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

The endangered Hawaiian monk seal, *Monachus schauinslandi*, was studied on Laysan Island in the Northwestern Hawaiian Islands from 28 February to 20 June and from 24 October to 13 November 1988. Data were collected on haul-out patterns, population structure, reproductive patterns, and factors affecting survival (primarily adult male aggression toward adult female and immature seals). Census counts including pups ranged from 73 to 128 seals ($\bar{x}$ = 105); counts excluding pups ranged from 61 to 116 seals ($\bar{x}$ = 87). There were 331 individual seals identified (286 excluding pups). All weaned pups and 41 adult males were tagged, and 3 subadults were retagged. Minimum first-year survival of tagged 1987 pups was 86%. At least 45 pups were born (24 males, 19 females, and 2 of unknown sex), and 40 survived to weaning. This represents the highest number of births documented on Laysan Island since extensive research began in 1977. Average nursing period was 39-40 days. Exchanges of pups were observed 17 times between 14 nursing females. Adult female reproductive rate was at least 61%. Of the 45 parturient females observed, 31 were identifiable from previous years. Average time between births in successive years was 382 days. This season, three 5-year-olds and a 22-year-old pupped, representing the youngest and oldest ages at parturition on record. One seal was observed giving birth, and two were observed immediately following parturition. In 1988, interatoll movement was documented for 11 seals, which moved between Laysan Island and Lisianski Island or French Frigate Shoals. At least 92 injuries were sustained across all age groups. Seven seals were found entangled in debris and were released by observers. In all, 485 items of debris were inventoried and destroyed. At least 17 seals disappeared during the 1988 field season. Nothing unusual was noted before 12 of these disappearances, but circumstantial evidence indicates 5 were probably deaths. In addition, at least 14 seals died. Adult male aggression resulted in 35 injuries, 4 probable deaths, and 7 known deaths.

CONTENTS

INTRODUCTION

One of the major haul-out and pupping areas used by the endangered Hawaiian monk seal, *Monachus schauinslandi*, is Laysan Island (lat. 25°42'N, long. 171°44'W) in the Northwestern Hawaiian Islands (NWHI). Extensive research has been conducted on the Laysan Island population since 1977 (e.g., Johnson and Johnson 1978, 1981a, 1981b, 1984). The National Marine Fisheries Service (NMFS) began an ongoing research program on Laysan Island in 1981, establishing research camps for 3 to 9 months annually to monitor and aid in the recovery of this population. Findings of the ongoing research are presented in Knudtson (1981) for 1981, Alcorn (1984) for 1982, Alcorn and Buelna (1989) for 1983, Johanos et al. (1987) for 1984, Johanos and Austin (1988) and Becker et al. (1989) for 1985, Alcorn and Westlake (in prep.) for 1986, and Becker and Ching (in prep.) for 1987.

For the 1988 field season, the primary objectives were to collect data on adult male behavior and to monitor adult male aggression toward adult female and immature seals. Additional objectives were to conduct frequent censuses; identify all adult and subadult seals in the population, apply and maintain bleach marks on molting adults and subadults, continue individual identification by natural markings, and tag adult males to maintain identification; monitor reproduction and tag all weaned pups; monitor interatoll movement; monitor survival, injuries, entanglements, disappearances, and deaths; perform necropsies; collect scat and spew samples for food habit analysis; collect tissue samples from weaned pups and adult males for DNA analysis; and inventory and destroy debris capable of entangling seals. The data collected during the 1988 field season are summarized in this report.

MATERIALS AND METHODS

Field camps were established during 28 February-20 June and 24 October-13 November 1988 on Laysan Island, located within the Hawaiian Islands National Wildlife Refuge. Also included are incidental data collected by U.S. Fish and Wildlife personnel during 22 June-30 August and by NMFS personnel during a single day visit on 30 August. The itinerary of the 1988 fieldwork at Laysan Island is presented in Appendix A.

The island's geology, flora, fauna, and history are described in detail in Ely and Clapp (1973). The island's perimeter was divided into 20 sectors (Fig. 1) for a 1982 study (Alcorn 1984); these same sectors have been used for all subsequent seal data collection. Sector boundaries are marked by natural features or by plastic poles left in place from field season to field season.

Individual Identification

All individual seals mentioned in this report are referred to by unique, permanent identification numbers unless noted otherwise. Individual seals were identified by existing or newly applied tags, applied bleach marks, and natural markings during censuses and patrols and on a daily, opportunistic basis. They also were classified by sex and size.

