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U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
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ABSTRACT

Research was conducted on the Hawaiian monk seal, *Monachus schauinslandi*, at Kure Atoll, 23 March-5 October 1982 and 20 April-30 June 1983. Censuses conducted at 2- to 4-day intervals showed a mean beach count (excluding pups) of 25 seals and a high count of 43 in 1982; 1983 had a mean of 23 seals and a high count of 37. In 1982, five pups (one male and four females) were born. One female died within a week of birth, and the three remaining females were collected after weaning for temporary captive maintenance and then released in September. Only males (four) were born in 1983; therefore, no females were available for captive maintenance, and the field season was terminated early. Four of the five female pups that were part of the 1981 captive maintenance program were resighted in the 1982 and 1983 seasons, and all three females in the 1982 program were resighted in 1983.

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INTRODUCTION

The Hawaiian monk seal, *Monachus schauinslandi*, is one of three species of *Monachus* worldwide. The Mediterranean monk seal, *M. monachus*, is extant along the Mediterranean Sea and the northwest coast of Africa (Ronald and Duguy 1979), whereas the Caribbean monk seal, *M. tropicalis*, was last sighted in 1952 and is now believed extinct (Rice 1973; Kenyon 1977; Le Boeuf et al. 1986). Having separated from its ancestral North Atlantic population more than 15 million years ago (Repenning and Ray 1977), the Hawaiian monk seal presently ranges along the Northwestern Hawaiian Islands (NWHI), from Nihoa Island in the southeast to Kure Atoll in the northwest. Although monk seals have been sighted at Johnston Atoll (Schreiber and Kridler 1969) and occasionally off the main Hawaiian Islands from Kauai to Hawaii, no evidence indicates that any of these locations outside of the NWHI have ever been used as major pupping sites or haul-out grounds.

In the NWHI, monk seals have existed without land predators and have never evolved a mechanism for survival in their presence (Kenyon and Rice 1959). Thus, sealing expeditions of the 19th century discovered a readily available seal resource that showed little or no flight response when ashore, and as a result, the seal population was almost exterminated (Kenyon and Rice 1959). Monk seals were afforded some protection in 1909 when President Theodore Roosevelt set aside the Hawaiian Islands Reservation (known as the Hawaiian Islands National Wildlife Refuge since 1940) to protect seabird colonies. However, since beach counts monitoring the monk seal population began in the late 1950s (Kenyon and Rice 1959; Rice 1960), the counts have declined to less than 50% of their former level (Johnson et al. 1982a). Primarily for this reason, the Hawaiian monk seal was declared an endangered species in 1976 under the U.S. Endangered Species Act. A Hawaiian monk seal recovery team was formed in 1980 to identify research needed to determine the causes related to the continued population decline of the monk seal (Gilmartin 1983). These causes probably include adult male seal aggression (Wirtz 1968; Johnson and Johnson 1978), shark predation (Wirtz 1968; Taylor and Naftel 1978; Balazs and Whittow 1979), human harassment (Kenyon 1972; Schulmeister 1981), ciguatera poisoning (Gilmartin et al. 1980), and entanglement in fishing debris (Henderson 1984). Any of these causes could contribute to low recruitment and survival of immature seals (Kenyon and Rice 1959).

At the northwest end of the Hawaiian Archipelago lies Kure Atoll (lat. 28°25'N, long. 178°10'W), where the decline of the monk seal population has been particularly severe. During the 19th and 20th centuries, Kure Atoll was the site of many shipwrecks, the survivors of which often ate seal meat and seabirds until rescued (Woodward 1972). Monk seal beach counts at Kure Atoll ranged from 105 to 117 seals in the late 1950s (Kenyon and Rice 1959; Rice 1960), but decreased by the late 1970s to high counts of 26-50 (Johnson et al. 1982a). Kure Atoll was placed under control of the Secretary of the Navy in 1936, became a wildlife refuge under the jurisdiction of the Territory of Hawaii in 1952, and became a State seabird sanctuary in 1978. In 1960, the U.S. Coast Guard (USCG) began construction of a loran station on Green Island, Kure Atoll; the station became operational in 1961 and is currently maintained by a 20-person crew. Intentional and unintentional human disturbance of the seals on Green Island is believed to be a major contributing

factor in the drastic decline of their numbers to about 25% of the level prior to the construction and operation of the loran station (Kenyon 1972; Johnson et al. 1982a).

Documented research began in 1957 and 1958 when Kenyon and Rice (1959) surveyed Kure Atoll, prior to the construction of the loran station. Researchers (Wirtz 1968; Woodward 1972) from the Pacific Ocean Biological Survey Program of the Smithsonian Institution monitored seals and birds at Kure Atoll from 1963 through 1969. Johnson et al. (1980b) conducted seal research from 1977 through 1979, and Kenyon (1979, 1980) revisited the atoll in 1979 and 1980. In 1981, Gilmartin et al. (1986) conducted a pilot project for the temporary captive maintenance of female monk seal pups.

Monk seal research was conducted at Kure Atoll in 1982 and 1983 by the Honolulu Laboratory of the Southwest Fisheries Science Center, National Marine Fisheries Service (NMFS), NOAA. In addition, temporary captive maintenance of female pups was conducted during the 1982 season. The primary goals were to monitor the monk seal population by conducting regular beach counts, enhance survival of female pups by maintaining weaned female pups in a fenced enclosure for protection from sharks and adult male seals, tag all pups, and identify individual seals by scars, tags, and bleach or paint marks.

STUDY SITE

Kure Atoll (Fig. 1) is 9.5 km in diameter and has one large, vegetated island, Green Island, and two sand islets, Sand and Shark Islands. Green Island, a crescent-shaped island, is situated at the southeast margin of the atoll and measures 2.3 X 0.6 km at its widest point. Shark and Sand Islands are temporary islets that are prone to becoming awash during harsh weather. The beaches of all three islands were divided into sectors (Fig. 1). Green Island consisted of sectors 1-8 and sector 13, the latter being a fenced, ocean-beach enclosure for female pups which were noted but excluded from census totals. Shark and Sand Islands were each classified as a separate sector, 9 and 10, respectively. Sector 11, known locally as Stark Reef, was a shallow area in the lagoon, and sector 12 was any area not included in the other sectors. Sector boundaries were similar to those used in the 1981 pilot project (Gilmartin et al. 1986) and were approximately the same boundaries used in 1972 (Woodward 1972) and 1977-79 (Johnson et al. 1980). Sectors were unequal in shoreline distance, vegetation level, beach slope, and nearshore habitat. Each beach was divided into categories: wet sand, dry sand, and permanent beach above the crest.

