# MARINE WILDLIFE BIOLOGICAL OBSERVATIONS IN THE LEEWARD HAWAIIAN ISLANDS 8-27 SEPTEMBER 1966

by

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## INTRODUCTION

The September 1966 expedition to the Leeward Hawaiian Islands, which comprise the Hawaiian Islands National Wildlife Refuge, accomplished several objectives: (1) The general condition of island habitats and wildlife were ascertained. Kridler and Walker, using prepared forms, recorded an inventory of birds and plants found on each island. (2) Refuge signs, both metal and wood were repaired, replaced, and cleaned. A large new sign was placed on Necker Island (fig. 1), which had not previously been marked as refuge property. These signs are an important deterrent to unauthorized trespass. (3) Biological information on the Hawaiian monk seal and several species of birds was obtained. (4) Carlquist collected and photographed all species of plants that we found. His ultimate objective is to prepare a book on the flora of the Hawaiian Islands, including the main islands and the Leeward chain. Endemic species on some of the islands are reduced to relict populations which may soon disappear, as introduced species of animals and plants and increasing human activity change the native environment. (5) Evidence of unauthorized military trespass was observed. Through conversations with military personnel on Midway, improved liaison with the military was promoted and improvement of their understanding of refuge regulations and problems was accomplished.

The problems caused by military presence in the proximity of oceanic National Wildlife Refuge islands is similar in both the Hawaiian and Aleutian areas. The causes of these problems are basic and will require constant attention in the foreseeable future. They are: (1) Military men lack knowledge of biological factors which upset island ecology and which determine the loss or survival of island fauna and flora. (2) To military men, because of their limited point of view, military objectives appear more important than biological or natural environmental conditions.

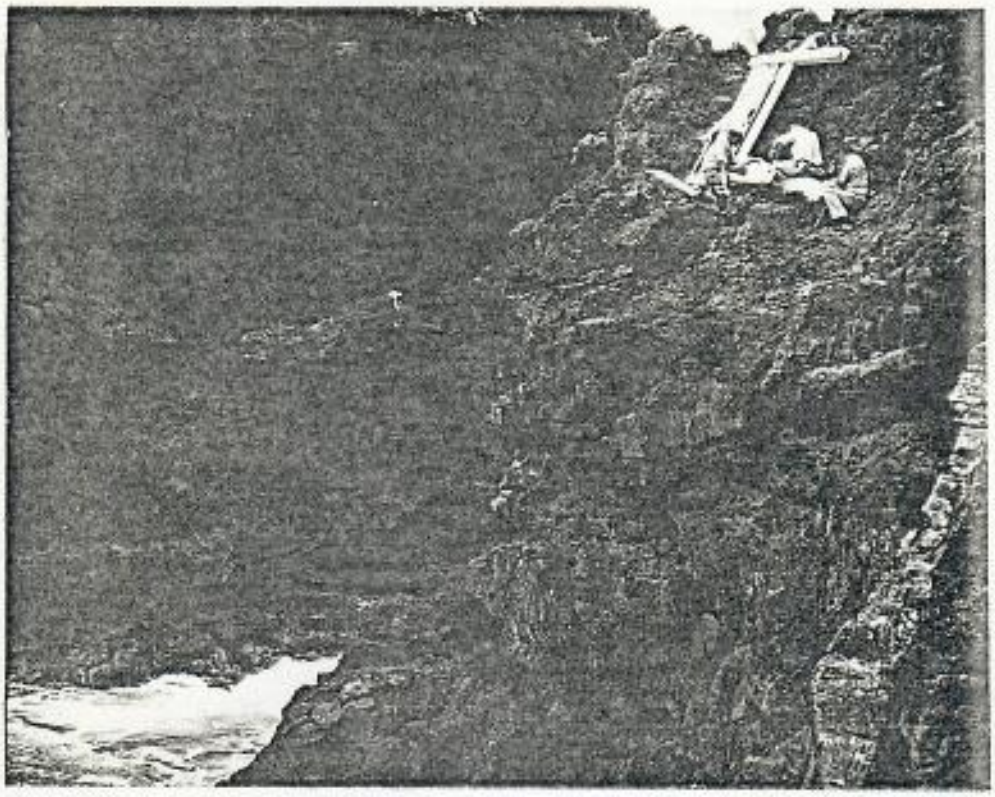

Figure 1 (KWK 66-21-12). --Erection of refuge sign on Necker Island, 10 September 1966. An important purpose of the refuge inspection was sign erection and maintenance. On Necker Island the parts of this sign were hauled up the cliff and assembled in the only suitable place near the landing on this precipitous, volcanic island. Signs on refuge islands are an important deterrent to military parties who might otherwise visit them without knowing of their refuge status. Kridler has now placed signs on all of the Hawaiian refuge islands. Because the landing place is precarious on Necker, a sign could not be erected on previous trips. In addition to the large wooden sign shown here, a smaller metal sign was also erected. On the larger atolls where the lagoon contains several islets, the large wooden refuge sign is placed on the largest islet near the best landing spot. Small metal signs are on each of the smaller islets. There is today no excuse for unauthorized trespass on these refuge islands. Such trespass could result in the introduction of exotic plants, the seeds of which are carried in socks and pants cuffs. Tern Island of French Frigate Shoals (occupied by a U.S. Coast Guard Station) is heavily overgrown with an obnoxious introduced weed having irritating spines. Undoubtedly this plant will eventually reach other islets in this lagoon. Midway is practically overgrown with introduced species.

(3) Military personnel are perpetually moving from one duty station to another. During the year or two that an individual remains in an island environment he may become appreciative of the natural island biota and a cooperative conservationist. But then he is replaced and the education of his replacement must start again from the beginning. (4) The military organization controls unlimited means of transportation. This they use to gain illegal and often secret access to refuge islands. In order to preserve the ecology of fragile island environments and thus their flora and fauna, perpetual vigilance is necessary.

Against this background, the task of properly managing oceanic island refuges is a difficult one. Fortunately, Kridler understands it and is doing an excellent job. He does, however, need help. It is unreasonable that one man should be expected to conduct all management duties for which the BSFW is responsible in the State of Hawaii.

Because Kridler and Walker recorded, as nearly as possible, a complete enumeration of nesting and nonnesting resident birds and conducted a green turtle marking program, I include little of these data in this report, but present a review of certain biological information primarily on the Hawaiian monk seal and Laysan Albatross.

Nihoa is the only major island in the refuge that we did not visit. Several tiny sand islets, having little apparent wildlife significance, at French Frigate Shoals and Pearl and Hermes Reef were also omitted. The islands and atolls visited are shown on maps 1-7, appendix.

## ITINERARY

| Sept. 1966 | Time | Location |
|---|---|---|
| 5 | 0800 | Depart Seattle |
| | 1315 | Arrive Honolulu |
| 8 | 1500 | Depart Honolulu aboard USCG Ironwood |
| 10 | 1420 | Arrive Necker Island, camp ashore |
| 11 | 1520 | Depart Necker Island, return to Ironwood |

| Sept. 1966 | Time | Location |
|---|---|---|
| 12 | 1320-1825 | At French Frigate Shoals<br>Visit Tern I. and Trig I. |
| 13 | 0835 | At French Frigate Shoals<br>Visit Tern I., Whale-Skate I., and East I. (10 naut. mi.) Camp all night. |
| 14 | 1410 | Depart East I. and return to Ironwood |
| 16 | 0840-1120 | On Gardner Pinnacle (large rock) |
| 17 | 1328 | Arrive Laysan Island, camp ashore |
| 18 | 1430 | Depart Laysan Island, return to Ironwood |
| 19 | 1000-1505 | On Lisianski Island |
| 20 | 0835 | Arrive Southeast I., Pearl and Hermes Reef and set up camp |
| 21 | 0750-1635 | In rubber boat with outboard, visit Grass I., Seal I., and Kittery I. (15 naut. mi., round trip) |
| 22 | 0820-1630 | In rubber boat with outboard, visit North I., and South-North I. (19 naut. mi., round trip) |
| 26 | 1730 | Depart Southeast Island and return to Ironwood |
| 27 | 1255 | Arrive U.S. NS Midway I., Sand Island |
| 28 | 0930-1200 | Visit Eastern Island. |
| 28 | 2240 | Depart Midway on MAC Flight N020 |
| 29 | 0250 | Arrive Honolulu |
| 30 | 1305 | Depart Honolulu |
| 30 | 2200 | Arrive Seattle. |

## EXPEDITION MEMBERS

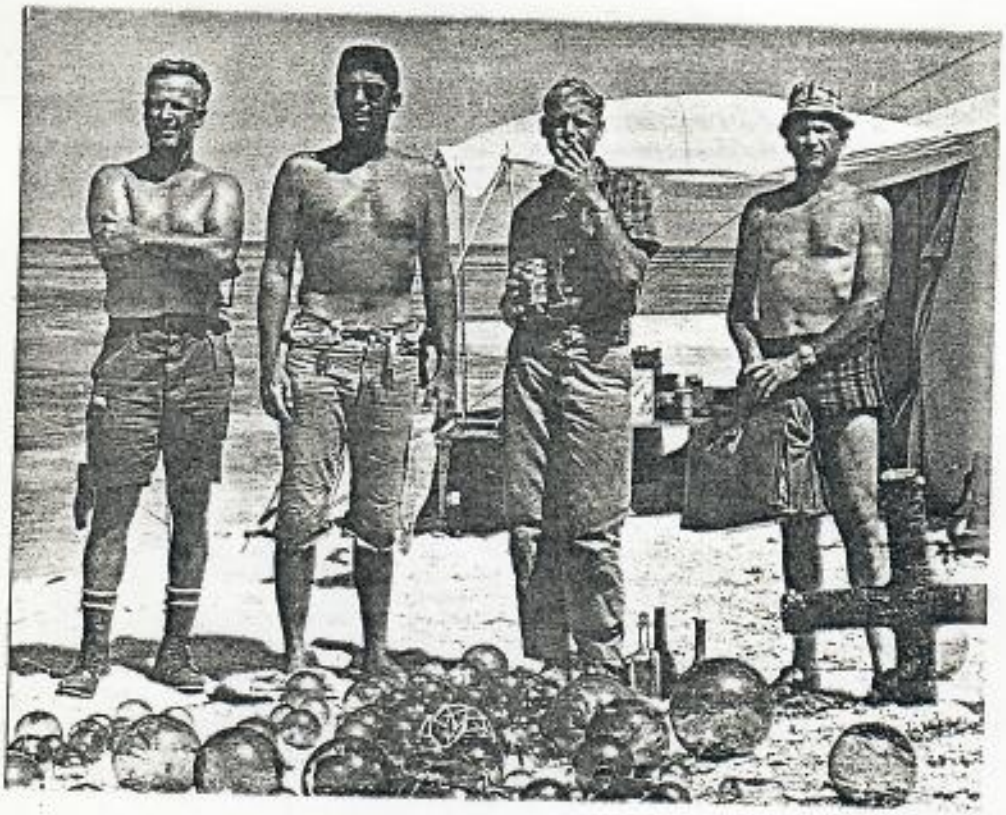

Figure 2 (KWK 66-28-30). --Southeast Island, Pearl and Hermes Reef, 24 September 1966. Left to right: Eugene Kridler, Refuge Manager, Division of Refuges, BSFW; Ronald L. Walker, Game Biologist, State of Hawaii, Division of Fish and Game; Dr. Sherwin Carlquist, Professor of Botany, Pomona College, Claremont, California; and Karl W. Kenyon, Biologist, Division of Wildlife Research, BSFW. Warren Roll, Photographer, Honolulu Star Bulletin, accompanied us ashore only on Necker Island and French Frigate Shoals. On the beaches of all atolls we found numbers of Japanese glass and plastic (cross) floats, bottles, and plastic items of many kinds. The 8-man tent provided protection from midday heat and rain squalls that were frequent at night.

## COOPERATION

The 8-27 September Hawaiian Islands NWR Survey trip was made possible through the cooperation of the U.S. Coast Guard. We were transported abord the USCGC Ironwood (fig. 3) (length 180 feet, displacement 1,025 tons), a buoy tender. The Coast Guard travels the 1,260 nautical mile distance from Honolulu to Kure Atoll once each spring and fall. The Coast Guard furnished transportation between the ship and islands in the ship's motor launches and loaned us an inflated rubber boat and outboard engine for our transportation between islands in Atoll lagoons. We obtained food supplies from the ship for use while camping on islands. The Commanding Officer, LCDR Nielson, and Executive Officer, Lt. Lockwood, and their crew extended their full cooperation in every way, both while we were aboard and while we were ashore, thus making our refuge survey successful.