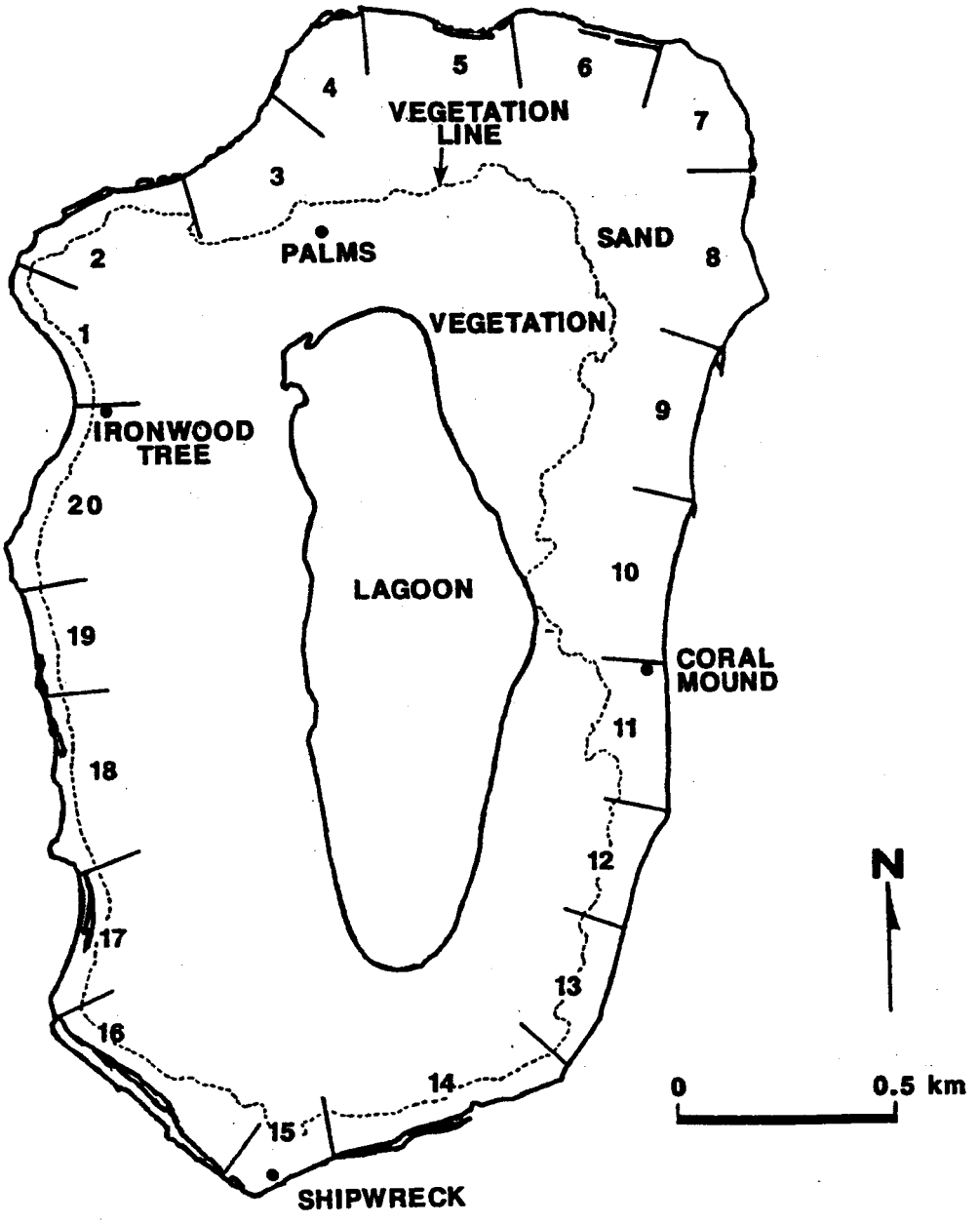

Figure 1.--Map of Laysan Island showing 20 sectors.

Procedures for seal identification and size classification are described in detail in Stone (1984).

All pups were tagged with a tan, plastic Temple Tag[1] on each hind flipper (Gilmartin et al. 1986) as soon as possible after weaning. Adult males were tagged with a plastic Riese tag on one hind flipper. Special pliers were used to drive the male side of the tag through the webbing and into the female side, spearheaded by a metal pin which then dropped out. The tags were applied between the digits of the hind flippers, with the trailing edge of the tag even with the end of the flipper. A metal Monel tag was also applied if one was not already present [see Alcorn and Buelna (1989) for procedures]. To compare tag retention and wear, some adult males received a tan, plastic Temple Tag on each hind flipper in addition to the Riese and Monel tags. Lone adult males were captured with a hoop net and restrained by three or four observers. Restraint and recovery time were recorded. Tagging was done either early or late in the day, and the seal was kept damp throughout the procedure to minimize heat stress.