MATERIALS AND METHODS

Censuses

Monk seal censuses were conducted at 2- to 4-day intervals at Kure Atoll during 24 March-5 October 1982 and 22 April-28 June 1983. Because greater numbers of seals haul out during the afternoon (Kenyon and Rice 1959; Johnson et al. 1980), censuses commenced between 1230 and 1400 (Hawaii standard time). The time required for a single

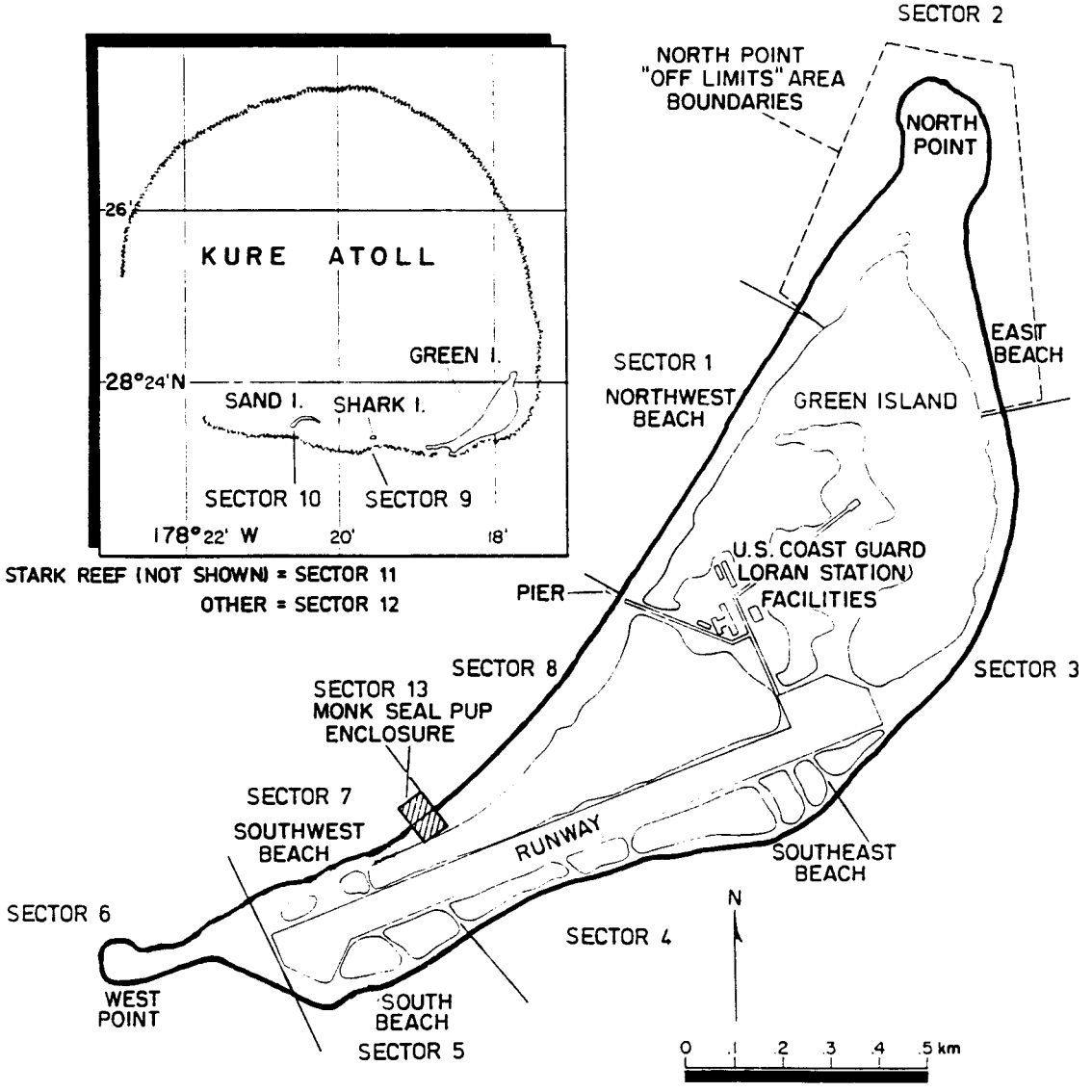

Figure 1.--A map showing Kure Atoll and the sectors used during the 1982-83 field season.

census varied with weather, number of seals, and number of observers (one or two), all of which were noted. If a seal moved from one haul-out location to another during a census, it was possible to count it more than once; therefore, censuses were conducted as expeditiously as possible to reduce the chance of a multiple count. If a seal was identified by scars or tags and was seen more than once during a census, it was counted only once. The location, by sector and beach category, of each seal was noted. Not all sectors and categories were always present, especially on the islets where ocean conditions could result in major sand shifts, sometimes causing the islets to disappear. If that was the case or if no seals were present, it was indicated as such in the data. Only hauled-out seals were counted; seals in the water were noted but not included in census totals. Seals were sexed if the ventrum was visible; classified by size; and individually identified, if possible, by scars, tags, and bleach or paint marks. Details of size classification guidelines and census procedures are reported in Stone (1984). The molt status of each seal was recorded as percentage (1-100%) of body area molted and was monitored as closely as possible from date of onset to completion of molt.

Marking and Tagging

Daily patrols were conducted to note molting or pupping seals and to opportunistically mark individuals. Juvenile and subadult seals were marked with either a commercial bleach hair lightener or red or blue paint for individual identification. Paint or bleach was applied with a squeeze bottle applicator to the middorsal and midlateral areas in a letter-number combination; the letter *K*, signifying Kure Atoll, preceded a two-digit number. In 1983, an attempt was made to bleach mark all seals not individually recognizable from scar patterns or tags. All weaned Kure pups were tagged with gray tags to designate Kure Atoll as the seal's birth site. A unique two-digit number was preceded by an *O* on 1982 tags and an *A* on 1983 tags. One tag was applied to each hind flipper in the webbing between the fourth and fifth digits. Lost tags were replaced. Further details on tagging procedures and tag description are in Gilmartin et al. (1986).