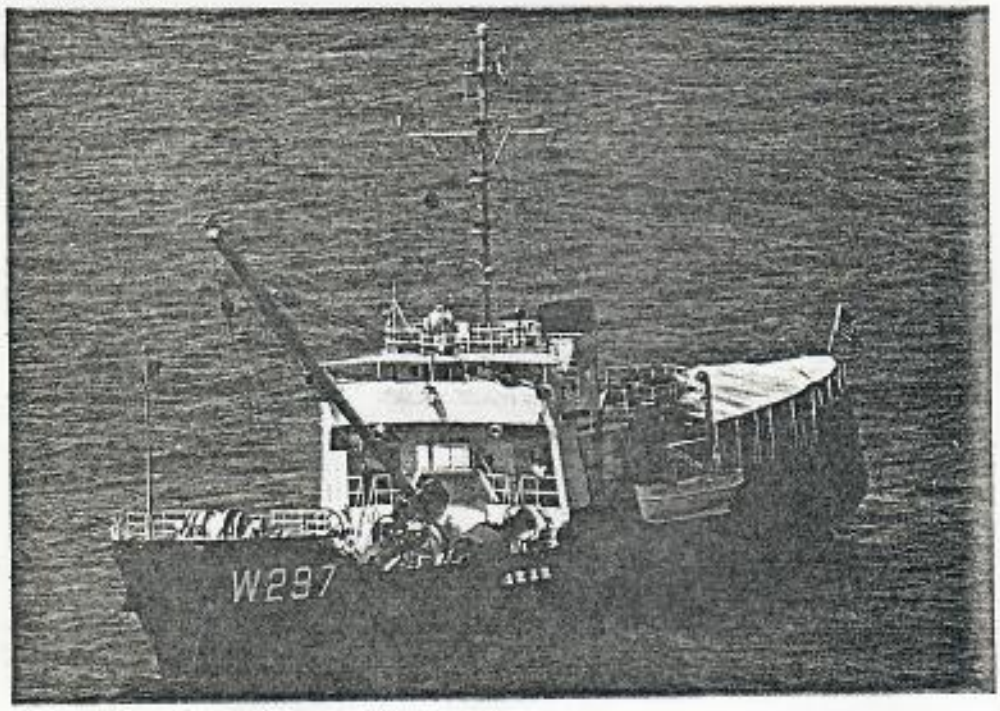


Figure 3 (KWK 66-22-2). --U.S. Coast Guard Cutter Ironwood took us aboard on 8 September at Honolulu and provided quarters and transportation for us from there to Midway, where we arrived on 27 September. The motor whale boat shown hanging in the davits was used to ferry us to and from islands.

## MILITARY REFUSE ON REFUGE ISLANDS

French Frigate Shoals. --Tern Island is occupied by about 20 Coast Guardsmen who maintain a loran station and airstrip. Because the airstrip and buildings occupy about two-thirds of the island, it has comparatively little refuge value for birds and apparently none for the monk seal. A large trash dump at the water's edge is on the north side of the island.

Whale-Skate Island was apparently used for some military purpose at one time. An old barge and numerous vertical iron rods in the water near shore remain.

East Island was a manned Coast Guard station prior to the time Tern Island was taken over. Several high telephone poles and the rusting remains of Quonset huts, large walk-in refrigerators, and other buildings (fig. 4) litter perhaps one-fifth of the island's surface.

Gardner Pinnacles. --Where the top of the larger pinnacle was blasted off to create a flat spot for a temporary military observation camp and helicopter landing place in recent years we found the following: one 55-gallon drum of diesel oil, one 55-gallon drum of gasoline, four 55-gallon drums containing water, and three empty drums (total nine drums). The tops of several drums had rusted through and contained the remnants of at least 15 birds that had fallen into them and starved to death. One entrapped Masked Booby was liberated, but because it was weak and saturated with filth it was probably doomed. Besides Masked Boobies, identifiable remains of Red-tailed Tropic Birds were present. All drums were rolled into the sea. In addition to the drums, a number of yards of electric wire lay among the rocks. At least one Frigate Bird had died after becoming entangled in this.

Laysan Island. --Several large lockers which contained rusting metal fittings lay abandoned near the camping place. I was told that these had been left there by an unauthorized military survey team that visited Laysan a few years previously.

Figure 4.(KWK 66-25-13). --Military debris, East Island, French Frigate Shoals, 14 September 1966. On islands, where military stations were established either during or after World War II, the rotting structures remain to destroy the natural beauty of these areas. Because of the heat, high humidity, and salt spray, buildings such as those shown in the background are disintegrating. These structures do not appear to be detrimental to bird life. Red-footed Booby nests containing downy young were among the remains of the structures and the immature birds shown may have been hatched here. A Red-tailed Tropic Bird was incubating beside a crumbling metal wall. Nevertheless, the military should be obliged to remove material when they abandon a base such as this.

Pearl and Hermes Reef. --On Southeast Island there is a stack of about 15 rusty, 55-gallon oil drums and a rectangular rusting metal tower about 20 feet high, of military origin.

Kittery Island had recently been visited by an unauthorized military party in a helicopter. The party left behind a 55-gallon drum of aviation gasoline.

It appears that if a military party sets foot on an island it must leave a litter of durable trash behind.

## THE HAWAIIAN MONK SEAL[1/]

When compared to other pinnipeds, the biology of the monk seal presents certain interesting features: (1) It is the only truly subtropical seal. (Its latitudinal range is overlapped by the California sea lion and northern elephant seal in Baja California, Mexico but water and air temperatures there are lower than in the Leeward Hawaiian Islands.) (2) It bears young during a prolonged pupping season that extends about 9 months, from December into August. (3) The season of molt is prolonged. Molting seals have been observed from May to November. (4) Although genetically tame and easily approached, it apparently will not tolerate human disturbance on its basking and breeding beaches.

During the September 1966 inspection of the Leeward Hawaiian Islands, we attempted to obtain as much biological data as possible. If this rare seal is ultimately to be preserved in the face of growing human population pressures, considerably more knowledge of its biology should be gained. During our short September trip we gathered information that I believe points up the need for a comprehensive, long-term study of the Hawaiian monk seal.

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1/ Some of these data have been written as a preliminary draft for possible journal publication. I hope that Kridler and Walker will consent to be coauthors.

For example, we have today only fragmentary information on the following biological questions:

1. Little is known concerning courtship and breeding. Where and when does it take place?

2. Do seals regularly move from one atoll to another? If so, do they always return to a home territory to bear young?

3. What is the significance of the extended molting and pupping seasons?

4. What has happened to monk seal populations where human populations are now superimposed on their habitat?

5. Is there any way to preserve a monk seal population in close proximity to a human population?

6. How many monk seals exist?

7. Do the seals regularly spend long periods at sea? Apparently they do but when and why individuals leave the basking beaches or conversely why they spend long periods on the beaches are not known.

8. What portion of the seal population is at sea in different seasons?

9. What is the annual mortality and recruitment rate?

10. How much influence do introduced species, for example flies (figs. 5 and 6), have on basking behavior?

Distribution

Monk seals are known to breed only on the six atolls having low sandy islands (from west to east, Kure, Midway, Pearl and Hermes Reef, Lisianski, Laysan, and French Frigate Shoals), but they have been recorded among the main islands as far as 700 nautical miles from the nearest breeding ground.

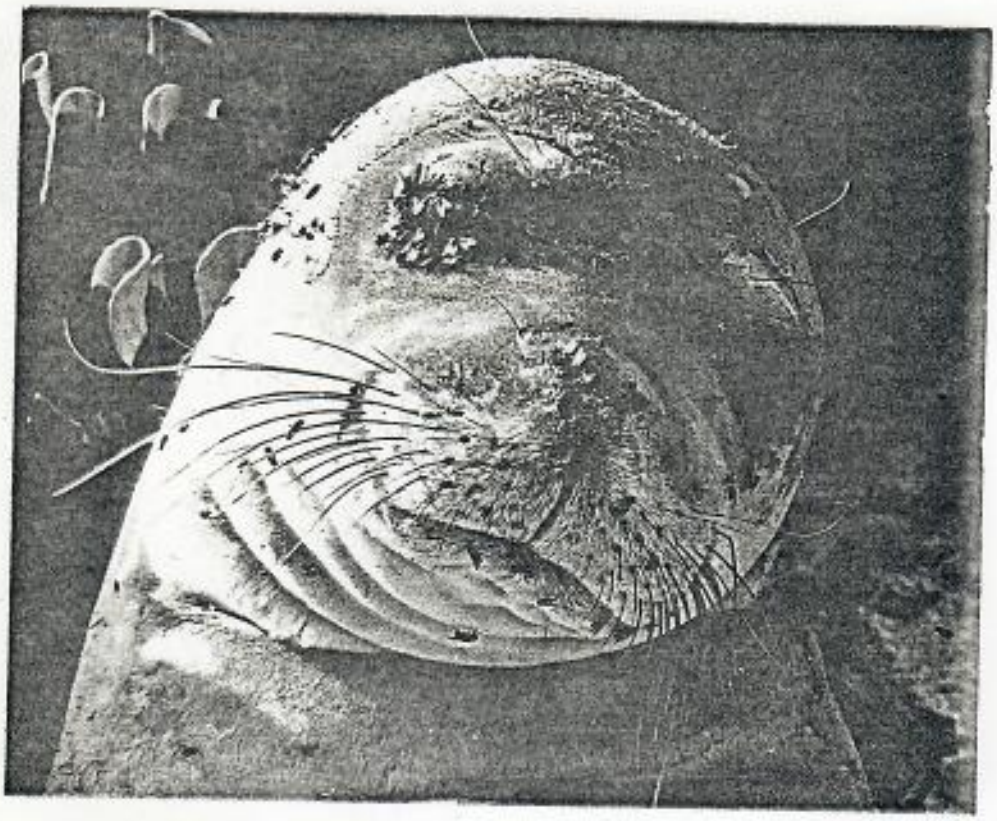

Figure 5 (KWK 66-27-25). --Laysan Island, 18 September 1966. Swarms of flies, as shown here, accumulate when monk seals sleep high on beaches during the day. Perhaps it is for this reason (see Butler and Udvardy, 1966) that monk seals move to the water's edge after sleeping all night near the edge of Scaevola, about 30 meters from the water. The photograph was taken shortly after sunrise. Soon afterward the seal went to the water's edge. It is said that guano diggers of the late 1800's introduced an Asian house fly. This fly is now extremely abundant. At no time during daylight hours were there less than 100 about the head of each expedition member.

Molting is also demonstrated in this photograph. The epidermis with old hair attached still clings to the top and sides of the head. The new hair is shown on the muzzle, neck, and chest.

In September 1964, Kridler saw 6 monk seals on Necker Island and on the September 1966 trip we saw 10 there. In addition, we found five monk seals at Gardner Pinnacles (table 1). These are the first recorded sightings of seals on these islands. Because these islands are precipitous, hauling-out places are limited. At Necker we saw seals hauled out on four narrow, rocky beaches having north and east exposures as shown on Appendix Map 1. During storms from northerly or easterly directions, these hauling grounds would probably be wave-washed and unsuitable. Since the areas noted appear to be the only available for hauling out, it is doubtful that Necker could become an important breeding island.

At Gardner Pinnacles the seals hauled out on a sloping shelf of wave-smoothed rock on the southwest exposure of the smaller pinnacle (Appendix Map 3). We saw no other suitable hauling-out place and during stormy weather the one we saw would surely not be usable.

The observations of seals at these islands are an additional indication (see Kenyon and Rice, 1959) that monk seals travel long distances in the open sea. The nearest known breeding area is French Frigate Shoals, 75 miles northwest of Necker and 115 miles southeast of Gardner Pinnacles.

Numbers

Soon after landing on each island, we walked the entire beachline and recorded data on each of the 521 seals that we saw. When possible, the sex and approximate age of each seal was ascertained (table 1).

Aerial and surface counts of monk seals were conducted in the winter to spring period of 1956-57 and in the spring of 1958. These yielded total counts of 1,013 and 1,206 seals, respectively, on the six known breeding atolls (Kenyon and Rice, 1959, p. 221; Rice, 1960, p. 377). The 1966 counts on the five atolls that we visited are compared with the 1958 counts in table 1.

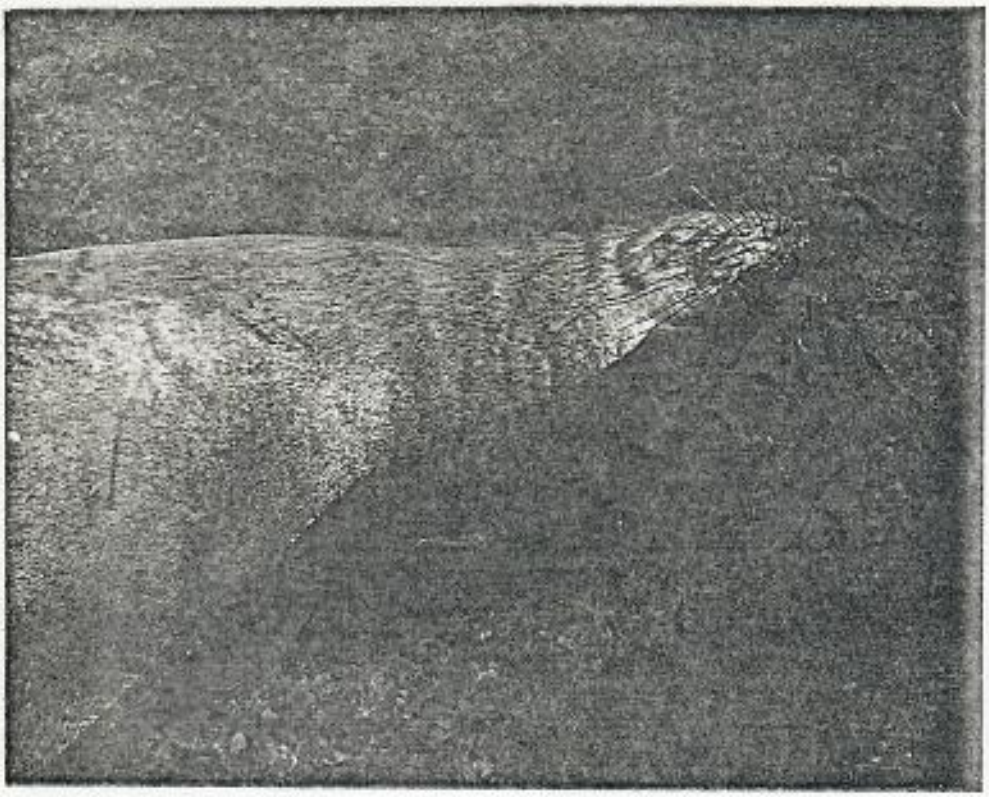

Figure 6 (KWK 66-23-8). --Southeast Island, Pearl and Hermes Reef, 23 September 1966. Monk seals often spend the days sleeping partially submerged in shallow water near shore. This seal, which was resting at the edge of a small lagoon, was surrounded by a swarm of small fish which nibbled at the pelage. Presumably they ate the green algae (Pringsheimiella) that grows in the pelage of monk seals. On land, seals' eyes, nose, and mouth are often covered by flies (fig. 5). Possibly it is for this reason that the seals sleep where they are washed by the surf or, as in this case, actually in the water. This seal periodically raised its nostril above the surface and inhaled, then lowered its head and exhaled slowly while the nostrils were under water. It did not seem to be disturbed by the fish.

