narrow (about 10–15 m wide), and backed by abundant vegetation behind the berm. The shoreline along most beaches drops off quickly to 1 m or more in depth; only occasionally are the beaches abutted by shallow reef. The island has been divided into 49 sectors for recording seal sightings (Figure 5, *right*).

The mideastern beach is primarily low, rocky ledges with small tide pools, expanding to wider (100–150 m), flat, sandy beaches toward the south end of the island. Sector 28 (Figure 5, *right*) contains a rocky ledge at the shoreline and has a coral ridge 3–5 m from

the beach that is exposed at low tide. The coral ridge parallels the beach, forming a shallow channel alongshore. The beach here is slightly sloped and ca. 15 m wide. At the beach crest, large clumps of bunchgrass (*Eragrostis variabilis*) and other vegetation provide shelter for seals from wind and rain. At the waterline of sectors 23–25 is a coral ledge that creates pools protected from the deeper water. The entire ledge runs parallel to the shoreline and slopes up above the water into dense vegetation that climbs farther up a steep embankment. The protected, shallow shoreline beaches of sectors 23–29 provide the only large area of this type of habitat at Lisianski Island.

Although coverage of the island by NMFS personnel during the field seasons varied greatly from 1982 to 1986 (no data for 1984 or 1987), it is evident from the data that births are most concentrated on the southeast beaches (Table 5). Of the 33 known birth and neonatal sightings recorded in 4 yr, 17 occurred in sectors 23–29. Sector 28, about 2% of the island's perimeter, was clearly the pre-

TABLE 5
LISIANSKI ISLAND MONK SEAL BIRTH LOCATIONS

SECTOR	1982	1983	1984	1985	1986	TOTAL
2	1					1
5		1				1
11	1					1
12		1				1
13				1		1
17	1					1
19					1	1
20	1					1
21					1	1
23	1					1
24	1					1
25	1	1				2
27	1					1
28	5	3		1	1	10
29	2					2
31		1				1
32	1					1
36	1					1
39	1					1
40		1				1
43		1				1
44		1				1
Total						33

NOTE: See Figure 5, *bottom*, for sector locations.