All adult and subadult seals were bleach marked (Stone 1984) to allow individual identification. Molting adults and subadults were re-marked to maintain their identity. The composition of the solution used for bleach marking is described in Johanos et al. (1987). Some lactating females and their pups were marked with Nyenzol dye and bleach, respectively, for a concurrent study on pup exchanges (Boness 1990).

Tags, bleach marks, scars, and other natural markings were sketched on a scar card for each seal. The scar cards were revised throughout the field season to maintain a current file. Photographs of scars and natural markings were added to the individual identification files begun in 1982.

Censuses and Patrols

A summary of the types of data collected on Laysan Island in 1988 and a typical daily schedule are in Appendix B. From 10 March until 15 June, the combination of censuses and patrols ensured that the entire island was monitored at least once a day, and areas where intense adult male aggression has been observed were monitored at least twice daily 6 days per week and at least once on the remaining day. The island was monitored for seals marked at other islands and for events such as births, deaths, weanings, adult male aggression, shark-seal interactions, entanglements, injuries, and illnesses.

When possible, observers minimized disturbance of seals by staying above the beach crest and using vegetation for cover. Census and patrol data were recorded on the standard census form (Forsyth et al. 1988) following the 1988 coding instructions in Gerrodette and

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

Frizelle (1988). In addition to the standard codes listed in the census form instructions, other codes were developed specifically for Laysan Island in 1988 (see Appendix B).

Censuses

Censuses (duration, 2.0-3.5 hours each) were conducted by two observers every fourth day from 4 March to 13 June and every second day from 28 October to 9 November, starting at 1300 Hawaii standard time (Appendix B). Census methods and criteria used for counting seals are outlined in Johanos et al. (1987). Census duties rotated among five observers until 19 May, then among four observers until 13 June. Censuses were performed by two observers in the fall. On census days, tagging and bleaching were not done until after the census.

Behavior Patrols

Data on adult monk seal behavior patterns were collected during behavior patrols (see Appendix B). These patrols recorded all adults or large subadults and their associations with any other seals, molting seals, and mother-pup pairs. Behavior patrols were designed to detect adult male aggression, such as mobbings (i.e., adult males being collectively aggressive toward and inflicting obvious injury on an individual seal). Extra behavior patrols (patrol types D and E, Appendix B) were conducted in sectors 1-8 and 18-20, where adult male mobbings have been previously observed (Johnson and Johnson 1981a; Alcorn 1984; Johanos et al. 1987; Johanos and Austin 1988; Alcorn and Buelna 1989; Alcorn and Westlake in prep.). Mobbings typically occur in the water; therefore, attention was directed out to sea as much as possible. The observers carried a VHF radio, and when an aggressive incident was observed, other observers were alerted, and they proceeded to the location if assistance was necessary.

The behavior patrols were conducted daily from 10 March to 15 June, but were canceled on 6 days because of logistics. From 10 March to 30 May, morning and evening patrols started at about 0800 and 1500, respectively. After 30 May, evening patrols started at 1400. Patrols typically lasted 3 hours but ranged from 1 to 10 hours.

On noncensus days, morning patrols (patrol types A and B) covering the entire island were conducted by two observers, with the exception of 1 day per week when only one observer covered the entire island (patrol type C). One observer traveled north from sectors 1 through 8 while the other traveled south from sectors 20 through 9. Evening patrols covered sectors 18-20 and 1-8 (traveling north) and were conducted by one or two observers (patrol type E). These patrols were extended to include sector 17 after 23 May.

On census days, morning patrols covering only sectors 18-20 and 1-8 (traveling north) were conducted by one or two observers (patrol type D). These patrols were also extended to include sector 17 after 23 May.

Incidental Patrols

Data recorded on census forms during incidental patrols from 29 February to 11 November included sightings of identified individuals, molting seals, nursing mother-pup pairs, and noteworthy events not already recorded during censuses or behavior patrols.

Behavioral Observations

Focal animal and focal group observations (Altmann 1973) were made on adult males and on adult male-female pairs. Focal observations typically lasted 2 hours each. Priority was placed on observing specific males chosen for a comparative study, and on females that had recently weaned a pup. Procedures and results will be reported elsewhere.