Table 1. --Monk seals observed in the Leeward Hawaiian Islands in September 1966

| Location | Date Sept. 1966 | Male | | | Female | | | Sex? | | | 1966 total | 1958 total[1/] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Ad. | S. ad. | Pup | Ad. | S. ad. | Pup | Ad. | S. ad. | Pup | | |
| Necker I. | 10-11 | 1 | 1 | 1 | 2 | - | - | 5 | - | - | 10 | |
| | | | | | | | | | | | 10 | - |
| French Frig. S. | | | | | | | | | | | | |
| Shark I. | 12 | - | - | - | - | - | - | 1 | 1 | - | 2 | |
| Trig I. | 12 | 2 | 1 | 1 | 5 | 1 | - | 1 | 2 | 4 | 17 | |
| Whale-Skate | 13 | 3 | 4 | 4 | 1 | 1 | 2 | 2 | 1 | 5 | 23 | |
| East I. | 13 | 2 | 1 | 1 | 2 | - | 1 | - | 1 | - | 8 | |
| Gin I. | 13 | 2 | - | - | 1 | 1 | 1 | - | - | - | 5 | |
| Tern I. | 12-13 | - | - | - | - | - | - | - | - | - | 0 | |
| | | 9 | 6 | 6 | 9 | 3 | 4 | 4 | 5 | 9 | 55 | 43 |
| Gardner Pinn. | 16 | - | - | - | - | - | - | 3 | 2 | - | 5 | |
| | | | | | | | | | | | 5 | - |
| Laysan I. | 17 | 69 | 19 | 9 | 19 | 28 | 11 | 26 | 21 | - | 202 | |
| | | | | | | | | | | | 202 | 326 |
| Lisianski I. | 19 | 63 | 8 | 8 | 27 | 8 | 7 | 11 | 5 | 2 | 139 | |
| | | | | | | | | | | | 139 | 281 |
| Pearl and Hermes Reef | | | | | | | | | | | | |
| Kittery F. | 21 | 9 | 2 | - | 3 | 1 | - | 4 | 2 | - | 21 | |
| Seal | 21 | 1 | 1 | 3 | - | - | 2 | 2 | - | - | 9 | |
| Grass | 21 | 3 | - | 1 | 1 | 1 | - | 3 | 3 | - | 12 | |
| Sand | 21 | - | 1 | - | 1 | - | - | 1 | - | - | 3 | |
| Southeast | 20 | 2 | 1 | 2 | 4 | 5 | 1 | 2 | 8 | 2 | 27 | |
| S. North | 22 | 3 | 1 | - | 3 | - | 1 | 1 | 1 | 1 | 11 | |
| North | 22 | 2 | 1 | 3 | 5 | 5 | 2 | 5 | 1 | 2 | 26 | |
| | | 20 | 7 | 9 | 17 | 12 | 6 | 18 | 15 | 5 | 109 | 338 |
| Midway Atoll[2/] | 28 | - | - | - | - | - | - | 1 | - | - | 1 | |
| | | | | | | | | | | | 1 | 76 |
| Total | | 162 | 41 | 33 | 74 | 51 | 28 | 68 | 48 | 16 | 521 | 1,064 |
| Group totals | | | 236 | | | 153 | | | 131 | | | |

1/ From Rice, 1960, p. 377.

2/ Incomplete coverage. Only Seal Islet, Rocky Islet, Sandspits, Dynamite Islet and Eastern Island were seen.

It is shown that the 1966 fall count was approximately one-half the 1958 spring count for the areas covered. This does not necessarily indicate that the monk seal population declined in the 1958 to 1966 period. Aerial counts of seals are usually higher than surface counts, particularly where seals may be on small islets or reefs that are difficult to visit on a surface survey. Sample counts at Midway Atoll during a year (1956-57) revealed that monk seals are least abundant on land in summer and fall and most numerous there in winter and spring.

The 1966 count on Midway can be compared with earlier counts only to a limited degree (see: Behavior when disturbed). The available data apparently indicate, however, that a population reduction has occurred at Midway. Observations and counts from Midway are needed to document the present condition of the Midway population. Particularly needed are aerial counts comparable to those made in the 1956-58 period.

No observations were obtained at Kure Atoll on the September 1966 trip. In the light of the available Midway observations, data from Kure should be obtained for comparison with data from there prior to 1960 when it became occupied by a permanently manned U. S. Coast Guard Station.

Data (see: Behavior when disturbed) from Midway Atoll, Pearl and Hermes Reef, and French Frigate Shoals appear to indicate that human disturbance may cause population reduction in local areas. The significance of local disturbance on the total Hawaiian Islands monk seal population should be studied. It is quite possible that the monk seal population today is less than the estimate of 1,350 made by Rice (1960).

Table 2 summarizes five comprehensive counts of monk seals made in the Leeward Hawaiian Islands from 1957 to 1966. On the three most important islands (Laysan, Lisianski, and Pearl and Hermes Reef), where counts were obtained during the five study periods, the fluctuation is such that no population trend is indicated. Since selection of high counts was made in 1957 and 1958, the totals shown are not comparable with the 1964 and 1966 counts which were made on one trip around each island. The only conclusion indicated by these counts is that the monk seal populations at the three important islands did not change in a detectable way.

Table 2. --Counts of monk seals in the Leeward Hawaiian Islands, 1957-66

| Island | 1957 Spring 1/ | 1958 Spring 2/ | 1964 March 3/ | 1964 Sept. 3/ | 1966 Sept. 4/ |
|---|---|---|---|---|---|
| Nihoa | NC | NC | 1 | 1 | NC |
| Necker | NC | NC | NC | 6 | 10 |
| French Fr. Shoals | 35 | 43 | NC | 43 | 55 |
| Gardner Pinnacles | NC | NC | NC | NC | 5 |
| Laysan | 233 | 326 | 310 | 252 | 202 |
| Lisianski | 256 | 281 | 180 | 121 | 139 |
| Pearl and Hermes Reef | 290 | 338 | 121 | 88 | 109 |
| Midway | 71 | 76 | NC | NC | 1 |
| Kure | 128 | 142 | NC | NC | NC |
| Total | 1,013 | 1,206 | 612 | 511 | 521 |

NC=no count.

1/ Highest count; various aerial and surface counts made (Kenyon and Rice, 1959).

2/ Highest count; various aerial and surface counts made (Rice, 1960).

3/ Surface counts (Kridler letter, 1966).

4/ Surface counts.

Marking

Tagging.--Monel cattle-ear tags, manufactured by the National Band and Tag Company, Newport, Kentucky, were placed in the web of the hind flippers of 86 seals of all ages and both sexes (table 3).

Three procedures were used: (1) young seals, about 1 to 6 months of age and still in gray postnatal pelage, were captured by hand and held by the hind flippers by one man while a second applied the tag. (2) Yearlings and 2-year-olds were captured by two men using a nylon tarpaulin fastened between two metal rods (fig. 7). The thrashing, squirming seal was then forcibly held down by the captors while a third man grasped the hind flippers (fig. 8) and applied the tag. Even when restrained in this way, there was danger that one of the captors would be bitten. (3) Sleeping seals were stealthily approached and the tag was applied quickly. Often seals awoke at the instant the tagging pliers touched the flipper (fig. 9). Large seals, once awakened were not tagged.

The tagging of very young seals (pups and yearlings) is preferable: (1) The age of pups is known quite accurately and of yearlings approximately. Therefore, returns will be more useful in future population dynamics, aging and growth studies than returns from seals tagged at an unknown age. (2) The tag can be checked closely after application to assure that it is clinched. Unknown tag loss caused by faulty application could cause considerable inaccuracy in certain population dynamics studies.

Most tag returns must be obtained by reading the number while the tag is attached to the flippers of sleeping seals. The present tags having a number on only one side render this difficult or impossible if the numbered side is down. I saw two seals bearing tags from a previous season which I was unable to read for this reason. As soon as I touched the tags the seals awoke and energetically departed. Kridler expects to obtain tags bearing a number on both sides before his next expedition.

Table 3. --Monk seal tagging summary, 1966

| Date 1966 | Location | Male | | | Female | | | Sex? | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Ad. | S. ad. | Pup | Ad. | S. ad. | Pup | Ad. | S. ad. | Pup | |
| 13 Sept. | French Frigate Shoals | - | 1 | 4 | 1 | - | 2 | - | - | - | 8 |
| 18 Sept. | Laysan I. | 1 | 1 | 4 | - | 1 | 3 | - | 1 | - | 11 |
| 19 Sept. | Lisianski I. | 2 | 3 | 4 | - | 1 | 5 | - | - | - | 15 |
| 20-26 Sept. | Pearl and Hermes Reef | 8 | 5 | 11 | 12 | 4 | 9 | 2 | - | 1 | 52 |
| Total | | 11 | 10 | 23 | 13 | 6 | 19 | 2 | 1 | 1 | 86 |
| | | | 44 | | | 38 | | | 4 | | |

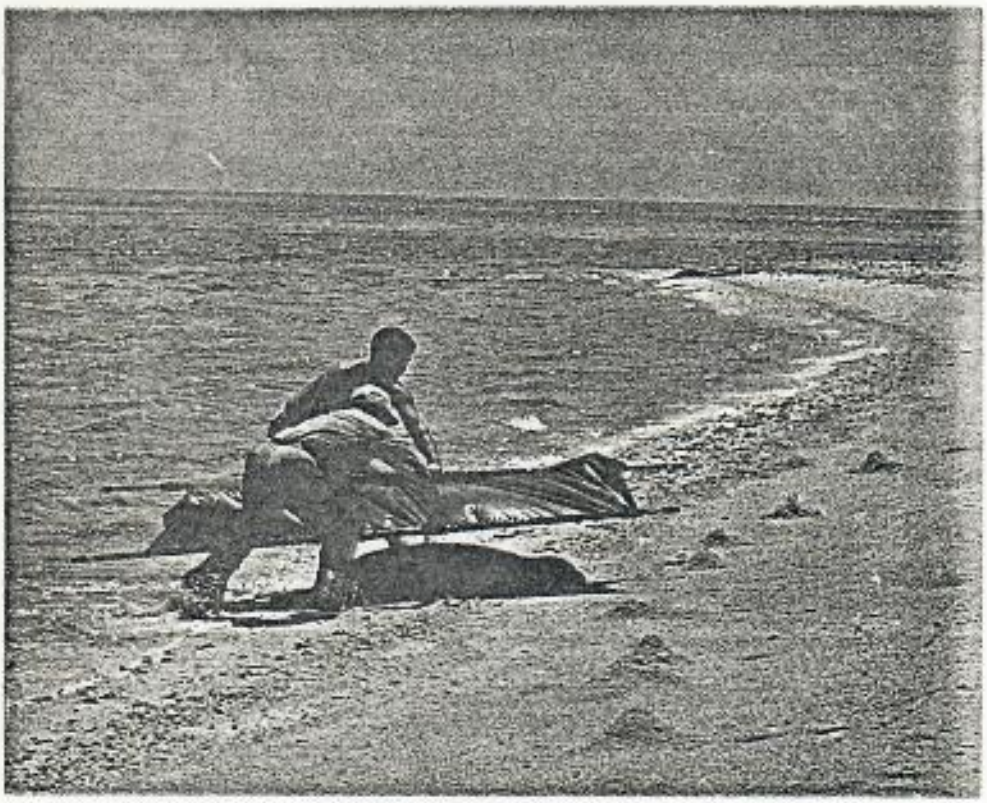

Figure 7 (KWK 66-24-14). --Whale-Skate Island, French Frigate Shoals, 13 September 1966. A sleeping monk seal is captured under a nylon tarpaulin held rigid by two metal rods on the edges. This device was reportedly developed by biologists of the Pacific Project working on Kure Atoll. We found it effective for catching and holding seals 1 and 2 years of age. Older seals could be captured with a similar but more heavily constructed device. The animals struggled violently and if the head was not covered there was danger to personnel from the seal's teeth. The sand mounds on the beach were made by ghost crabs.

Painting. --At Southeast Island, Pearl and Hermes Reef, on 20 September, four seals were marked on their backs with red paint from a pressure spray can. On the following morning one of these was seen at Grass Island about 5 nautical miles west of where it was marked. This observation and others of seals at intermediate points between islands in the lagoon indicate that the home range of seals may include several or all islets of the lagoon. The usefulness of paint in marking seals is, of course, limited to short-term studies.