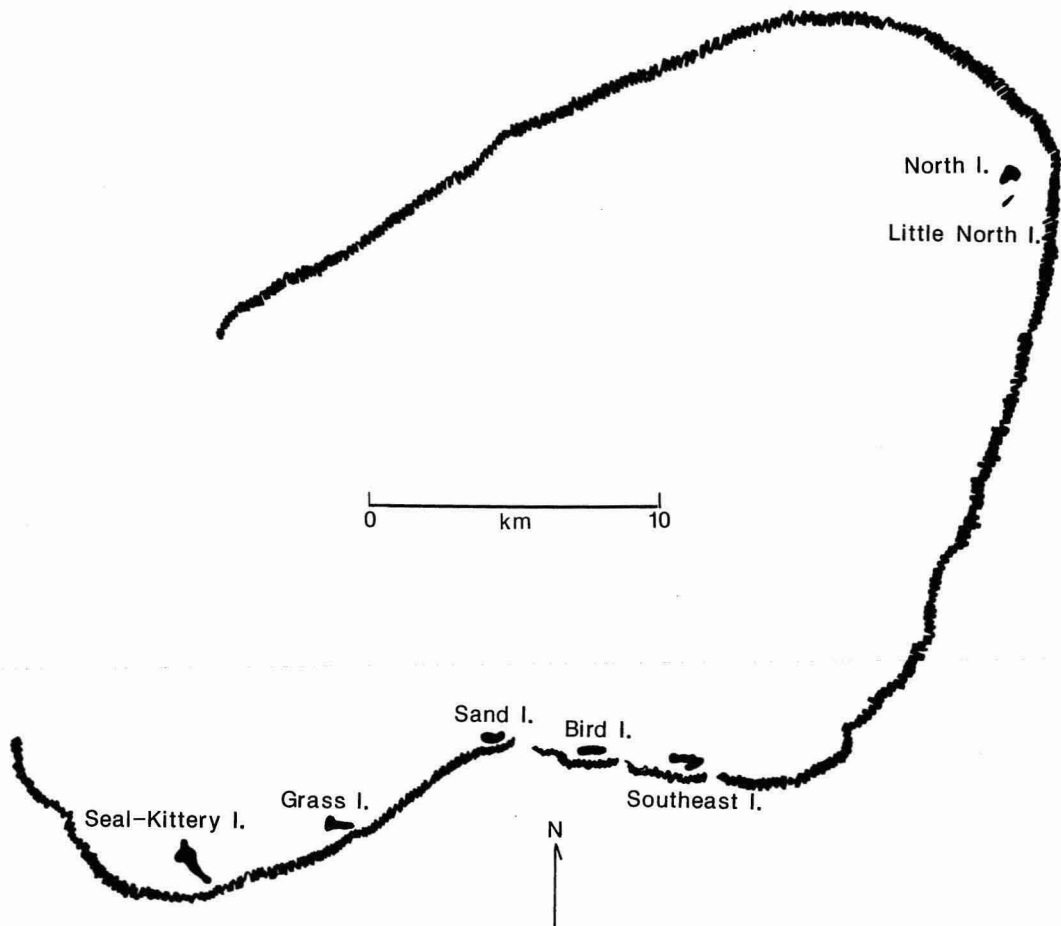


FIGURE 6. Pearl and Hermes Reef.

ferred area overall, with 10 (30%) of the known births occurring there. Additional sightings of older nursing pups at first arrival of field camps indicate that sector 20 is also an important nursery habitat.

Pearl And Hermes Reef

Pearl and Hermes Reef usually consists of seven small islands and their associated sand spits (Figure 6). Only four of the islands have vegetation above all or some of the beaches. The atoll is ca. 32 km wide, and the fringing reef has a wide opening at the west end and several smaller channels through the reef along the south side.

The northernmost islands within the atoll

are North Island, with its associated sand spits, and Little North Island, a few hundred meters southeast of North Island (Figure 7). These two islands are separated by a channel 3–4 m deep. North Island is a vegetated, comma-shaped island with gradually sloping, sandy beaches and a sand spit extending southward off the west side. Depending on the tide and the season, a variable number of small sand islets in shallow water emerge off North Island's south tail and provide haul-out space for seals. Little North Island is a long, narrow sand spit lacking vegetation and frequently changing in size and shape.

Of the 35 observed births and mothers with newborn pups at Pearl and Hermes Reef, 30 (86%) were seen on these two northernmost

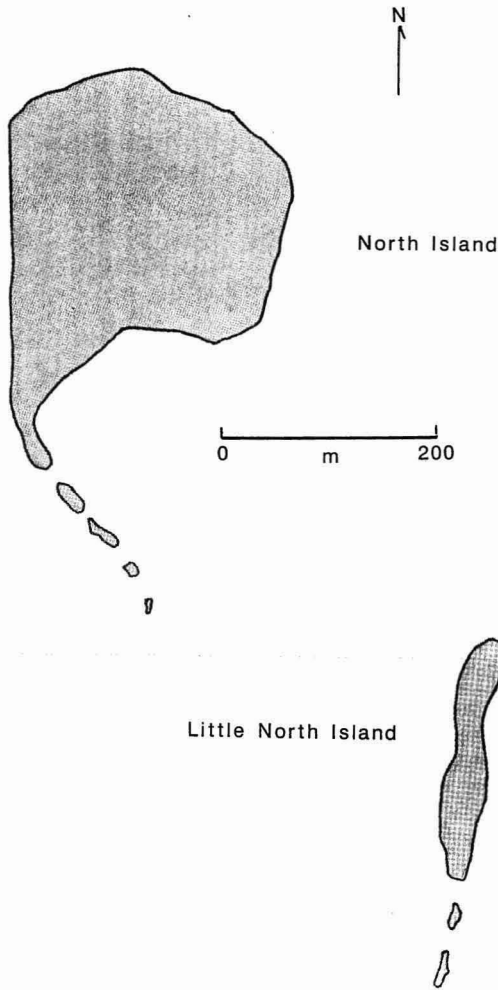


FIGURE 7. North and Little North Islands, Pearl and Hermes Reef.

islands, with the majority of pairs using the west shore of North Island and its spit islets (Figure 7, Table 6). Most of the mother-pup pairs on Little North Island also appeared along the west (leeward) side. The calm and very shallow (<0.5 m deep) leeward waters cover an extensive area near shore. Mother-pup pairs using the exposed sand islets off the southern tip of North Island have been observed to move between these islets (WGG, personal observation). The water is also very shallow (≤ 0.5 m) around these islets and may be formed into small, stagnant pools by the sand. Large tiger sharks have been seen in the deep channel that separates Little North Island from North Island, and no movement of mother-pup pairs across the channel has been documented.