Pup Monitoring and 1982 Captive Maintenance Program

Adult females were closely monitored to obtain pupping and weaning dates and locations. A pup was determined to be weaned if the mother was absent for at least 24 hours after some period of continuous attendance, usually 5 to 7 weeks. All newly weaned pups were captured with a hoop net, which was suspended beneath a tripod, and weighed with a 200 kg hanging scale. Standard length and axillary girth measurements were taken, and tags were applied to the rear flippers. Male pups were released near the waterline; female pups were placed in a fenced, ocean-beach enclosure for temporary captive maintenance. In 1982, bleach numbers were applied when the pups were found sleeping ashore. Female pups were observed daily and weighed at monthly intervals to monitor their general health until they were released from the enclosure.

The fenced enclosure (36 X 61 m) in which the weaned female pups were kept during the 1982 field season until their release on 20 September was located on the southwest side of Green Island; approximately one-third of its area extended into the lagoon to a

maximum depth of 1.5 m. It was constructed of 5 cm galvanized pipe posts placed at about 3 m intervals in the water and of steel fence T-posts on the beach, all overlaid with welded-wire (5 X 10 cm mesh) fencing material. The ocean portion of this fencing was covered with chicken wire (2.5 cm mesh), thereby allowing a standing stock of live fish to be maintained within the enclosure to encourage the pups to learn to forage independently. Fish were trapped in the lagoon by deploying one to four baited fish traps (1.0 X 1.0 X 0.5 m) in the vicinity of coral heads. To minimize human contact, fish were added to the pen while the pups were asleep. Although there is no record of ciguatera poisoning at Kure Atoll, any fish species implicated elsewhere in harboring dangerous levels of ciguatoxin (Ito and Uchida 1980) were not transferred to the pen. Records were kept of species and the weight of fish introduced. Scale samples and otoliths from apparently conspecific specimens were removed to update a reference collection.

Scats and Spews

Seal scats and spews were collected daily on an opportunistic basis, with an attempt to obtain scats from seals of known size class and sex. This was accomplished by placing a bamboo stake, marked with a seal's size class and sex, near a sleeping seal. If the seal defecated before returning to the water, the specimen was collected and labeled accordingly. All scats and spews were collected and stored in individual plastic bags and either processed immediately or frozen for analysis at a later date.

Collection of Fishing Net Debris

All beaches at Kure Atoll were inventoried for fishing net debris, and the material was marked to prevent recounting it; new net debris was noted as it appeared. Net samples were collected, and the following data recorded: 1) mesh size (stretch measure), 2) strand diameter and type of material, 3) estimated total weight, and 4) beach location and date. Samples were analyzed for fishery of origin (Henderson et al. 1987).

RESULTS AND DISCUSSION

Censuses

Forty-two atoll-wide censuses (i.e., those including Green, Sand, and Shark Islands) were conducted at Kure Atoll from 24 March to 19 September 1982 (Table 1). Thirty-three atoll-wide censuses were conducted from 25 April to 7 October 1983 (Table 2). Atoll-wide census data were collected unless hazardous weather conditions or an inoperable outboard engine precluded censusing the outer islands. The mean count for atoll-wide censuses, excluding pups, was 25 in 1982 and 23 in 1983. Beach counts from March to September 1982 peaked in early April, then stabilized from late April to early July. Numbers decreased again during July and early August, followed by a sharp rise until the end of the census period. The higher counts in August and September may be due to seals hauling out to avoid the harsh weather or to adult male seals hauling out to molt. Mean counts in March-September 1982 showed three times as many adult males as adult females while sexes in

Table 1.—Summary of atoll-wide census counts of Hawaiian monk seals, by size class and sex, at Kure Atoll, 24 March-19 September 1982 (M = male, F = female, and U = unknown).

Date	Adult			Subadult			Juvenile			Pup			Total[a]		
	M	F	U	M	F	U	M	F	U	M	F	U	Non-pup	Pup	Grand
3/24	16	3	8	3	1	0	2	1	3	0	1	0	37	1	38
4/01	16	4	6	4	4	1	2	2	0	0	1	0	39	1	40
4/05	14	3	11	2	1	0	3	6	3	0	1	0	43	1	44
4/13	5	4	8	0	0	3	1	2	2	0	3	0	25	3	28
4/17	10	4	5	1	2	1	1	0	3	0	3	0	27	3	30
4/22	9	3	6	0	1	2	3	3	0	0	3	0	27	3	30
4/26	7	1	5	0	3	2	1	1	0	0	1	0	20	1	21
4/30	10	2	2	1	2	1	2	0	1	0	2	0	21	2	23
5/05	3	4	6	0	2	2	3	2	4	0	2	1	26	3	29
5/10	9	4	2	0	3	1	3	2	1	0	3	0	25	3	28
5/14	9	2	4	1	2	2	1	3	2	0	3	0	26	3	29
5/19	7	2	5	0	1	0	3	4	0	0	2	0	22	2	24
5/25	3	3	3	0	2	3	2	1	2	0	2	0	19	2	21
5/29	13	3	3	1	1	1	4	1	0	0	3	0	27	3	30
6/01	3	2	8	1	2	2	5	1	1	0	3	0	25	3	28
6/05	10	2	3	1	3	0	1	2	1	0	3	0	23	3	26
6/09	10	5	3	1	0	0	4	3	1	0	3	1	27	4	31
6/13	6	2	3	0	3	1	3	3	0	1	2	0	21	3	24
6/17	8	2	4	1	2	1	3	0	1	1	2	0	22	3	25
6/21	2	4	5	2	1	0	4	3	1	1	0	0	22	1	23
6/25	7	2	3	2	3	1	6	2	0	1	3	0	26	4	30
6/29	10	4	4	0	2	1	7	4	1	1	3	0	33	4	37
7/03	6	3	3	1	0	1	2	2	1	1	3	0	19	4	23
7/06	5	3	6	2	2	0	0	1	2	0	3	0	21	3	24
7/09	13	2	3	0	0	0	1	2	0	1	3	0	21	4	25
7/10	5	5	5	0	1	1	2	1	1	1	0	0	21	1	22
7/14	5	3	3	2	1	3	3	0	4	1	2	0	24	3	27
7/18	10	4	1	1	0	1	2	1	1	0	2	0	21	2	23
7/22	6	1	5	2	1	1	0	2	0	1	2	0	18	3	21
7/26	6	4	3	2	3	1	1	1	1	1	3	0	22	4	26
7/30	5	0	5	2	2	1	0	1	1	1	3	0	17	4	21
8/05	6	2	1	5	1	0	1	0	0	1	3	0	16	4	20
8/09	13	2	3	0	0	0	1	2	0	1	3	0	21	4	25
8/13	8	2	3	0	0	2	1	1	1	1	3	0	18	4	22
8/17	13	0	2	1	0	0	3	2	1	1	3	0	22	4	26
8/20	8	0	6	2	0	2	1	0	0	1	3	0	19	4	23
8/25	14	2	2	1	0	1	3	0	0	1	3	0	23	4	27
8/29	12	4	3	3	1	2	4	1	2	1	0	0	32	1	33
9/02	13	3	3	1	1	1	2	2	0	1	3	0	26	4	30
9/09	17	0	10	1	0	1	3	2	0	1	3	0	34	4	38
9/16	21	4	5	1	0	1	3	3	0	1	0	0	38	1	39
9/19	12	1	13	0	1	0	3	3	0	0	0	0	34[a]	0	34