Figure 8 (KVK 66-24-10). --Whale-Skate Island, French Frigate Shoals, 13 September 1966. After a sleeping monk seal was captured under the tarpaulin, its hind flippers were held and the web spread so that a tag could be attached. Tagging by this method is superior to tagging a sleeping seal on the beach because the tag can be checked to see if it has clinched properly.

## Behavior When Disturbed

If monk seals are awakened and disturbed by the close approach of human observers (fig. 9) they usually take to the water. When a tag is attached to the flipper of a sleeping seal, it awakens with a violent start and immediately enters the water. Because of our activities on Southeast Island, Pearl and Hermes Reef, we frequently disturbed monk seals that hauled out to rest or sleep on the beaches.

Figure 9 (KWK 66-28-36). --Southeast Island, Pearl and Hermes Reef, 26 September 1966. Refuge Manager Eugene Kridler attempts to tag a resting, subadult, Hawaiian monk seal. Monk seals often slept soundly enough so that they could be approached and a monel metal tag attached to the web of the hind flipper. Often the seal awoke the instant it was touched, as in this case, and could not be tagged. Usually seals do not awaken if they are quietly approached, but if touched on any part of the body they awaken immediately.

In order to evaluate the effects of disturbance on the seals, data on the number of seals on land was kept on 4 days during 10 complete circuits of the island (table 4).

Table 4. --Monk seals counted on Southeast Island, Pearl and Hermes Reef, September 1966

| Date | Time of observation | Seals on land | Remarks[1/] |
|---|---|---|---|
| 20 Sept. | 1030-1140 | 27 | Hot, sunny--seals disturbed by tagging. |
| 24 Sept. | 1500-1600 | 18 | Hot, sunny--seals disturbed by tagging. |
| 24 Sept. | 1920-2005 | 17 | Dark, seals not disturbed. |
| 25 Sept. | 0600-0705 | 13 | Sunrise 0615--seals not disturbed. |
| 25 Sept. | 1545-1630 | 19 | Hot, sunny--seals disturbed by tagging. |
| 26 Sept. | 0000-0200 | 9 | Dark, seals disturbed by tagging. |
| 26 Sept. | 0600-0645 | 9 | Sunrise 0615--seals not disturbed. |
| 26 Sept. | 0930-0945 | 6 | Hot, sunny--seals disturbed by tagging. |
| 26 Sept. | 1400-1445 | 6 | Hot, sunny--seals disturbed by tagging. |
| 26 Sept. | 1500-1600 | 10 | Hot, sunny--seals disturbed by tagging. |

1/ Tags were placed on a total of 33 seals during the observation period.

When we arrived at the island on 20 September there were 27 seals on land. Many of these left the beach during our first circuit and the highest number subsequently on land at one time was 19. Our highest count on 26 September, our last day on the island, was 10 seals. It appears that some seals, once frightened off the beach, do not soon return. Certain recognized individuals, however, repeatedly returned to a favorite resting place.

During the study period, 33 seals were tagged on Southeast Island. It is thus apparent that "new" seals were constantly coming to the island. It is indicated also that when seals were disturbed and entered the water, many individuals did not return there during this period.

An important question is: How much human disturbance can a local monk seal population tolerate before permanently abandoning breeding and hauling grounds? If, by disturbance, the population of an island or atoll is forced to abandon an area, and population in other areas are already near a natural maximum density, it follows that the total population of the species may become permanently reduced. Also, Rice (1960) demonstrated that at Midway, where human activity was a dominant feature of the environment, survival of young to weaning was much lower than at uninhabited atolls.

Perhaps at Midway Atoll and French Frigate Shoals the population is already permanently reduced. At Midway in late September of 1957 the mean of three boat counts was about 25 seals (Kenyon and Rice, 1959, p. 231). On a boat trip through the same area on 28 September 1966 I saw only one seal. During a complete circuit of Eastern Island, on the same day, I saw no seals. In 1957 I do not remember ever seeing fewer than three to six seals and sometimes more on the beaches of Eastern Island. Reports of other observers and conversations with people now living at Midway reveal human activity on the beaches of Eastern Island is greater today than it was in 1957 and that monk seals are seldom seen there at any season (see Map 7).

Green Island, Kure Atoll, has had a human population since 1960. Reports indicate that the monk seal population there may be following a pattern of reduction similar to that observed at Midway. Ronald Walker told me that occasionally monk seals now haul out on Green Island but that they usually resort to offshore sandspits. On 5 June 1957, we counted 128 seals at Kure, most of them on the beaches of Green Island.

Tern Island at French Frigate Shoals has been occupied by a U.S. Coast Guard Loran Station for a number of years. During our visit there on 12 and 13 September 1966 I was told by one of the men stationed there that during regular beach searches for glass floats they rarely saw a seal and we found none there. On visits to four other islets in this atoll (rarely visited by the men) we found seals on each and counted a total of 55 (table 1, map 2).

Since the Hawaiian monk seal is known to breed on only six atolls, the possible loss of important hauling-out and breeding areas at Midway, Kure, and French Frigate Shoals (where we found about 23 percent of the 1957 population) is unfortunate.

The desertion by seals of islands having a human population and the quantitative data gathered in September 1966 at Southeast Island, Pearl and Hermes Reef, indicate that when seals are subjected to continuous human disturbance they tend to abandon the area of disturbance. In this respect they apparently differ in some degree from some other marine wildlife species such as the northern fur seal and Laysan Albatross. These species continue to return to traditionally used areas in spite of continuing human disturbance. Perhaps this behavioral characteristic of Monachus is in part the reason that the Mediterranean monk seal is reduced to a relict population and the Caribbean monk seal is apparently extinct.

## Pupping Season

Births were previously recorded in the period December to June, with an apparent peak of frequency in the mid-March to mid-May period. On 13 September 1966 a nursing gray (postnatal pelage) pup was found on East Island, French Frigate Shoals (fig. 10). From the condition of its pelage and estimated weight (ca. 100 lb.) its age was estimated at about 4 weeks (see Kenyon and Rice, 1959, p. 248), so that it must have been born in mid-August. Another gray pup in company with its mother was seen on 22 September 1966 on North Islet, Pearl and Hermes Reef. It appeared near weaning age of about 5 weeks. Fat, recently deserted, gray pups were also recorded on Laysan (2), Lisianski (4), Pearl and Hermes Reef (5). Based on previous field observations, I estimated their ages to be about 6 to 10 weeks. Thus it would appear that young may be born during a longer period than was previously known. Since no pups in the black natal pelage were seen, it may be presumed that the pupping season extends through the 9-month, December-August period.

## Sex Ratio

Adults. --In a previous study we found that when the sex of seals on beaches was recorded, males sometimes outnumbered females. The mean ratio in five counts was 66 percent males to 34 percent females (Kenyon and Rice, 1959, p. 222). These figures were obtained in the January to May period. It is thus of interest to note that our September counts yielded a similar ratio, from table 5, 69 percent males to 31 percent females among 236 adults recorded. The difference between the observed number of adult males and females is significant ($X^2$=32.8 with 1 degree of freedom; $P<.001$). The highest ratio of males (78 percent) to females (22 percent) was found among 88 adult seals on Laysan Island.

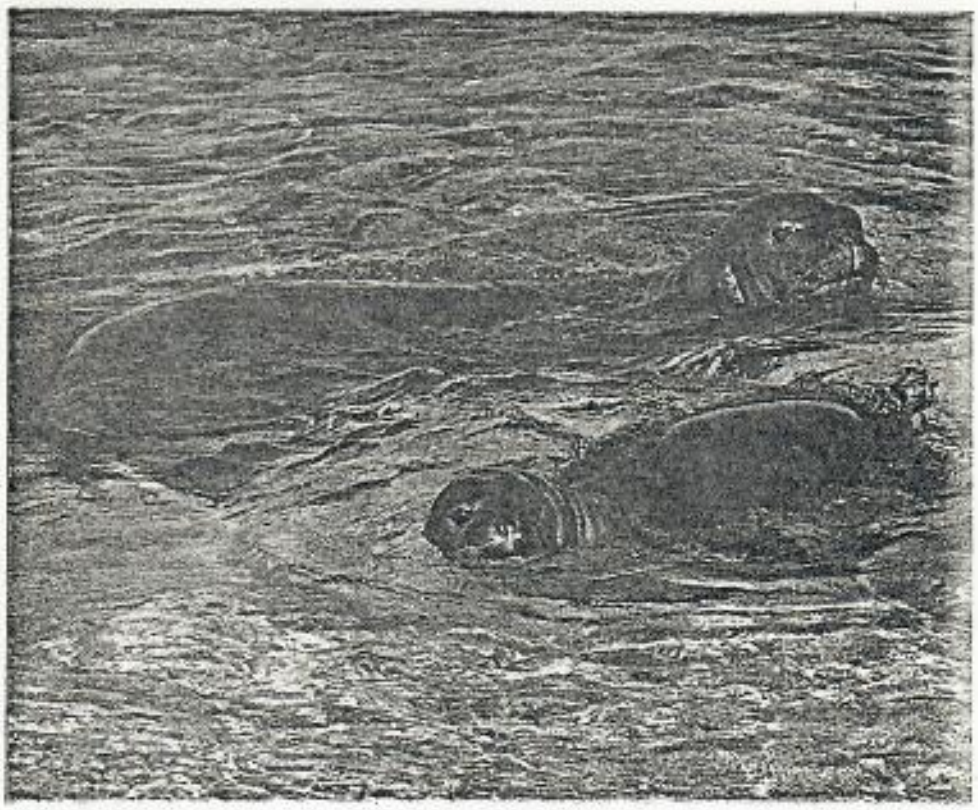

Figure 10 (KWK 66-25-20). --This 4-week-old monk seal, accompanied by its mother, was found at East Island, Pearl and Hermes Reef. On the basis of data on molt and growth previously obtained, the estimated time of birth of this one and another at Pearl and Hermes Reef was mid-August. This is the latest time of birth recorded. The estimated weight of this pup was 90 to 100 pounds. Young are deserted by the mother at the end of the 5- to 6-week nursing period when they weigh about 130 to 145 pounds.

Immature. --Among juveniles (estimated ages 1 month to 3 years) the sex ratio was more nearly equal. Among 153 animals, 48 percent were males and 52 percent females (table 5). Previous studies (Kenyon and Rice, 1959, p. 222; Rice, 1960, p. 382) also indicated that the sex ratio at birth was approximately 50:50.

Table 5. --Sex ratio of monk seals observed on Hawaiian Islands beaches in September 1966

| Location | Date | Adults | | | | Juveniles | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | ♂ | | ♀ | | ♂ | | ♀ | |
| | | No. | % | No. | % | No. | % | No. | % |
| Necker I. | 10-11 | 1 | 30 | 2 | 70 | 2 | 100 | - | - |
| French Frigate Shoal | 12-13 | 9 | 50 | 9 | 50 | 12 | 63 | 7 | 37 |
| Laysan I. | 17 | 69 | 78 | 19 | 22 | 28 | 42 | 39 | 58 |
| Lisianski I. | 19 | 63 | 70 | 27 | 30 | 16 | 52 | 15 | 48 |
| Pearl and Hermes Reef | 20-22 | 20 | 54 | 17 | 46 | 16 | 47 | 18 | 53 |
| Total | | 162 | 69 | 74 | 31 | 74 | 48 | 79 | 52 |

Possible explanations for the difference in the sex ratio of adults are: (1) The female monk seal remains constantly with her pup from birth until she deserts it at the end of approximately a 6-week nursing period. She does not eat while nursing her pup. Her fat reserves supply enough milk to permit her pup to nearly quadruple its birth weight during the approximately 5- to 6-week nursing period. At parturition the female is extremely obese. Perhaps, in order to attain a large blubber reserve, the females feed at sea for extended periods. In general, males are less obese than females, possibly they eat less and perhaps for this reason are seen in greater numbers on shore. (2) If females spend more time at sea feeding, they are exposed to mortality factors (such as sharks) to a greater degree than males and thus, in the adult population males may actually outnumber females because of differential mortality.

A continuing study which would include many observations of tagged seals will be necessary to obtain an understanding of the causes of the difference in the numbers of adult males and females seen basking on beaches.

Food Habits

Two spewings of stomach contents were found near resting places frequented by seals on the beach of Southeast Island, Pearl and Hermes Reef. Specimen samples from the spewings were identified (table 6) by Donald W. Strasburg, Bureau of Commercial Fisheries, Hawaii. In a letter of transmittal, John C. Marr said of these specimens that "all of these forms are common on our reefs, and some are cryptic by day. This suggests that they may have been consumed at night."

The largest individuals among the food items consumed were the octopuses. The largest may have weighed about 0.2 kg. (1/2 pound). The fish were all smaller. A nearly intact Aweoweo skeleton measured 95 mm. (3-3/4 in.) in length and a filefish 88 mm (3 in.). All fishes were similar in size. The eel skeletons were broken into pieces but the largest individual probably did not exceed 400 mm (16 in.) in length. Remains of food organisms larger than those mentioned were not found in the stomach contents

Table 6. --Food of two Hawaiian monk seals

| Food species | Sample 1[1/] | | Sample 2[1/] | |
|---|---|---|---|---|
| | Number individuals | Percent volume | Number individuals | Percent volume |
| Octopus sp. | 5 | 50 | - | - |
| Moray eel Gymnothorax sp. | 2 | 10 | - | - |
| Aweoweo or redfish Priacanthus cruentatus | 33 | 30 | 13 | 75 |
| Filefish Pervagor spilosoma | 6 | 10 | 4 | 25 |
| Total | 46 | 100 | 17 | 100 |

1/ The spewings were dry when found on 23 September 1966. Their approximate volume when wet was estimated to be: sample 1, ca. 1,500 ml., and sample 2, ca. 500 ml.

of two seals that were previously examined (Kenyon and Rice, 1959, p. 232). The available specimen material indicates that when monk seals feed in atoll lagoons where moderately large fish of many species are abundant they select small fishes, eels, and cephalopods.