The islands at the south end of the atoll are farther apart (1–2 nmi) and are surrounded by water along the beaches that becomes deep (1–2 m) quite rapidly. Although mother-pup pairs have occasionally been seen on Bird Island, Southeast Island, and Seal-Kittery Island, they constitute a small percentage (14%) of the total births observed at Pearl and Hermes Reef.

Midway Islands

Monk seals once occupied Midway Islands (Figure 1) in high numbers, with beach counts exceeding 70 animals, but the population was nearly eliminated in the 1960s and 1970s because of human disturbance and has yet to show signs of recovery (Kenyon 1972,

TABLE 6
PEARL AND HERMES REEF MONK SEAL BIRTH LOCATIONS

LOCATION	1983	1984	1985	1986	1987	TOTAL
North Island and sand spits	4	2	4	7	8	25
Little North Island	3	2				5
Southeast Island		1		1		2
Bird Island	1		1			2
Sand Island						—
Grass Island						—
Seal-Kittery Island	1					1
Total	9	5	5	8	8	35

NOTE: See Figures 6 and 7 for island locations.

Johnson et al. 1982). NMFS and USFWS personnel have attempted to monitor Midway Islands for pupping activity since 1980 with intermittent visits annually. During that time, an average of less than one pup per year has been born on Eastern Island and the sand islets between Eastern and Sand islands, the atoll's two major islands. Because of the very low number of births, the uncertainty of the exact birth locations (no births were witnessed in the last decade), and the possibility that human disturbance still influences birth site selection, preferred monk seal birth sites at Midway Islands are not discussed here.

Kure Atoll

Kure Atoll, about 2220 km from Honolulu, is the westernmost atoll in the NWHI and also the northernmost coral atoll in the world (Figure 1, 8). The atoll consists of a large (130 ha), permanently vegetated island, Green Island (Figure 8), and up to three small sand islets, the size and presence of which are dependent upon the current and weather. Green Island has a maximum elevation of 7.5 m, and the beaches are backed by a very dense, deep cover of *Scaevola taccada*. Sandy beach projections at both ends of Green Island change slightly with the weather and seasons (Woodard 1972). Sand Island, the largest and most stable of the sand islets, may be up to 20 m wide and 200–300 m long.

In 1961, the USCG began operation of a 20-person loran station on Green Island, where almost all monk seal births had occurred. Thereafter, the preferred pupping sites on Green Island were abandoned under the pressure of human disturbance, and the seals began to use the sand islets to give birth and rear their pups. This resulted in an increase in pup mortality, a slow decline in beach counts of seals because of little or no recruitment, and then decreasing numbers of births (Kenyon 1972, Gerrodette and Gilmartin, in press). These changes were attributed to human disturbance, which included harassment by dogs and vehicles driven on the beaches.

In 1976, the USCG made several changes in the beach-use policy at Kure Atoll to reduce impact on monk seals, and this began to

slowly reverse the changes that had occurred in haul-out patterns. An off-limits area was designated at the north end of Green Island, dogs were removed from the island, recreational use of vehicles on the beaches was prohibited, and the sand islets were placed off limits. These actions gave the seals some relief and refuge from human activities, and in time births resumed on Green Island (Gerrodette and Gilmartin, in press). In 1981, NMFS began an intensive field program at Kure Atoll in an attempt to increase pup survival. This work focused on the temporary captive maintenance of female pups after weaning (Gilmartin et al. 1986) and on monitoring USCG beach activities.

In 1981, six of 10 Kure Atoll pups were born on Green Island beaches and the other four were born on Sand Island. From 1981 through 1984 the births on Green Island occurred on all beaches except sector 8, which is the primary USCG recreational beach. Beginning in 1985, birth sites have been almost exclusively (15 of 18 births) limited to sectors 5–7 (Table 7), the west point of the island with beaches 15–30 m wide, and the sand bar extending off sector 6. The nearshore water off these sectors is shallow, with a coral and sand bottom. The topography along sectors 3–4 is similar to that at sectors 5–7, but the east beach area has not been used in recent years for pupping. Sector 2 is the off-limits beach on the island, and although it has been the most used by seals for resting and molting, only five births have occurred there in 4 yr. The bottom along the shore on the west side (sectors 1–2 and 8) drops off quickly to a sandy bottom 1–2 m deep. From 1982 to 1989, 31 of 33 pups were born on Green Island.