[a]Total includes a seal that was not placed in any size class.

Table 2.--Summary of atoll-wide census counts of Hawaiian monk seals, by size class and sex, at Kure Atoll, 25 April-7 October 1983 (M = male, F = female, and U = unknown).

Date	Adult			Subadult			Juvenile			Pup			Total[a]		
	M	F	U	M	F	U	M	F	U	M	F	U	Non-pup	Pup	Grand
4/25	9	2	9	1	4	2	1	4	2	2	0	0	34	2	36
4/27	5	0	2	1	2	0	3	3	2	1	0	0	18	1	19
4/29	11	1	3	2	3	0	2	3	0	2	0	0	25	2	27
5/01	10	3	2	1	3	1	2	4	0	2	0	0	26	2	28
5/03	11	1	4	4	4	2	2	3	2	1	0	0	33	1	34
5/05	10	2	4	1	2	0	3	6	0	1	0	0	28	1	29
5/07	6	2	5	0	3	0	3	3	0	2	0	0	22	2	24
5/09	9	5	2	1	3	0	1	4	0	1	0	0	25	1	26
5/11	8	0	4	2	3	0	3	3	0	0	0	0	23	0	23
5/13	7	3	1	0	3	0	1	2	0	2	0	0	17	2	19
5/15	5	1	4	1	3	0	1	3	0	1	0	0	18	1	19
5/17	12	4	4	2	2	0	1	3	0	2	0	0	28	2	30
5/19	9	3	3	1	4	0	2	4	0	1	0	0	26	1	27
5/21	8	4	2	2	2	2	2	4	0	1	0	0	26	1	27
5/23	7	3	1	2	3	0	3	3	0	1	0	0	22	1	23
5/25	9	3	2	3	2	0	3	2	0	0	0	0	25[a]	0	25
5/27	9	2	2	2	2	1	2	1	0	1	0	0	21	1	22
5/29	10	3	1	2	2	0	1	2	0	2	0	0	21	2	23
5/31	11	2	3	2	2	0	2	1	1	2	0	0	24	2	26
6/02	10	4	4	3	2	0	2	3	0	1	0	0	28	1	29
6/04	4	3	2	2	2	0	2	3	0	1	0	0	18	1	19
6/06	6	3	1	2	1	0	2	2	0	0	0	0	17	0	17
6/08	6	3	0	2	2	0	3	2	0	1	0	0	18	1	19
6/10	6	1	1	2	1	1	2	2	1	0	0	0	17	0	17
6/12	9	2	1	0	2	0	2	1	1	0	0	0	18	0	18
6/14	7	4	1	1	1	0	3	1	0	0	0	0	18	0	18
6/16	12	2	1	1	1	1	3	2	0	1	0	0	23	1	24
6/20	4	3	1	1	2	1	1	1	0	0	0	0	14	0	14
6/24	8	3	0	2	1	0	1	3	0	2	0	0	18	2	20
6/28	9	3	0	2	3	0	3	1	0	3	0	0	21	3	24
9/21	3	1	20	0	0	1	0	1	1	0	0	0	27	0	27
9/29	15	6	9	0	1	2	2	2	0	1	0	0	37	1	38
10/07	8	3	13	0	0	0	1	2	0	0	0	0	27	0	27

[a]Total includes a seal that was not placed in any size class.

Table 3.--Summary of Hawaiian monk seal pups born at Green Island, Kure Atoll, in 1982-83 (U = unknown).

Pup ID No.	Tag No.[a] L	Tag No.[a] R	Sex[b]	Date Born	Date Weaned	Birth sector	Days nursed	Mother ID No.	Date tagged	Measurement tagging (cm) Girth	Measurement tagging (cm) Length	Protective enclosure Capture date	Protective enclosure Release date	Protective enclosure Total No. days in enclosure
							1982							
K134	028	029[c]	F	2/27[d]	4/06	7	39	K068	4/11	109	134	4/09	9/20	167
K142	031	030	F	4/06	5/11	7	36	K090	5/12	107	127	5/12	9/20	131
K143	032	033	F	4/10	5/23	5	44	K009	5/24	129	134	5/24	9/20	120
K164	--	--	F	5/01	(died 5/07)[e]	1	6	K072	--	042[e]	106[e]	--	--	--
K199	034	035	M	6/07	7/20	2	43	K198	7/21	107	110	--	--	--
							1983							
K500	A01	A02	M	3/03	4/14	6	42	K024	3/29	107	120	--	--	--
K501	A04	A03	M	4/06	5/24	6	48	K063	5/29	109	134	--	--	--
K502[f]	A05	A06	M	6/21	U	2	U	K070	U	U	U	--	--	--
K518[g]	U	U	M	U	U	U	U	U	U	U	U	--	--	--

[a]L = left hind flipper; R = right hind flipper.

[b]F = female; M = male.

[c]Tag No. K029 lost and replaced with tag No. K051 on 17 September 1982.

[d]Date of birth ± 1 day.

[e]Measurements were taken at time of death; pup never tagged.

[f]Pup weaned after field season was terminated.