## Time of Feeding

On several occasions at Southeast Island, Pearl and Hermes Reef, we saw seals haul out in late afternoon or early evening and found them in the same location during the night and at dawn. Two of these, at different locations, awoke naturally just before sunrise and entered the water. They headed out into the lagoon, swimming submerged but near the surface until about 100 to 200 meters from shore. Then the seals appeared to find a feeding place as they surfaced in the same location following several dives. One dive was timed at 2.5 minutes, after which the seal moved about at the surface shaking its head about and moving its jaws, and appeared to be swallowing food. It thus appeared that these seals preferred to sleep on land all night and fed after dawn. Similar feeding behavior was not observed later in the day.

## Molt

Molting in the monk seal occurs in all seasons. Little quantitative data have previously been recorded on the stages of molt at any particular season. During our September 1966 survey we recorded the observed stages of molt of 304 seals of known sex and estimated age in an attempt to ascertain whether or not different age or sex classes displayed differences in their time of molt.

Stages of molt. --As described in Kenyon and Rice (1959) the pelage in the premolt period is dull brownish in color. During the molting period, the epidermis and hair are shed in large patches. The new pelage of the postmolt period is whitish ventrally and bright, silvery gray dorsally. By inspection, we classified each seal seen in one of these categories (table 7). The two categories most quickly recognized were "molting" and "postmolt." The length of time required for the new pelage to change from bright silver to dull brown is not known.

Table 7. --Molt in 304 Hawaiian monk seals, 10-22 September 1966

| Stages of molt | Adults | | | | | | Subadults | | | | | | Pups and yearlings | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ♂ | | ♀ | | Total | | ♂ | | ♀ | | Total | | ♂ | | ♀ | | Total | |
| | No. | % | No. | % | No. | % | No. | % | No. | % | No. | % | No. | % | No. | % | No. | % |
| Pre-molt | 23 | 17 | 10 | 17 | 33 | 17 | 0 | 0 | 5 | 12 | 5 | 7 | 8 | 35 | 5 | 24 | 13 | 30 |
| Molting | 23 | 17 | 8 | 14 | 31 | 16 | 4 | 13 | 1 | 3 | 5 | 7 | 1 | 4 | 0 | 0 | 1 | 2 |
| Post-molt | 86 | 65 | 40 | 69 | 126 | 66 | 27 | 87 | 33 | 85 | 60 | 86 | 14 | 61 | 16 | 76 | 30 | 68 |
| Total | 132 | | 58 | | 190 | | 31 | | 39 | | 70 | | 23 | | 21 | | 44 | |

In general, when seals were seen in the process of losing epidermis and attached hair the new silvery pelage was seen beneath it. In two adults, however, the new hair had not erupted before the old hair and epidermis were lost. The dark, brownish-black skin was bare except where pieces of coral sand adhered to it.

Unknown factors might bias the data in table 7. For example: It is probable that seals come ashore and remain there during the molting period. Several seals, covered with strips and loose patches of skin and hair, entered the water when disturbed. When they emerged a short time later all loose skin and hair were washed away. It thus appeared that these seals had spent a number of days continuously on land while molting. The seals seen on land, therefore, may be there because they are molting and therefore form a biased sample of the total population in this respect. It has been observed (Kenyon and Rice, 1959) that in female seals the molt is delayed until after the nursing period. Because parturition may occur from December to August, it might be expected that molting females would be seen at varying times in the year. In the following discussion it should be remembered that because we lack comprehensive knowledge of many aspects of the biology of the monk seal, some unknown factor may bias the data.

Adults and subadults. --The data from all areas visited is summarized in table 7. There is no difference in the time of molt according to sex among adult and subadult seals on the beaches in September (table 7). According to age, however, the difference in the time of the stages of molt is significant. In mid-September, 86 percent of the immature seals had completed the molt and only 66 percent of the adults ($X^2=18.63$, d.f. =7; $P<0.01$).

This finding is in accord with the discovery of Scheffer and Johnson (1963) that in the northern fur seal immature animals begin the molt earlier than adults. Old female fur seals were the last to complete the molt.

Pups and yearlings. --Included in this category were 44 seals (table 7) that ranged in age from a few weeks to more than 1 year. The natal coat is lost a few weeks after birth and the pupping season is long. In recording our data, freshly molted pups were lumped with probable yearlings establishing their annual molting cycle and the pattern of molt in these early stages is obscured by this mixed data and has been excluded from this discussion.

## Mortality

Remains of two dead seals were found on Laysan Island and one on North Island, Pearl and Hermes Reef. All three had been dead for a long period and no cause of death could be assigned. No specimens were saved from the Laysan remains because the parts were scattered. The skull was preserved from the seal, aged about 1 year, found at Pearl and Hermes Reef. Kridler will add this to his refuge reference collection.

Because all beaches on all islands visited were surveyed and only the remains of three seals were found, it is indicated that mortality, on land at least, is low. Because a comprehensive program of marking and recovering marked seals has not yet been conducted, nothing is known of mortality at sea.

## ALBATROSSES

No living Laysan (Diomedea immutabilis) or Black-footed Albatrosses (D. nigripes) were seen at sea or on land. Remains of dead birds were, however, found on all breeding islands. The largest numbers were seen on Laysan Island and at Pearl and Hermes Reef, and a study of the remains was made at Southeast Island.

### Ingestion of Indigestible Matter by the Laysan Albatross[2/]

The ingestion of quantities of indigestible materials, primarily pumice and plastics by the Laysan Albatross (Diomedea immutabilis) has not previously been recorded. The ingestion of pumice by the Southern Skua (Catharacta skua lonnlergi) is discussed by Simpson (1965), and Bierman and Voous (1950) present information on stomach stones found in Antarctic Petrels.

During an inspection of the Hawaiian Islands National Wildlife Refuge from 8 to 28 September 1966, an opportunity was afforded to examine the hard materials in the remains of Laysan Albatrosses that had died in the June to August 1966 fledging period. On 24 September specimens from 100 birds were collected on Southeast Island, Pearl and Hermes Reef (lat. 27°46'45" N., long. 175°48'45" W.).

Materials and methods.--A total of 386 dead Laysan Albatrosses were counted above the high-water mark on a circuit of the island, the maximum dimensions of which are approximately 900 and 300 meters. Most of the birds were on the beach or in the vegetation (primarily Tribulus and Portulaca) near it.

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2/ This is written as a preliminary draft to be submitted later for journal publication. I hope that Kridler may add supplementary data on number of young albatrosses observed on Southeast Island in recent years and consent to be coauthor.

A few were scattered farther inland. Remains of some at the tideline that had been broken into fragments by wave action were not enumerated, but after an examination of all beaches and inland areas we estimated at least 450 to 500 Laysan Albatrosses had died there shortly before fledging. Remains of only four Black-footed Albatrosses (Diomedea nigripes) were identified. In the 1957-58 nesting season it was estimated from aerial photographic counts that 14,000 pairs of Laysan Albatrosses were on this island. If the population has remained stable, it is indicated that mortality in the final stages of the nesting season is about 3 to 4 percent.

In the 2 to 3 months after death, dermestid beetles and other insect larvae had consumed all soft body parts, leaving only feathers, bone, and hard items that were in the gastrointestinal tract at death. Body oils, rain, and salt spray had caused the feathers to stick together protecting, like a tent, the skeleton and other hard items within.

The exposed side (usually the back) was lifted off to reveal the contents of the body cavity (fig. 11). All foreign nonfood items were collected and tabulated. Later in Seattle they were washed, dried, sorted, and weighed (table 8). Squid beaks, being the remnants of normal albatross food were not preserved for the present study, except that samples for identification were taken.

The study sample was obtained in two areas. Half was taken along the western beaches and half along the eastern beaches of the island. Each bird in order along the beach was examined. No selection was made, except that birds that were mutiliated (presumably by wind or the passage of monk seals (Monachus schauinslandi)) and their parts scattered were omitted.

Results. --In table 8 the number of pieces and weights of various items found are summarized. Only 9 birds were empty and in 11 squid beaks were absent. Squid beaks were numerous in the majority of birds, ranging from about 10 to several hundred. It was thus indicated that nearly 90 percent of these dead birds were fed until shortly before they died.

Figure 11 (KWK 66-28-23). --Contents of the body cavity of a Laysan Albatross found on Southeast Island, Pearl and Hermes Reef, 24 September 1966. Plastic container caps and toys, pumice stones, and squid beaks were revealed, cradled in the sternum, after the back (feathers and skeletal material) was lifted off. Beetle larvae had consumed all soft parts in the 2 to 3 months following death.

When placed in water, 99.4 percent of the items found in the dead birds floated. Of the items that did not float (table 8), two appeared to be parts of some plastic device that may have floated and one was a bone, presumably from a food organism. The two small pebbles appeared to be bits of limestone or coral rock.

The specific gravity of the indigestible material present in greatest quantity was less than one-half that of water (6.5 g. pumice displaced 15 cc. water), thus the total volume of this material was approximately 3,000 cc.

Table 8. --Indigestible material in 100 Laysan Albatross carcasses on Southeast Island, Pearl and Hermes Reef, Hawaii, 24 Sept. 1966

| Item | Number | Weight | Frequency of occurrence | Greatest number in one bird |
|---|---|---|---|---|
| | | G. | Percent | |
| Pumice[1/] | | | | |
| Large (40-60 mm.) | 27 | 235 | | |
| Medium (25-39 mm.) | 173 | 563 | | |
| Small (10-24 mm.) | 346 | 265 | | |
| | 546 | 1,063 | 85 | 93 |
| Plastic | | | | |
| Caps (bottle and tube) | 83 | 69 | | |
| Misc. (broken pieces, toys, etc.) | 157 | 111 | | |
| Bag (polyethylene) | 1 | 3 | | |
| | 241 | 183 | 74 | 8 |
| Nuts | | | | |
| Kukui (Aleurites moluccana) | 7 | 45 | | |
| Walnut (Juglans cineria) | 3 | 15 | | |
| Strongylodon | 2 | 3 | | |
| | 12 | 63 | 12 | 1 |
| Squid beaks[2/] | unknown | unknown | 89 | |
| Charcoal | 13 | 68 | | |
| | 13 | 68 | 10 | 3 |
| Wood | 4 | 21 | | |
| | 4 | 21 | 4 | 1 |
| Sponge | 4 | 2 | | |
| | 4 | 2 | 4 | 1 |
| Line | 2 | 3 | | |
| | 2 | 3 | 2 | 1 |
| Nonfloating | | | | |
| Pebbles | 2 | 3 | | |
| | 2 | 3 | 2 | 1 |
| Bone | 1 | 1 | | |
| | 1 | 1 | 1 | 1 |
| Hard plastic | 2 | 1 | | |
| | 2 | 1 | 2 | 1 |
| Totals | 827 | 1,408 | | |

1/ Greatest dimension is measurement shown.

2/ Fiscus examined the cephalopod beaks and stated: "Probably 10 to 12 species of squid are represented in the collection. The following families were tentatively identified: Octopodoteuthidae, Ommastrephidae, Onychoteuthidae, and Sepiolidae or Sepiiadae. One beak was positively identified as Tremoctopus sp.

Figure 11 gives some indication of the size (volume) of the individual items that were ingested. The largest item was a piece of Paulownia charcoal, the greatest dimensions of which were 178 x 33 mm. (7 x 1-3/8 in.).

The beaches of Southeast Island where the dead albatrosses were studied are composed of broken coral, ranging in size from coarse sand to large pebbles. Many of these were similar in size, shape, and color to the pumice stones found in the dead birds. Only 2 tiny coral pebbles, however, were found among the 827 nonfood items.

Also scattered about on the beaches were pieces of pumice and plastic scraps similar to the ones contained in the albatross skeletons. That albatrosses were the source of these items, rather than that the items were gathered from the beach by the young birds is indicated by observations made at Laysan Island. There, on 17 and 18 September 1966, we noted that the high-water line of the lagoon was littered abundantly with small plastic items and pumice stones. There is no channel connecting the lagoon (map 4) with the sea, thus these items could not have been washed to the lagoon from the sea. Among a number of Laysan Albatross carcasses that lay scattered over the flats adjacent to the lagoon I examined one. It contained a plastic container cap and several small pumice stones. In summer and fall the water in the lagoon is low but during winter and spring rains it rises. Thus, the disintegrating albatross skeletons are broken apart by the rising water and the plastic and pumice pieces float ashore and are deposited at the high-water line.

It is a behavioral characteristic of albatrosses (as well as some other pelagic birds) that items (food or other things) are normally not picked up on land. It is therefore not surprising that nearly all of the foreign material found in the dead birds floated. It is concluded that these items were picked up at sea by the parents and then passed on with regurgitated food to the young.