The locations selected by Hawaiian monk seals for parturition are not randomly distributed along the beaches available to them. At all of the breeding locations (except Necker and Nihoa islands) up to about 10 km of beach could be used for giving birth, but the distribution of pupping is actually very limited to relatively short shoreline distances. These particular areas also appear to be used repeatedly by parturient females over periods

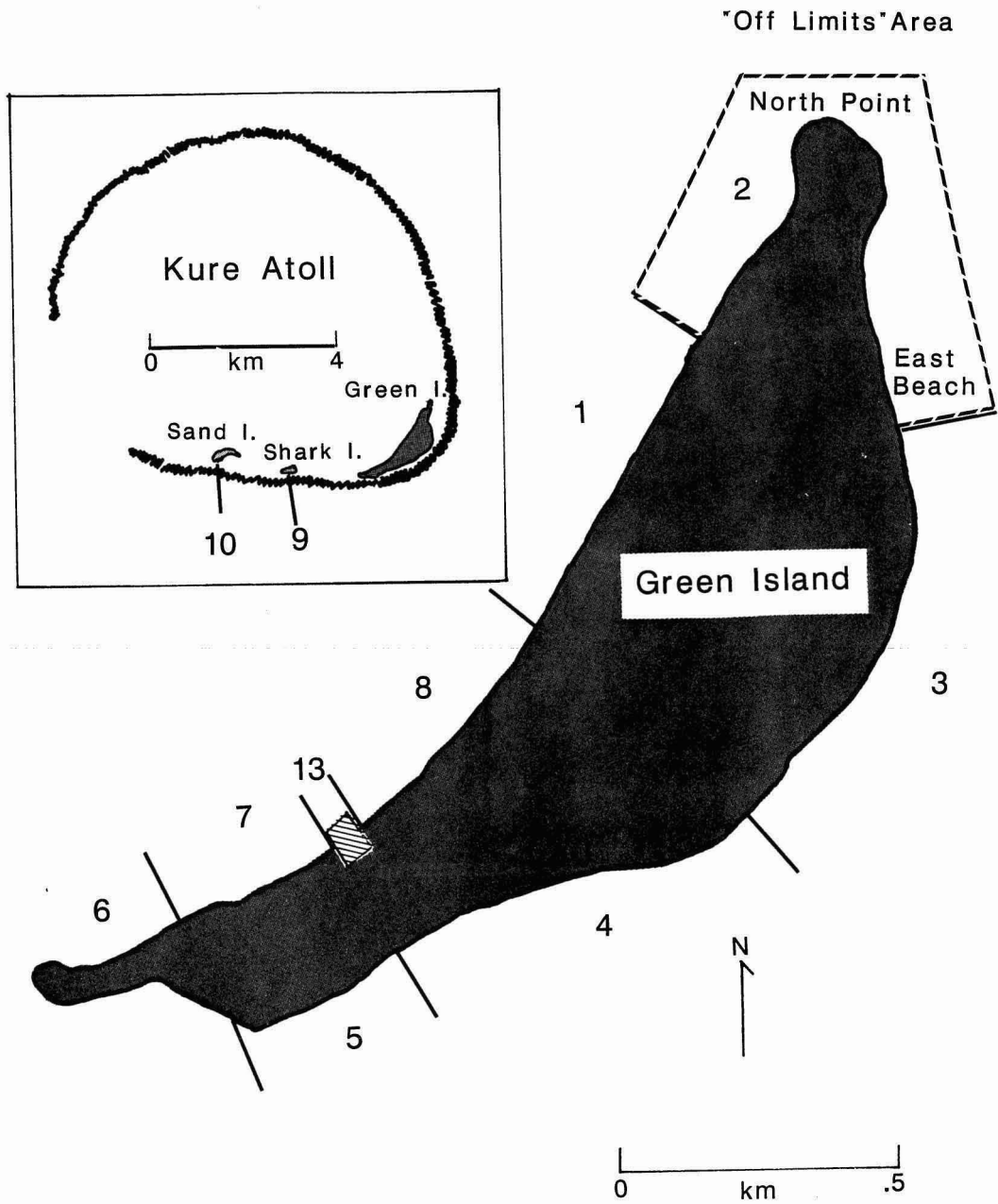


FIGURE 8. Kure Atoll (inset) and Green Island (sector 13 is the fenced pup enclosure).