[g]Pup born late in the season; personnel returned to Kure Atoll and tagged it, but all data were lost in transit. The pup was never resighted.

the immature size classes had approximately equal counts. High counts by size class and sex during any census in the 1982 season included 21 adult males, 5 adult females, 5 subadult males, 4 subadult females, 7 juvenile males, and 6 juvenile females. High counts can underestimate the population size and may misrepresent composition for two reasons: (1) not all seals haul out at any one time, and (2) on days of high counts, some seals in each size class were not sexed.

Distribution

Data on the haul-out location of female monk seals within the atoll in 1982 revealed some general patterns. Green Island was the preferred haul-out site for most of the 1982 season, but during the last half of August and the first half of September, more seals used the smaller islets. A factor contributing to the declining use of Green Island may have been the increase of recreational use of its beaches by the USCG during the same period. For resting, adult females favored the northern sectors of Green Island, whereas pupping and nursing occurred predominately at the south and southwest sectors (Table 3). Subadult females preferred Green Island to the islets during most of the season, but in late March, early August, and late September, they hauled out on the islets. When resting on Green Island, subadults preferred the northern sectors. The use of Green Island by juvenile females declined from late March to early August, then increased through the conclusion of the field season in late September. When they were on Green Island, sectors 2 and 4 were the preferred haul-out sites.

Molt

In 1982, 35 seals were individually identified during molt. Seasonal molt patterns (Table 4) were similar to those of molting seals on Laysan Island (Johnson and Johnson 1981a). Eighty percent of all sightings of molting seals occurred on the northern half of Green Island, sectors 1, 2, and 3 (Table 5). Molting adult females mainly used sector 2 (53% of the sightings) and the combined sectors of 1 and 2 (88% of the sightings). Subadult

Table 4.--Molt dates of Hawaiian monk seals, by size class and sex, at Kure Atoll, 1982. N = number of seals seen molting.

	Molt onset-end dates by sex	
Size	Female	Male
Adult	Mid-May to mid-Sep. (N = 9)	Mid-Aug. to early Oct. (N = 12)
Subadult	Mid-Apr. to early Jul. (N = 7)	Jun. (N = 1)
Juvenile	Late Aug.-late Sep. (N = 2)	Early Jun. to Sep. (N = 4)

Table 5.--Total sightings[a] of molting Hawaiian monk seals, by size class, sex, and sector, on Green Island, Kure Atoll, 1982.

		No. of seals by Green Island sectors							
Size[b]	Sex[c]	1	2	3	4	5	6	7	Total
A	F	6	9	1	0	1	0	0	17
A	M	2	16	6	0	3	1	0	28
A	U	0	9	0	0	0	1	1	11
S	F	0	1	11	0	2	4	0	18
S	M	1	3	0	0	0	1	0	5
S	U	1	3	1	0	1	0	0	6
J	F	0	6	0	0	4	0	0	10
J	M	1	5	2	0	1	0	0	9
J	U	0	0	0	1	0	0	0	1
Total		11	52	21	1	12	7	1	105

[a]Includes the number of sightings rather than the number of molting seals. An individual observed molting during several censuses would be included here for each sighting.
[b]A = adult, S = subadult, and J = juvenile.
[c]F = female, M = male, and U = unknown.

females predominately molted in sector 3 (61%), whereas molting juvenile females used sector 2 (60%). Sometimes the continuity in molt data was interrupted because of personnel turnover or high mobility of the molting seal. Also, the high sensitivity of seals to disturbance during molt apparently sometimes results in the movement of a seal to another beach site. High mobility was recorded in 1982; of the 25 seals observed for at least 2 days of molt, 48% moved either to another sector on Green Island or to one of the sand islets. Because of the short field season in 1983, a complete record of molt data is not available for that year.

Pup Production and Survival

All Kure pups were born on Green Island in 1982-83. Since 1981, 19 pups have been born at the atoll; 15 pups were born on Green Island (Table 6), and 4 pups were born on Sand Island, the largest sand islet. Four females and one male were born from 27 February through 7 June 1982; four males and no females were born from 3 March through 21 June

Table 6.--Number and location of Hawaiian monk seals born at Kure Atoll, 1976-83.

Year	Total of pups born	No. of pups born by island		Reference
		Green Island	Sand Island	
1976[a]	9	4	5	Johnson et al. 1982b
1977	10	4	6	Johnson et al. 1982b
1978	10	4	6	Johnson et al. 1982b
1979	10	3	7	Johnson et al. 1982b
1980[b]	6-13			Johnson et al. 1982b; Kenyon 1980
1981	10	6	4	Gilmartin et al. 1986
1982	5	5	0	This study
1983	4[c]	4[c]	0	This study

[a]Data provided by Commanding Officer Kichener, U.S. Coast Guard (USCG) loran station, Kure Atoll. This is likely a minimum count, as the USCG reported a total of 13 births to R. L. DeLong (Northwest Fisheries Science Center, Seattle, WA 98115-0070) in 1976.

[b]A minimum of six weaned pups was observed by Kenyon (1980). The USCG reported 13 births to him, but he was not sure of the reliability of this number. Kenyon (1980) observed weaned pups only, so the birth locations are less certain than in other years.

[c]One pup was born on Green Island after the field season ended, but its birth site is unknown.

1983 (Table 3). One female pup (ID No. K164) died within 1 week of birth and was the only known mortality in 1982. Autolysis of the recovered carcass prevented determination of the cause of death.

Two of the five females pupped not only in 1982 but also in 1981; two other seals pupped in 1981 and again in 1983 (Table 7). One of the females pupped in 1982 and again in 1983. Of the two that pupped in 1981 and 1982, one pupped in sector 6 in both years, while the other used sector 4 in 1981 and sector 1 in 1982.

The low number of pups born in 1982 and 1983 represents a serious reduction from the 9-10 pups born in each of the previous 5 years (Ruehle and Johnson 1977; Johnson et al. 1979, 1980; Kenyon 1980; Gilmartin et al. 1986) and the 30-32 born annually during the mid-1960s (Wirtz 1968). This may support Kenyon's (1980) prediction that, as the Kure adult population grows older, the number of reproductively active females will continue

Table 7.--Pupping frequency of identified adult female Hawaiian monk seals at Kure Atoll, 1981-83. Asterisk indicates female pupped that year.