To what degree large indigestible items may cause mortality among albatrosses before fledging is unknown. It is not known how much of this material is ingested by young that ultimately survive. A healthy adult albatross taken at sea on 6 December 1948 off California contained four small pieces of pumice (Kenyon, 1950). Possibly young birds are unable to disgorge certain bulky indigestible items with their normal castings of squid beaks. That plastic bags may thus be eliminated was indicated by two castings that we found on Southeast Island composed partially of transparent polyethylene plastic of the kind used in small kitchen bags. These castings appeared to have been protected from disintegration by the bags as other castings were not found.

Possibly the large volume of pumice stone, plastic items and other bulky indigestible matter prevented passage of food through the stomach or intestine. It may be significant that only one dead bird (aside from the nine empty ones) did not contain either pumice or plastic in addition to the other indigestible items listed in table 8.

## BIRDS, GENERAL

Data including a complete list of species, population estimates, stages of the breeding cycle, bands applied, and band recoveries were recorded by Kridler and Walker and are not recorded here.

### Laysan Island

The two endemic birds, the Laysan Duck (Anas platyrhynchos laysanensis) (fig. 12) and the Laysan Finch (Psittirostra cantans cantans) (fig. 13) were counted on transects simultaneously by three or four observers. The same transects are surveyed on each island visit by Kridler and those who accompany him. The numbers of both species observed on this trip were lower than on his previous trip. Several possible variables, however, are involved in making these counts and it would be difficult to say that either species has decreased. The variables inherent in this operation are: (1) Seasonal; it would be difficult to know

how to compare a spring with a fall count. Food availability and distribution and thus bird distribution might vary seasonally and counts on established transects would not be comparable. (2) Observers; different observers obtain different degrees of accuracy in their counts depending on their familiarity with the species being observed, its habits, behavior, and habitat. One cause is variation in visual acuity such as farsightedness, nearsightedness, etc. which may result in individually variable observations on a transect count. Because different observers are on each trip, individual variation cannot be evaluated and corrections made for inherent bias.

Figure 12 (KWK 66-27-10). --Ron Walker (left) and Eugene Kridler (right) banded and recorded information on a female Laysan Duck. Many hours were spent at night, using headlamps, to catch and band birds. Turnstones marked in previous weeks on the Pribilof Islands were recorded.

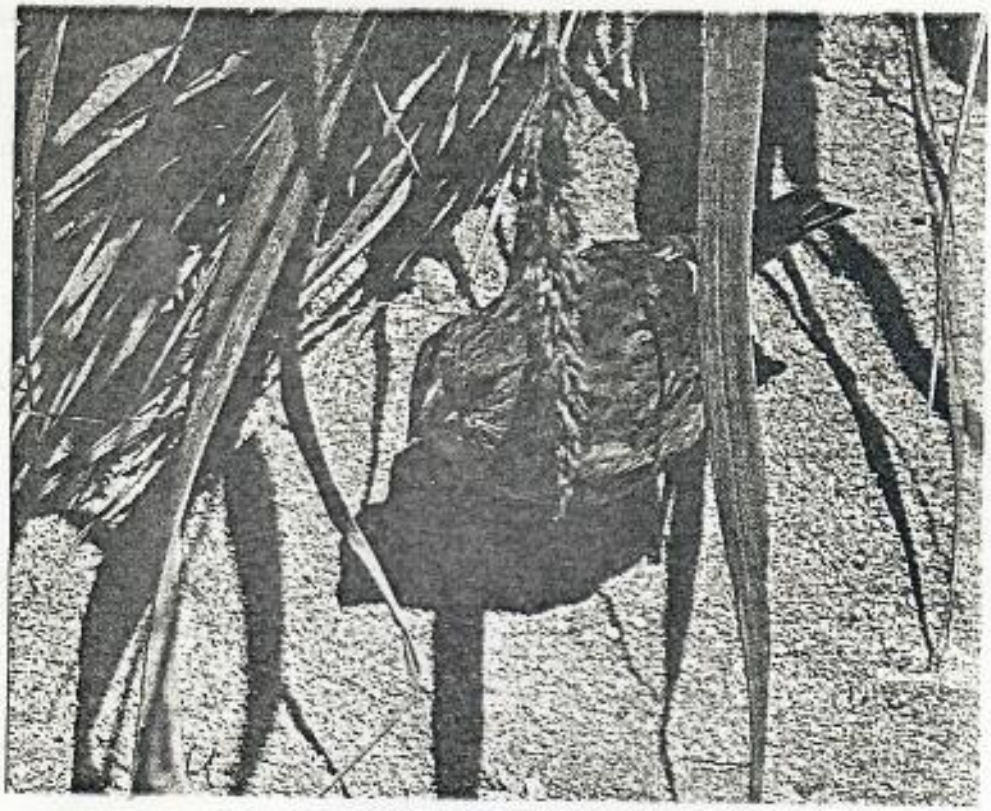

Figure 13 (KWK 66-27-33). --Laysan Island, 18 September 1966. The Laysan Finch was abundant everywhere except on open sandy beaches. They particularly accumulated in the heat of the day in an ironwood tree that stands near the boat landing. A wide range in color, from nearly unmarked yellow to the drab brown streaking shown here was noted. Apparently at this season the birds feed primarily on various moths and flies. They searched everywhere, under vegetation and on it, for food. Finches were counted on nine transects. This procedure is followed on each visit of the refuge manager for the purpose of obtaining an index of the size of the population.

## Mortality of Fledgling Terns

In some localities the breeding seasons of the Sooty Tern (Sterna fuscata), Gray-beaked Tern (Sterna lunata), and Brown Noddy (Anoas stolidus) were drawing to a close, but numbers of adults and nearly fledged young still occupied nesting areas.

On Laysan the sand was littered by hundreds of dead and dying young Sooty Terns. Although many could fly, they were weak and could barely stay aloft for short flights of a dozen yards. In the tall grass (Eragrostis) I captured about 15 fledglings. All were weak and emaciated with little flesh on the breast. On East Island (French Frigate Shoals) I watched at night while a Sooty Tern parent fed a fledgling and then I captured the young bird. It was weak and emaciated. Apparently the parents were weakly motivated to feed their young but were supplying insufficient nourishment. I suspect that few if any of the fledgling terns we saw in mid- to late-September survived to be successfully fledged.

Possible causes for the loss of parental motivation to feed their young are (1) the seasonal cycle to which the phase of the parental reproductive cycle is genetically attuned had nearly passed and the phase of the annual behavioral pattern that causes them to desert the nesting area was increasing in strength. (2) These parents may have been young birds nesting for the first time and their cycle of behavior had not matured sufficiently to cause them either to begin nesting activity early enough in the season or to carry through in an adequate way at the end.

The loss of young from late nestings is a factor that would tend to establish a nesting season within a limited part of the annual cycle.

## FLIES

Introduced houseflies (Musca domestica) on Laysan and Lisianski Islands are an infuriating pest during daylight hours. If any human activity other than those related to refuge management were to be undertaken there, the use of pesticides to eradicate the flies would undoubtedly be requested. The use of widely broadcast pesticides would, of course, destroy native insects as well as houseflies. This would deprive the endemic birds of important food resources and thus decrease or eliminate them. For this reason, in addition to many others, no nonrefuge activity should ever be permitted on Laysan Island.

## PROBLEMS AT MIDWAY ATOLL

Human activities at Midway have increased greatly since my last visit there in 1957. Then, Eastern Island was a restricted zone seldom visited by anyone who did not have official business there. Today it may be visited by almost anyone. The result is that the beaches are often walked by glass-ball hunters and monk seals are rarely seen there (see: Behavior when disturbed).

The communication structures that have been built (fig. 14) since 1957 present new bird problems. Ornithologists are disturbed that large numbers of albatrosses are killed by striking aerial cables. Communications Station personnel are disturbed because birds (Sooty Terns?) flying among the complicated antennas cause interference in electronic signals.

Before control of bird populations that is desired by the military is permitted a study of the bird-communication problem should be undertaken to establish: (1) The species of bird or birds that offend them, and (2) the most rational method of alleviating the situation.

## GREEN TURTLES

Turtles (Chelonia mydas) were found basking on beaches of all atolls, except Midway, that we visited and on the rocks at low tide on Necker Island. When time and other activities permitted, a numbered monel cattle-ear tag (the same as used on monk seals and fur seals) was placed in the axilla of the left front flipper (fig. 15). The center line length and width of the carapace of each marked turtle was measured with a steel tape. At Pearl and Hermes Reef several turtles were also marked with fast-drying red paint from a pressure spray can. The paint was useful in indicating tagged turtles so that the labor of flipping them over a second time was avoided. Forty-four turtles were tagged at Pearl and Hermes Reef, two at French Frigate Shoals, and one each at Laysan and Lisianski. Eight turtles previously marked were recovered.

Turtle marking is a project that Kridler has undertaken in order to gather information on movements, growth, and longevity of the green turtle.

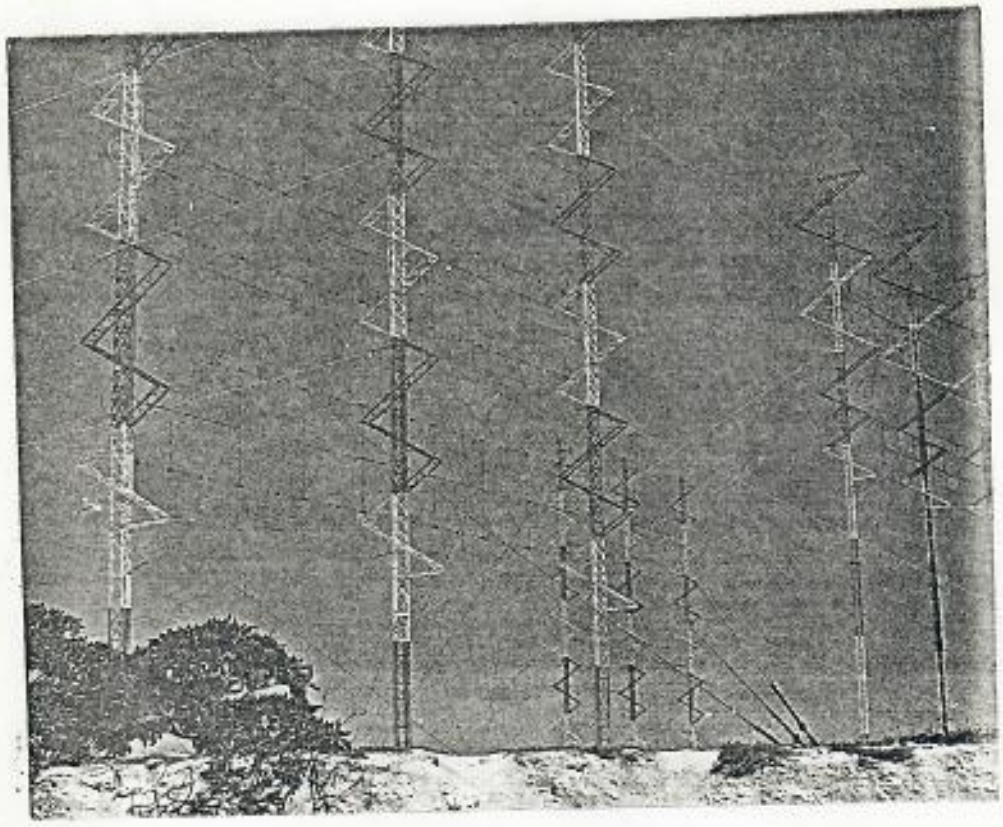

Figure 14 (KWK 66-29-4). --Eastern Island, Midway Atoll, 27 September 1966. Long-range communications system aerials about 300 feet in height involve about one-third of the island's surface. Because large numbers of Laysan Albatrosses collide with these and are killed, Harvey I. Fisher (1966) recommended that colored plastic streamers be attached to the guy wires. There is a question in my mind that streamers would save an appreciable number of birds. Albatrosses evolved on islands where high aerial structures did not exist. I have on a number of occasions seen albatrosses collide with trees on Midway. Because of the albatross' firmly established patterns of behavior, it might not be possible to effectively reduce mortality except through removal of the aerials. If communication satellites or other developments should eventually abolish the need for complicated communication aerials, it should be an obligation of the military service to remove these hazards to bird life as soon as they are obsolete.

Figure 15.(KWK 66-27-6). --Green turtle tagged on Laysan Island, 17 September 1966. Turtles came ashore both at night and during the day. They usually hauled out only a few feet from the water. Apparently they came ashore to rest and bask, since we saw no activity to indicate that they were laying eggs. On East Island, French Frigate Shoal, however, many pits made by turtles when laying eggs were found and on 13 and 14 September newly hatched turtles were emerging from the sand. At one digging 63 newly hatched young were found just below the surface. We watched a number of these as they progressed through a light surf and swam toward the outer reef. Several were taken by large fish when they had gone 15 to 20 feet from shore. Because of the abundance of fish, it is surprising that any survive. In order to immobilize the turtles for tagging, each one that was found was flipped quickly onto its back. If several were lying near together, they were flipped over in rapid succession. While lying inverted the turtles struggled helplessly, unable to right themselves. For about a minute the front flippers worked frantically, throwing considerable sand into the air. After they

quieted down, a tag was placed on the left front flipper. A total of 49 turtles was tagged and 8 tag recoveries were obtained. The carapace of the largest turtle measured over 43 inches in length. A number of cuts and bruises to personnel resulted from the flailing of the hard, scaly flippers.