TABLE 7
KURE ATOLL MONK SEAL BIRTH LOCATIONS

SECTOR	1981	1982	1983	1984	1985	1986	1987	1988	TOTAL
Green Island									
1	1	1							2
2		1	1	1				2	5
3	1			3					4
4	1								1
5		1		2	1		1		5
6	2		2		2	1		5	12
7	1	2			2		2	1	8
Subtotal									37
Sand Island									
	4			1			1		6
Total									43

NOTE: See Figure 8 for sector locations.

lasting at least several years. Although some mother-pup pairs may move 400–500 m along the shore during the nursing period (Alcorn 1984), they do not normally move beyond or between these protected beach areas.

These preferred pupping beaches have some similar characteristics. The primary attribute seems to be very shallow water along the beach. Also favored are sites with coral ridges or large rocks near the shoreline. They may fully or partially restrict shark entry to the water used by the mother-pup pairs during the day. These features, on either side (windward or leeward) of a permanent, vegetated island, seem to be highly attractive to Hawaiian monk seals about to give birth. A birth site with these beach characteristics should enhance survival of a pup through nursing and the early postweaning period, before the pup starts to move away from its natal beach.

Human disturbance in the past has caused monk seals to abandon preferred pupping and nursing sites, resulting in decreased pup survival. Several important birth sites have been described in this paper: Nihoa Island (Derby's Landing); Necker Island (sector 5a); at FFS, East Island (sectors 1–6), Whale-Skate Island (sectors 1–3, 6), and Round Island; Laysan Island (sectors 2–3, 11, 18–20); Lisianski Island (sectors 20, 25, 28–29); at Pearl and Hermes Reef, North Island (west side and spit islets) and Little North Island; and at Kure Atoll, Green Island (sectors 5–7). Re-

covery of the Hawaiian monk seal population is linked to protection of these areas from any disturbance that may cause monk seals to seek less satisfactory beaches for giving birth and nursing their pups.

ACKNOWLEDGMENTS

We appreciate the assistance of the other Marine Mammals and Endangered Species Program staff in collecting some of the birth site information presented herein and describing the habitat. We also received useful comments on the manuscript from G. Causey Whittow, Sheila Conant, and Leslie C. Williams.

LITERATURE CITED

- ALCORN, D. J. 1984. The Hawaiian monk seal on Laysan Island: 1982. U.S. Dep. Commer., NOAA Tech. Memo. NMFS, NOAA-TM-NMFS-SWFC-42. 37 p.
- ALCORN, D. J., and E. K. BUELNA. 1989. The Hawaiian monk seal on Laysan Island, 1983. U.S. Dep. Commer., NOAA Tech. Memo. NMFS, NOAA-TM-NMFS-SWFC-124. 46 p.
- ALCORN, D. J., R. G. FORSYTH, and R. L. WESTLAKE. 1988. Hawaiian monk seal research on Lisianski Island, 1984 and 1985.