Adult female ID No.	Pupping frequency		
	1981	1982	1983
K009	*	*	
K024	*		*
K039	*		
K052	*		
K055	*		
K063	*		*
K068		*	
K070		*	*

to decline. Recruitment at Kure Atoll has probably been negligible for a number of years, as demonstrated by the critically low numbers of immature seals in previous counts (Kenyon 1972; Johnson et al. 1982a; Gilmartin et al. 1986), and it is possible that the present-day juvenile and subadult females will not reach sexual maturity before more adult females die or reach a postreproductive period.

During the 1950s and 1960s, the overwhelming majority of pups were born and nursed on Green Island (Kenyon 1972; Woodward 1972). From 1968 to 1979, most were born on the sand islets, probably resulting in negligible recruitment of seals into the adult population (Kenyon 1972; Johnson et al. 1980). Kenyon (1972) postulated that one major factor leading to low survival of pups born during the late 1960s was related to pupping and nursing on the sand islets. These islets are precarious pupping sites because they are prone to becoming awash, are exposed to weather elements without the protection of vegetation, and are adjacent to deep waters with sharks and fast currents (Kenyon 1980). The shifting of pupping sites apparently began sometime after the USCG established the loran station on Green Island in 1961. Monk seals were then exposed to station personnel using the beaches for recreation, to harassment by pet dogs, and to vehicles driven along beaches (Kenyon 1972). The USCG enacted several measures in 1976 to alleviate some of the harassment problems. Dogs were removed from the island, vehicles were prohibited from driving along the beaches, and North Point (sector 2 on Green Island) and Shark and Sand Islands were declared off-limits to USCG crew and visitors. These measures appear to have benefited the seal population; most adult females are once again pupping on Green

Island, most adult and immature females use North Point as a resting site, and approximately half of the molting seal population is using North Point. With the continued cooperation of the USCG, it is hoped the positive trend will continue.

Termination of the 1983 Field Season

After the third male pup (ID No. K502) was born on 21 June, the adult female segment of the monk seal population at Kure Atoll was assessed for potential births. Seven of the eight known adult females had molted, indicating they would not pup again until the 1984 season; one adult female was still nursing. The probability of any additional births in 1983 was remote. Because no female pups were born at Kure Atoll during the 1983 season, it was decided to terminate the field camp. The USCG personnel agreed to periodically monitor the remaining nursing mother and pup and to report any problems to the NMFS in Honolulu. The 1983 season was terminated on 30 June. Sometime later in the summer, a fourth male pup was born, and the NMFS personnel returned to the atoll and tagged it. However, tagging information for this pup was lost at sea on the return trip to Honolulu.

Captive Maintenance Program (1982)

All three female pups (ID No. K134, K142, and K143) that were weaned were successfully captured and placed in the fenced enclosure which was always stocked with at least 25-35 reef fish. Appendix A lists fish species introduced into the enclosure and notes which species the pups were observed to eat or catch. Pups were first observed eating or catching fish on the following number of days after introduction into the enclosure: Pup ID No. K134, 16 days; K142, 15 days; and K143, 36 days. Feeding observations were conducted on an opportunistic basis, so they do not provide a complete composite of pup foraging preferences or behavior.

The three female pups maintained within the protective enclosure experienced an average weight loss of 37.8% during the first 3 months after weaning. Weight loss averaged 0.4 kg/day in the first month, 0.25 kg/day in the second month, and 0.21 kg/day in the third month. The weight of two pups (ID No. K134 and K142) stabilized after the third month. One pup (ID No. K143) showed a continued weight loss into the fourth month that may reflect her greater size at weaning. One male pup (ID No. K199) was born late in the 1982 season and could be monitored only for 1.5 months after weaning. His weight loss during that period paralleled that of the captive female pups.

On the morning of 3 August, during a period of exceptionally high tides and wave action, all three pups escaped from the enclosure, probably by going over the top of the fencing. All were recaptured later the same afternoon. During the following days, several other escapes were made, but all seals were recaptured and returned to the enclosure within several hours. All three pups were released on 20 September, and the enclosure was disassembled.

Tag Retention

Of the five pups double-flipper tagged in 1982, one lost a tag during that year. On 17 September, 5 months after the initial tagging, it was discovered that one pup (ID No. K134) was missing a tag, possibly the result of snagging it on the fencing mesh of the enclosure. The flipper was retagged. All of the 1982 and 1983 pups that were resighted had 100% tag retention, and there was no evidence of lesions or other complications at the tag sites.

Factors Affecting Survival

Injuries and Mortalities

Four fresh seal injuries were observed in 1982. One adult female appeared on 26 July with a deep gash extending from the tail to the right hip. The suspected cause of the wound was a large shark. The female was not subsequently resighted during the remaining 2 months of the field study, possibly indicating mortality. Three seals were observed with fresh wounds from the cookiecutter shark, *Isistius brasiliensis* (Table 8). Only one dead seal, a female pup, was found in 1982 (see Pup Production and Survival; Table 9).

Seven injuries were seen in 1983 (Table 8). Two were inflicted by sharks, two by adult male seals, and the causes of three were undetermined. Two dead seals were found in 1983, both adults, one male and one female (Table 9; Appendix B).

Some uncertainty exists for ascribing the origin of wounds. Seals may acquire lacerations from coral reefs (Taylor and Naftel 1978) and conspecific aggression. Wirtz (1968) postulated that wounds appearing in the scapular area or more posterior dorsal areas were caused by bites from adult male seals during sexually aggressive interactions. Subsequently, adult males have been observed inflicting such injuries on adult females at Laysan Island (Johnson and Johnson 1981b), French Frigate Shoals (Johnson and Johnson 1984), and Lisianski Island (Johanos and Kam 1986). Scapular or longitudinal dorsal scars were not considered to be shark-inflicted in this study.

Shark wounds.--In 1982, 18% of all seals older than pups had scars that could be attributed to attacks by large sharks. This compares with proportions of shark scars in past years of 35% at Pearl and Hermes Reef and 13% (DeLong and Brownell 1977) and 16% (Kenyon 1972) at Lisianski Island. Forty-eight percent of the seals older than pups had one or more small scars caused by bites inflicted by the cookiecutter shark, resulting in distinctive circular wounds or horseshoe-shaped scars (Jones 1971). These scars were found more often on older animals; more males were scarred than females.