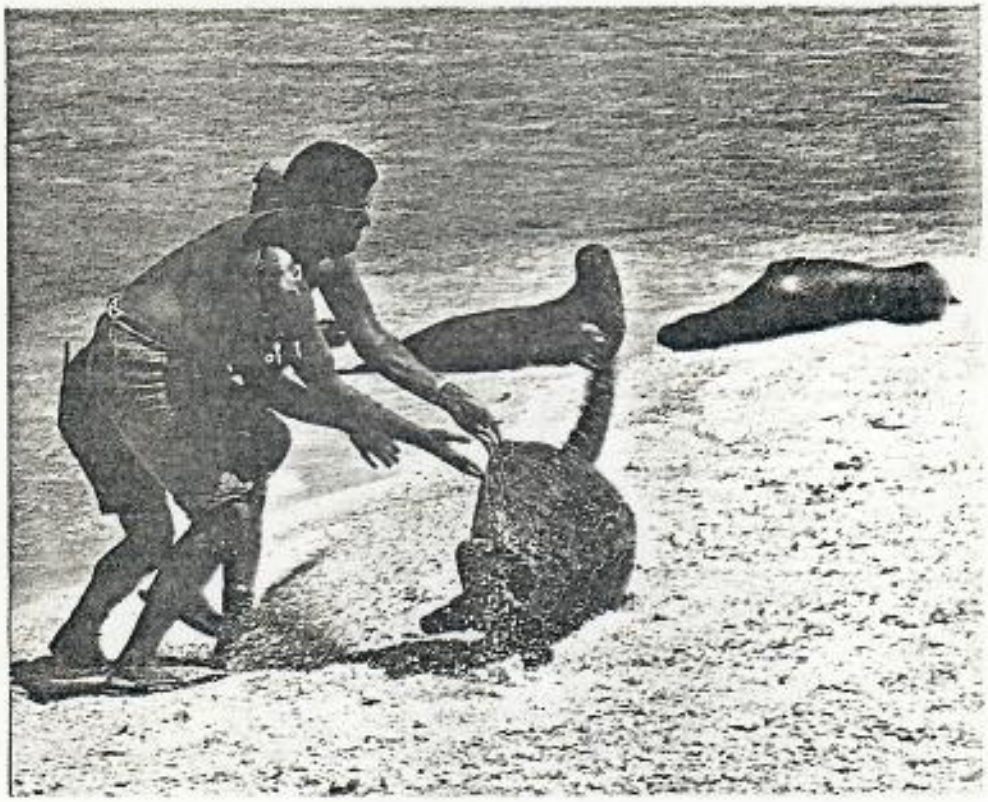

Figure 16 (KWK 66-23-8). --Southeast Island, Pearl and Hermes Reef, 20 September 1966. Monk seals and turtles often haul out near each other. Here Ron Walker and Eugene Kridler flip a green turtle over on its back in order to tag it. An awakened turtle proceeds steadily toward the water when disturbed and it is impossible to tag them without rendering them immobile by placing them on their backs. They are unable to right themselves and must be turned back over again after tagging.

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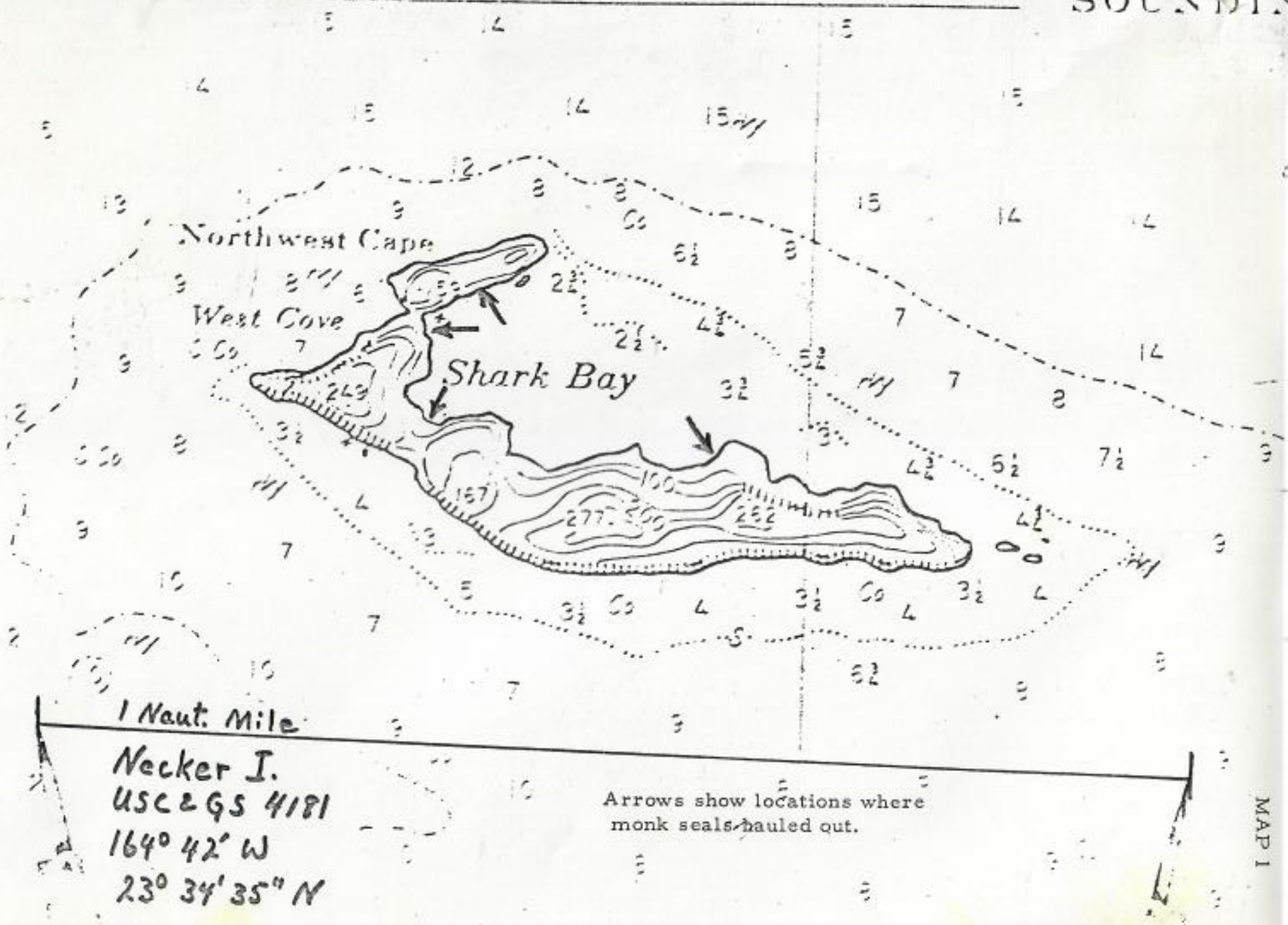
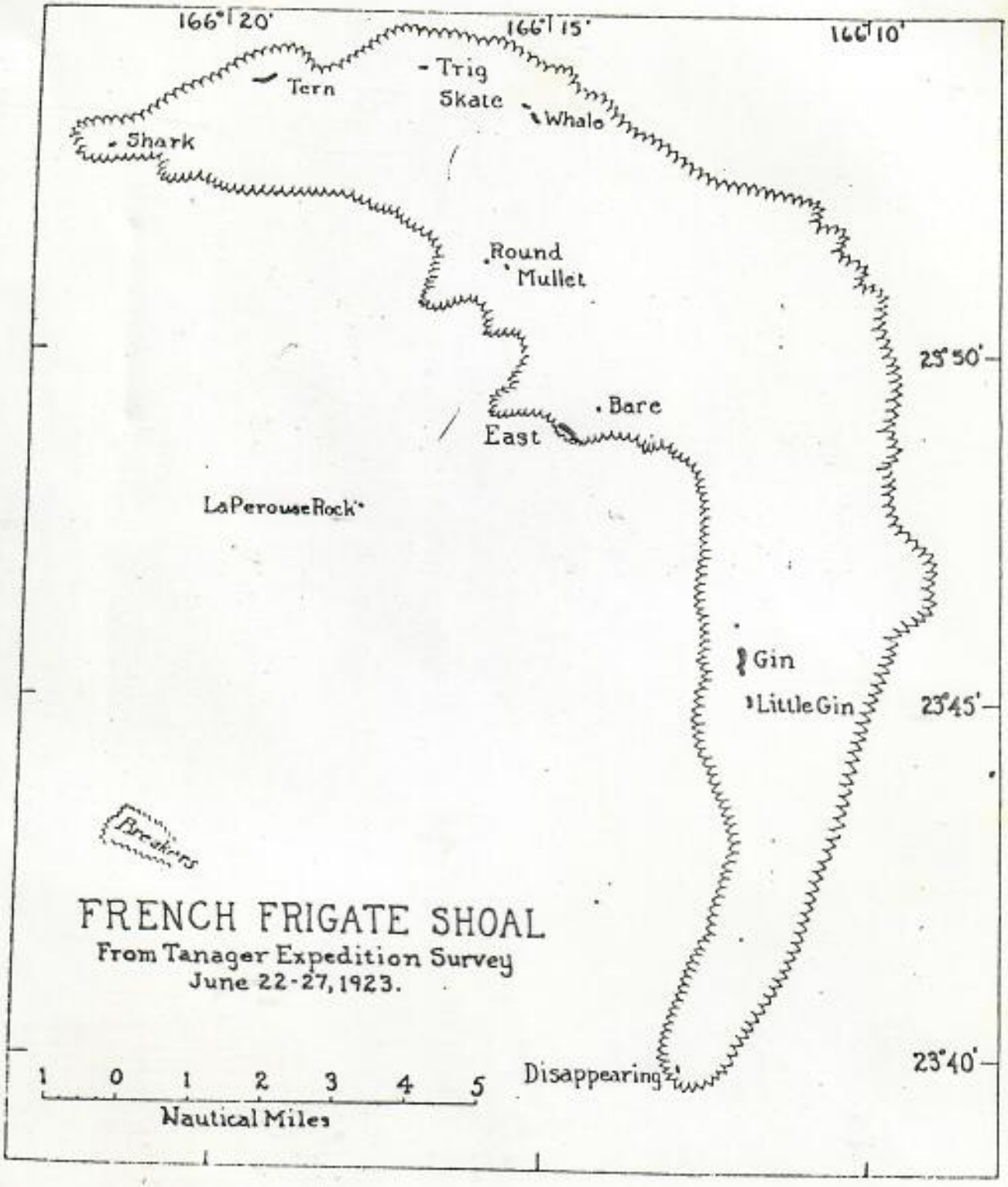
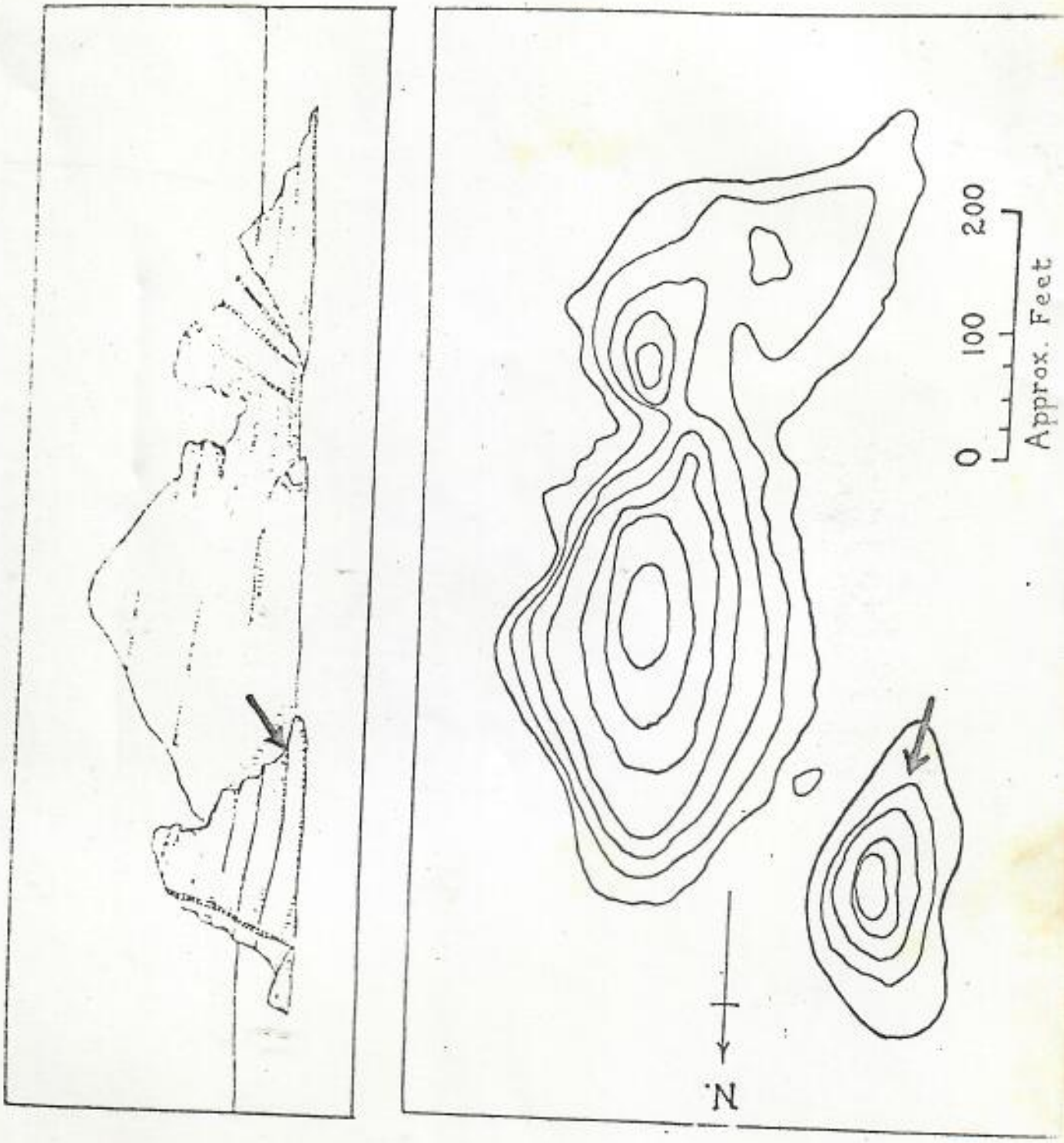

Northwest Cape
West Cove
Shark Bay
1 Naut. Mile
Necker I.
USC&GS 4181
164° 42' W
23° 34' 35" N
Arrows show locations where monk seals hauled out.