- U.S. Dep. Commer., NOAA Tech. Memo. NMFS, NOAA-TM-NMFS-SWFC-120. 22 p.
- AMERSON, A. B. 1971. The natural history of French Frigate Shoals, Northwestern Hawaiian Islands. *Atoll Res. Bull.* 150. 383 p.
- BECKER, B. L., R. J. MORROW, and J. K. LEIALOHA. 1989. Censuses and interatoll movements of the Hawaiian monk seal on Laysan Island, 1985. U.S. Dep. Commer., NOAA Tech. Memo. NMFS, NOAA-TM-NMFS-SWFC-135. 25 p.
- CLAPP, R. B., and W. O. WIRTZ, II. 1975. The natural history of Lisianski Island, Northwestern Hawaiian Islands. *Atoll Res. Bull.* 186. 196 p.
- CLAPP, R. B., E. KRIDLER, and R. R. FLEET. 1977. The natural history of Nihoa Island, Northwestern Hawaiian Islands. *Atoll Res. Bull.* 207. 147 p.
- CONANT, S. 1985. Observations of Hawaiian monk seals on Necker Island, Northwestern Hawaiian Islands. *'Elepaio* 46(2): 11-12.
- ELY, C. A., and R. B. CLAPP. 1973. The natural history of Laysan Island, Northwestern Hawaiian Islands. *Atoll Res. Bull.* 171. 361 p.
- FORSYTH, R. G., D. J. ALCORN, T. GERRODETTE, and W. G. GILMARTIN. 1988. The Hawaiian monk seal and green turtle on Pearl and Hermes Reef, 1986. U.S. Dep. Commer., NOAA Tech. Memo. NMFS, NOAA-TM-NMFS-SWFC-107. 24 p.
- GERRODETTE, T., and W. G. GILMARTIN. Demographic consequences of changed pupping and hauling sites of the Hawaiian monk seal. *Conserv. Biol.* (in press).
- GILMARTIN, W. G., R. J. MORROW, and A. M. HOUTMAN. 1986. Hawaiian monk seal observations and captive maintenance project at Kure Atoll, 1981. U.S. Dep. Commer., NOAA Tech. Memo. NMFS, NOAA-TM-NMFS-SWFC-59. 9 p.
- JOHANOS, T. C., and S. L. AUSTIN. 1988. Hawaiian monk seal population structure, reproduction, and survival on Laysan Island, 1985. U.S. Dep. Commer., NOAA Tech. Memo. NMFS, NOAA-TM-NMFS-SWFC-118. 38 p.
- JOHANOS, T. C., and J. R. HENDERSON. 1986. Hawaiian monk seal reproduction and injuries on Lisianski Island, 1982. U.S. Dep. Commer., NOAA Tech. Memo. NMFS, NOAA-TM-NMFS-SWFC-64. 7 p.
- JOHANOS, T. C., and A. K. H. KAM. 1986. The Hawaiian monk seal on Lisianski Island: 1983. U.S. Dep. Commer., NOAA Tech. Memo. NMFS, NOAA-TM-NMFS-SWFC-58. 37 p.
- JOHANOS, T. C., A. K. H. KAM, and R. G. FORSYTH. 1987. The Hawaiian monk seal on Laysan Island: 1984. U.S. Dep. Commer., NOAA Tech. Memo. NMFS, NOAA-TM-NMFS-SWFC-70. 38 p.
- JOHNSON, A. M., and E. KRIDLER. 1983. Interisland movement of Hawaiian monk seals. *'Elepaio* 44(2): 43-45.
- JOHNSON, A. M., R. L. DELONG [sic], C. H. FISCUS, and K. W. KENYON. 1982. Population status of the Hawaiian monk seal (*Monachus schauinslandi*), 1978. *J. Mammal.* 63(3): 415-421.
- JOHNSON, B. W., and P. A. JOHNSON. 1984. Observations of the Hawaiian monk seal on Laysan Island from 1977 through 1980. U.S. Dep. Commer., NOAA Tech. Memo. NMFS, NOAA-TM-NMFS-SWFC-49. 65 p.
- KENYON, K. W. 1972. Man versus the monk seal. *J. Mammal.* 53: 687-696.
- KENYON, K. W., and D. W. RICE. 1959. Life history of the Hawaiian monk seal. *Pac. Sci.* 13: 215-252.
- MORROW, R. J., and E. K. BUELNA. 1985. The Hawaiian monk seal and green turtle on Necker Island, 1983. U.S. Dep. Commer., NOAA Tech. Memo. NMFS, NOAA-TM-NMFS-SWFC-55. 11 p.
- REDDY, M. L. 1989. Population monitoring of the Hawaiian monk seal, *Monachus schauinslandi*, and captive maintenance project for female pups at Kure Atoll, 1987. U.S. Dep. Commer., NOAA Tech. Memo. NMFS, NOAA-TM-NMFS-SWFC-123. 37 p.
- REDDY, M. L., and C. A. GRIFFITH. 1988. Hawaiian monk seal population monitoring, pup captive maintenance program, and incidental observations of the green turtle

- at Kure Atoll, 1985. U.S. Dep. Commer., NOAA Tech. Memo. NMFS, NOAA-TM-NMFS-SWFC-101. 35 p.
- SCHREIBER, R. W., and E. KRIDLER. 1969. Occurrence of an Hawaiian monk seal (*Monachus schauinslandi*) on Johnston Atoll, Pacific Ocean. *J. Mammal.* 50(4): 841-842.
- WESTLAKE, R. L., and P. J. SIEPMANN. 1988. Hawaiian monk seal and green turtle research on Lisianski Island, 1986. U.S. Dep. Commer., NOAA Tech. Memo. NMFS, NOAA-TM-NMFS-SWFC-119. 18 p.
- WOODARD, P. W. 1972. The natural history of Kure Atoll, Northwestern Hawaiian Islands. *Atoll Res. Bull.* 164. 318 p.