Mobbing incident.--At 1715 on 1 June 1983, an adult female monk seal (ID No. K063) was observed resting in sector 2 on Green Island. An adult male (ID No. K243) was resting within 1 m of her. The female had a swollen area immediately posterior to her shoulders, similar to injuries attributed to attacks by male seals. By 1745, three additional males had moved close to the pair. One of the males approached the pair and was initially driven away by the attending male (ID No. K243), but soon returned and a fight ensued. The fight

Table 8.--Hawaiian monk seal injuries at Kure Atoll, 1982-83 (U = unknown).

Date	Size[a]	Sex[b]	ID No.	Injury	Probable cause
			1982		
5/03	A	F	U	Circular wound.	*Isistius brasiliensis.*
5/26	S	F	K251	Circular wound.	*I. brasiliensis.*
6/23	J	M	K193	Circular wound.	*I. brasiliensis.*
7/26	A	F	U	Deep gash from tail to right hip.	Large shark (?).
			1983		
5/02	A	M	K237	Top digit of right rear flipper is torn to the bone.	Unknown.
5/02	A	M	K248	Tissue torn near penile opening.	Unknown.
5/06	A	M	K239	Circular ventral wounds.	*I. brasiliensis.*
5/09	A	F	K244	Middorsal wound into blubber.	Male inflicted.
5/17	A	M	K249	Circular wound on right rear flipper.	*I. brasiliensis.*
5/20	A	M	K044	Wound across left pelvis.	Unknown.
6/01	A	F	K063	Dorsal swelling posterior to shoulder.	Male inflicted.

[a]A = adult.

[b]M = male; F = female.

[c]*Isistius brasiliensis* is also called the cookiecutter shark because of its propensity of leaving a mark similar to a biscuit cutter. The resultant wound may be up to 5.0 cm or more in depth.

Table 9.--Hawaiian monk seal deaths at Kure Atoll, 1982-83.

Necropsy No.	Date	Size[a]	Sex[b]	ID No.	Probable cause of death
				1982	
82-1	5/07	P	F	K164	Unknown.
				1983	
83-1	5/10	A	F	K244	Wounds inflicted by a male monk seal.
83-2	6/18	A	M	K258	Severely degenerated right kidney.

[a]A = adult; P = pup.
[b]F = female; M = male.

attracted the other two males, but caused the female to move higher up the beach. She was followed by the three males who continually fought among themselves. One of the males attempted to mount the female, inflicting two bites on her shoulder area. The approach of one of the remaining males caused him to disengage. By 1820, the adult female was lying near the vegetation as the three males continued to fight. One drew blood from the head and flipper of another. At this time, the female may have been injured further, so an observer intervened by positioning himself between the female and the three males. In response to the intervention, the female remained close to the vegetation, and the three males halted their advance but did not flee. The close approach allowed for the identification of one of the second two males as ID No. K113. Eventually all three males entered the water and swam away. The female was resighted on 2 and 4 June with a swollen back but was never resighted again (through 1987--NMFS data).

Scats and Spews

A total of 110 scats and 7 spews were collected from March to October 1982; those collected in 1983 were subsequently lost in transit to Honolulu. Results of sample analysis will be reported elsewhere.

Collection of Fishing Net Debris

Thirty sections of fishing net debris were collected and cataloged at Kure Atoll from 15 April to 28 June 1982 (Appendix C). Eleven pieces drifted onto the beaches after the initial 15 April inventory. The majority of the nets were found along the northern sectors of Green Island. Numerous observations were made of seals resting on top of or next to

net debris in 1982-83, but the only observed incident of entanglement was on 29 June 1982, when a subadult male was seen swimming with a line girdling his midsection. When he hauled out, photographs were taken, and the line was cut, removed, and collected.

In 1983, 18 sections of net debris were recorded on the beach prior to 20 April (Appendix C). From 21 April to 29 June, eight additional sections of net debris were noted. Net samples collected in 1983 were lost during transit to Honolulu.

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APPENDIXES

Appendix A.--Fish species introduced into the protective enclosure at Kure Atoll for the captive maintenance program for Hawaiian Monk Seal pups, 1982. Asterisk indicates the species that pups were observed to catch or eat.

Common name	Scientific name	Hawaiian name
Butterflyfish*	Unidentified Chaetodontidae	--
Bluestripe butterflyfish*	*Chaetodon fremblii*	Kikakapu
Milletseed butterflyfish	*C. miliaris*	Lau-wiliwili
Threadfin butterflyfish*	*C. auriga*	Kikakapu
Cardinalfish	*Apogon* sp.	Upapalu
Chromis	*Chromis* sp.	--
Jenkins' damselfish	*Stegastes fasciolatus*	--
Blackspot sergeant	*Abudefduf sordidus*	Kupipi
Hawaiian sergeant	*A. abdominalis*	Mamo
Fantail filefish	*Pervagor spilosoma*	O ili uwi uwi
Hawaiian flagtail*	*Kuhlia sandvicensis*	Aholehole
Whitesaddle goatfish	*Parupeneus porphyreus*	Kumu
Yellowfin goatfish	*Mulloidichthys vanicolensis*	Weke-ula
Stocky hawkfish	*Cirrhitus pinnulatus*	Poopaa
Rudderfish*	*Kyphosus* sp.	Nenue
Bigscale soldierfish	*Myripristis berndti*	U u
Crown squirrelfish	*Sargacentron diadema*	Ala ihi
Spotfin squirrelfish	*Neoniphon sammara*	Ala ihi
Convict tang	*Acanthurus triostegus*	Manini
Wrasse*	Unidentified Labridae	--
Belted wrasse	*Stethojulis balteata*	Omaka
Blacktail wrasse*	*Thalassoma ballieui*	Hinalea luahine
Christmas wrasse	*T. fuscum*	Awela
Saddle wrasse*	*T. duperreyi*	Hinalea lau-wili
Surge wrasse*	*T. purpureum*	Hou
Pearl wrasse	*Anampses cuvieri*	Opule

Appendix B.--Hawaiian monk seal necropsy reports, Kure Atoll, 1982-83.

NECROPSY NO.:	82-1
ID:	K164
DATE OF DEATH:	7 May 1982
DATE OF NECROPSY:	Not done
SEX:	Female
AGE:	6 days

CIRCUMSTANCES OF DEATH: Autolysis of the recovered carcass prevented determination of cause of death.

No further information collected.

Appendix B.--Continued.