MAP 1

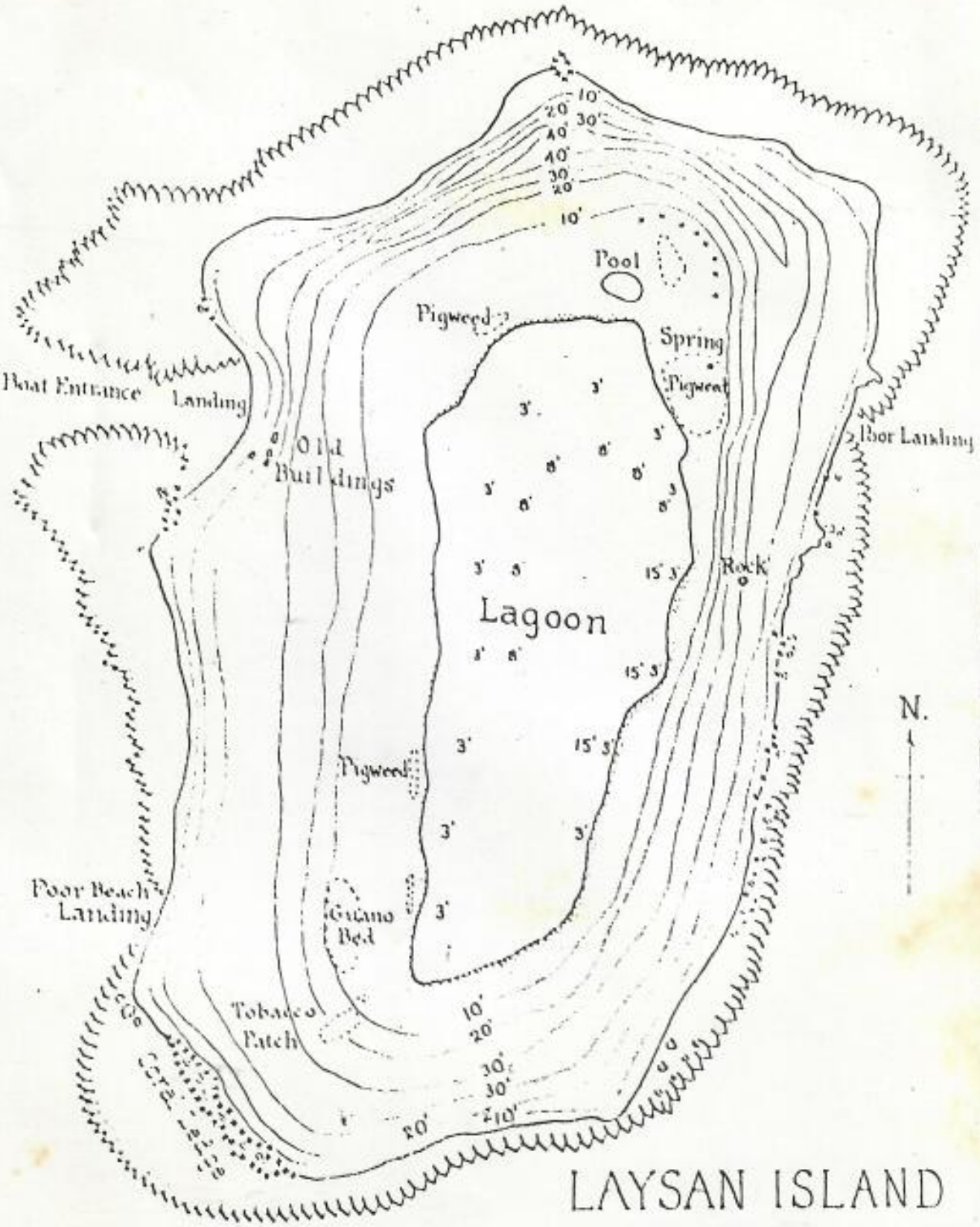
# French Frigate Shoal*

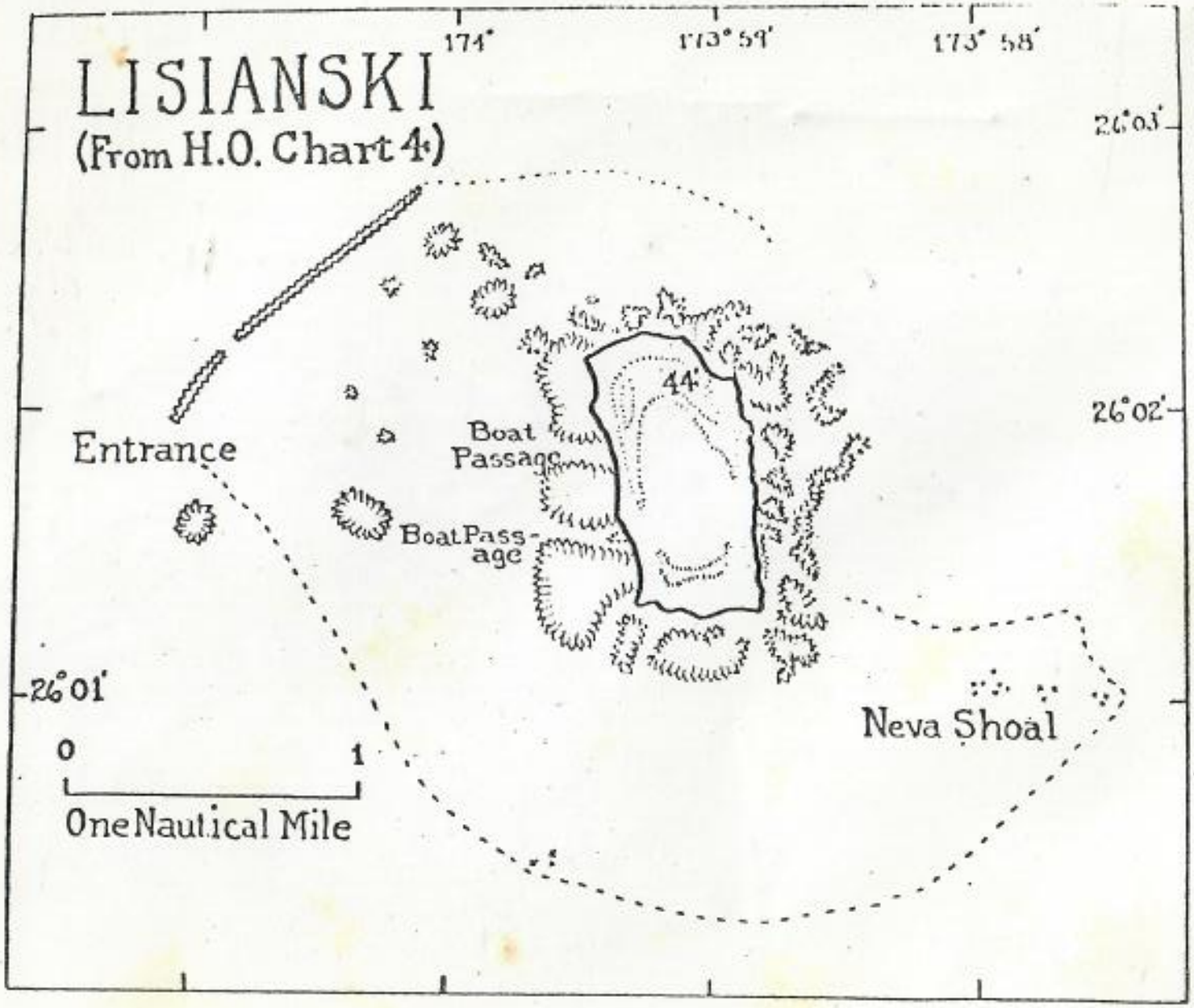


# Gardner Pinnacles

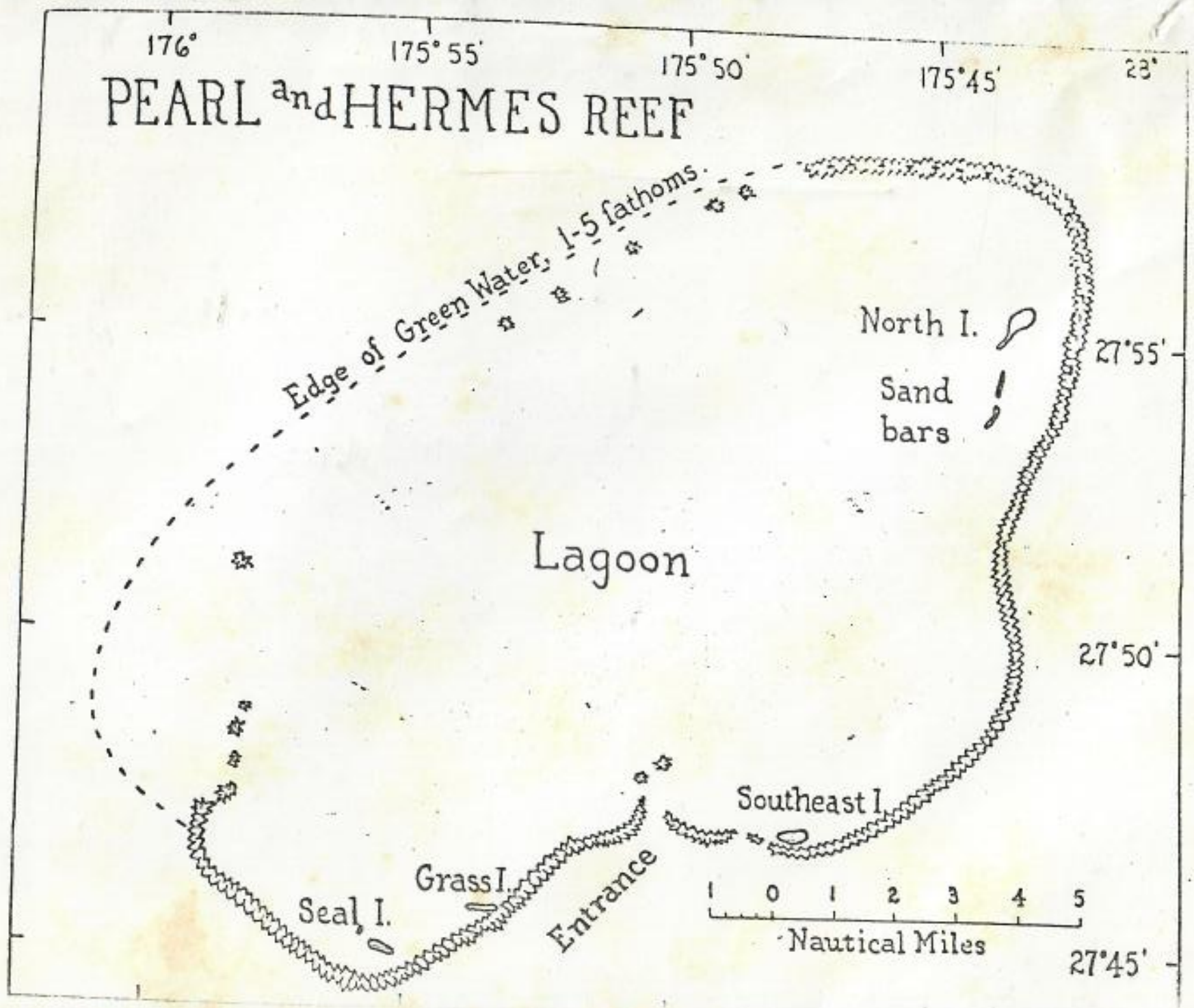



Arrow indicates seal hauling out location.


Pool
Pigweed
Spring
Pigweed
Boat Entrance
Landing
Old Buildings
Poor Landing
Rock
Lagoon
N.
Pigweed
Poor Beach Landing
Guano Bed
Tobacco Patch
LAYSAN ISLAND
Tanager Expedition Survey, Apr. 1923
1 Land Mile.
1 Sea Mile.


LISIANSKI
(From H.O. Chart 4)
174°
173° 59'
173° 58'
26° 03'
26° 02'
26° 01'
44'
Entrance
Boat Passage
Boat Passage
Neva Shoal
0
1
One Nautical Mile

MAP 5


176°
175° 55'
175° 50'
175° 45'
28°
PEARL and HERMES REEF
Edge of Green Water, 1-5 fathoms
North I.
Sand bars
Lagoon
27° 55'
27° 50'
27° 45'
Southeast I.
Grass I.
Seal I.
Entrance
1 0 1 2 3 4 5
Nautical Miles
MAP 6