NECROPSY NO.:	83-1
ID:	K244
DATE OF DEATH:	10 May 1983
DATE OF NECROPSY:	10 May 1983
SEX:	Female
AGE:	Adult

CIRCUMSTANCES OF DEATH: Dorsal wounds probably inflicted by adult male although attacks not observed. Several adult males were closely attending the wounded female the day before as well as the day of her death.

EXTERNAL DESCRIPTION: Severe dorsal wounds penetrating blubber and muscle.

Approximately 1 m of intestines extruded from anus.

Measurements:

1. Standard length--203 cm
2. Blubber thickness (midventral)--4.5 cm
3. Axillary girth--118 cm

INTERNAL: Uterus not enlarged; no fetus. Stomach empty.

SAMPLES COLLECTED:

Lung	Pancreas
Liver	Endoparasites
Spleen	Reproductive tract
Kidney	Skull
Heart	

PATHOLOGY SUMMARY: There is no obvious cause of death as determined by histologic examination. The presence of central fatty change and congestion in the liver is consistent with shock and the gross identification of recent wounds.

PATHOLOGIST: G. Stemmerman, M.D., Department of Pathology, Kuakini Medical Center, Honolulu, Hawaii 96817.

Appendix B.--Continued.

NECROPSY NO.:	83-2
ID:	K258
DATE OF DEATH:	17 June 1983
DATE OF NECROPSY:	18 June 1983
SEX:	Male
AGE:	Adult

CIRCUMSTANCES OF DEATH: Found dead near Sand Island.

EXTERNAL DESCRIPTION: Slightly bloated with superficial epidermal abrasions along dorsum. A thin thread of blood was coming out of the nostrils.

Measurements:

1. Standard length--128 cm
2. Blubber thickness (midventral)--3 cm
3. Axillary girth--187.5 cm

INTERNAL: Right kidney severely degenerated with white grittish fluid seeping into abdominal cavity; left kidney normal. Stomach was empty, except for parasitic round worms; minor ulcerated areas along the mucosal lining. Fecal material found in colon. Heart, lung, liver, gall bladder, and abdominal muscles looked normal.

SAMPLES COLLECTED:

Lungs	Pancreas
Liver	Skull
Spleen	Reproductive tract
Kidney	Stomach contents
Heart	

PATHOLOGY SUMMARY: This animal probably died as a result of a staphyloccal septicemia, arising from a nephric abscess. Interstitial calcification of the lungs, heart, and kidney as well as the nephrolithiasis indicate that this animal had hypercalcemia. In the absence of chronic renal disease, it must be presumed that the seal was afflicted with primary hyperpara- thyroidism. The interstitial necrosis, both recent and healing, in the myocardium can probably be explained on this basis as well.

Appendix C.--Net material collected on the beaches on Kure Atoll, 1982-83 (poly = polypropylene or polyethylene).

Date	Sector	Mesh size (mm)	Estimated weight (kg)	Fiber material	Fiber diameter (mm)
			1982		
4/15[a]	2	135	2.0	Nylon	5.0
	2	70	1.5	Nylon	5.0
	2	65	--	Nylon	6.0
	2	80	--	Nylon	2.0
	2	50	1.5	Nylon	2.0
	2	70	1.0	Nylon	7.5
	2	75	0.2	Nylon	1.0
	3	105	1.0	Nylon	3.0
	3	70	0.1	Nylon	2.5
	3	55	3.5	Nylon	5.0
	3	71	<0.1	Nylon	1.5
	3	65	--	Nylon	2.0
	3	105	0.6	Nylon	2.0
	3	64	<0.1	Nylon	2.0
	3	83	<0.1	Monofilament	1.0
	3	40	--	Nylon	2.0
	4	98	0.6	Nylon	2.5
	4	130	2.0	Nylon	5.0
	5	40	--	--	1.0
4/16	1	100	2.7	Nylon	7.0
4/19	1	40	--	Nylon	3.0
	1	125	2.7	Nylon	10.0
4/27	7	45	0.1	Nylon	15.0
4/28	7	120	1.0	Nylon	20.0
5/14	10	18	<0.1	--	2.0
5/17	1	55	>22.0	--	2.0
5/25	7	107	2.3	Monofilament	0.9
5/26	6	60	1.0	Nylon	7.0
	7	55	<0.1	Cord	3.0
6/28	5	65	1.0	Monofilament	30.0

Appendix C.--Continued.

Date	Sector	Mesh size (mm)	Estimated weight (kg)	Fiber material	Fiber diameter (mm)
			1983		
4/20[b]	4	95	2.0 X 0.8[c]	Nylon	4.0
	4	165	1.2 X 0.7	Nylon	4.0
	3	160	2.0 X 4.0	Nylon	2.0
		3	40	Nylon	2.0
		45[d]	2.0 X 0.7	Nylon	4.0
			100	Nylon	5.0
			45	Nylon	1.0
	3	105	1.0 X 0.4	Nylon	2.0
	3	60	2.0 X 1.4	Nylon	4.0
	3	100	1.0 X 0.8	Nylon	3.0
	2	23	4.0 X 0.2	Nylon	1.0
	2	80	1.8 X 0.8	U	4.0
	2	55	6.0 X 0.9	Nylon	2.0
	1	120	2.0 X 0.8	Nylon	4.0
	1	105	0.5 X 0.5	Monofilament	0.5
	3	110	7.0 X 1.5	Nylon	3.0
	6	110	0.8 X 0.2	Monofilament	0.5
	7	NM[e]	2.3 X 0.7	Nylon	NM
	7	NM	1.5 X 0.5	Monofilament	NM
	7	NM	5.8 X 1.1	Nylon	NM
	3	NM	NM	Monofilament	NM
5/02	9	140	4.7 X 2.4	Nylon	6.0
5/08	5	105	3.0 X 0.5	Nylon	3.0
			85[d]	Nylon	1.0
			95	Monofilament	0.5
5/15	9	115	9.0 X 2.0	Nylon	2.0
5/17	9	60	1.5 X 1.0	Nylon	4.0
5/19	9	55	4.0 X 2.5	Nylon	2.0
	10	140	9.0 X 3.0	Nylon	2.0
6/08	9	36	2.3 X 0.6	Nylon	2.0
6/22	10	38	1.5 X 1.5	Nylon	3.0

[a]Present on beach as of 15 April 1982.
[b]Present on beach as of 20 April 1983.
[c]In 1983, material recorded as estimated dimensions (m).
[d]Interconnected material.
[e]No measurement was taken.

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