Collection of Samples

Skin samples were collected from adult males and weaned pups for DNA analysis to determine parental lineage and to better understand the breeding hierarchy of the adult males. To minimize disturbance, the samples were collected in conjunction with tagging efforts. Placentas from newborn pups and various tissues from dead seals (including skin, muscle, heart, and liver) were collected for initial trials in the DNA analysis. Procedures and results of the DNA analysis will be reported elsewhere.

For each dead seal recovered, an external examination was made, photographs were taken, and external measurements and observations were recorded. Skulls were flensed and staked until completely dried. If the death was recent, an internal examination was made, and samples of tissue, organs, parasites, and stomach contents were collected. Detailed descriptions of necropsy procedures and sample collection are in Winchell (1990). Scats and spews were collected from seals of known sex or size class, following the methods in Alcorn (1984). All nets, lines, ropes, and other debris items capable of entangling seals and turtles were inventoried and destroyed, following the methods in Johanos and Kam (1986).

RESULTS AND DISCUSSION

Census Counts

In all, 33 censuses and 200 behavior patrols were conducted on Laysan Island in 1988. Census counts including pups ranged from 73 to 128 seals ($\bar{x}$ = 105); counts excluding pups ranged from 61 to 116 seals ($\bar{x}$ = 87). Mean counts were lower than those for the previous 3 years (Fig. 2). Census summaries for 1988 by sex and size class are presented in Table 1.

Table 1.--Hawaiian monk seal census counts for Laysan Island, 1988 (M = male, F = female, and U = unknown).

	Adult			Subadult			Juvenile			Pup			Total		
Date	M	F	U	M	F	U	M	F	U	M	F	U	Nonpup	Pup	Combined
3/4	29	16	21	12	9	4	10	10	5	0	0	10	116	10	126
3/8	33	25	6	9	7	0	13	9	2	6	1	5	104	12	116
3/12	37	22	1	5	6	2	12	14	3	0	0	16	102	16	118
3/16	31	26	5	13	10	0	12	8	4	3	1	12	109	16	125
3/20	31	22	7	7	9	1	10	3	4	2	0	11	94	13	107
3/24	34	23	1	13	11	3	6	9	0	2	1	12	100	15	115
3/28	37	24	2	10	8	2	6	8	4	10	4	4	101	18	119
4/1	42	23	3	11	7	3	8	12	2	9	7	1	111	17	128
4/5	29	18	4	5	3	3	4	6	1	4	2	11	73	17	90
4/9	29	17	0	8	10	0	11	7	0	6	2	8	82	16	98
4/12	32	18	4	9	9	0	8	8	0	7	5	8	88	20	108
4/17	30	21	0	4	7	0	10	11	0	7	4	6	83	17	100
4/21	29	15	3	6	11	1	14	8	1	14	7	2	88	23	111
4/25	35	25	1	7	7	2	10	7	3	14	8	8	97	30	127
4/29	38	24	3	7	9	0	10	9	0	13	5	9	100	27	127
5/3	34	21	2	4	13	1	14	9	2	8	7	10	100	25	125
5/7	45	20	1	9	9	0	11	6	1	15	4	3	102	22	124
5/11	29	19	4	3	11	2	5	3	2	13	6	8	78	27	105
5/16	17	8	11	1	7	3	7	6	1	7	4	3	61	14	75
5/20	22	15	6	5	8	2	7	5	1	16	7	4	71	27	98
5/24	29	20	3	5	9	1	7	8	1	15	10	4	83	29	112
5/28	28	22	1	3	9	2	7	6	0	14	8	7	78	29	107
6/1	33	22	1	5	8	1	7	7	1	9	5	4	85	18	103
6/5	28	16	0	2	8	0	7	7	0	11	11	3	68	25	93
6/9	29	28	0	4	9	0	6	7	1	16	11	3	84	30	114
6/13	32	25	1	3	9	2	10	3	2	7	4	1	87	12	99
10/28	33	8	9	4	5	4	9	4	0	5	8	0	76	13	89
10/30	30	10	6	3	7	2	7	7	0	4	9	0	72	13	85
11/1	32	9	7	3	5	1	6	7	0	4	3	0	70	7	77
11/3	32	16	9	5	8	2	7	8	1	4	6	0	88	10	98
11/5	21	8	18	7	5	1	3	3	1	3	3	0	67	6	73
11/7	25	9	10	8	3	0	5	4	2	4	6	0	66	10	76
11/9	27	8	10	5	6	1	8	6	1	4	7	0	72	11	83

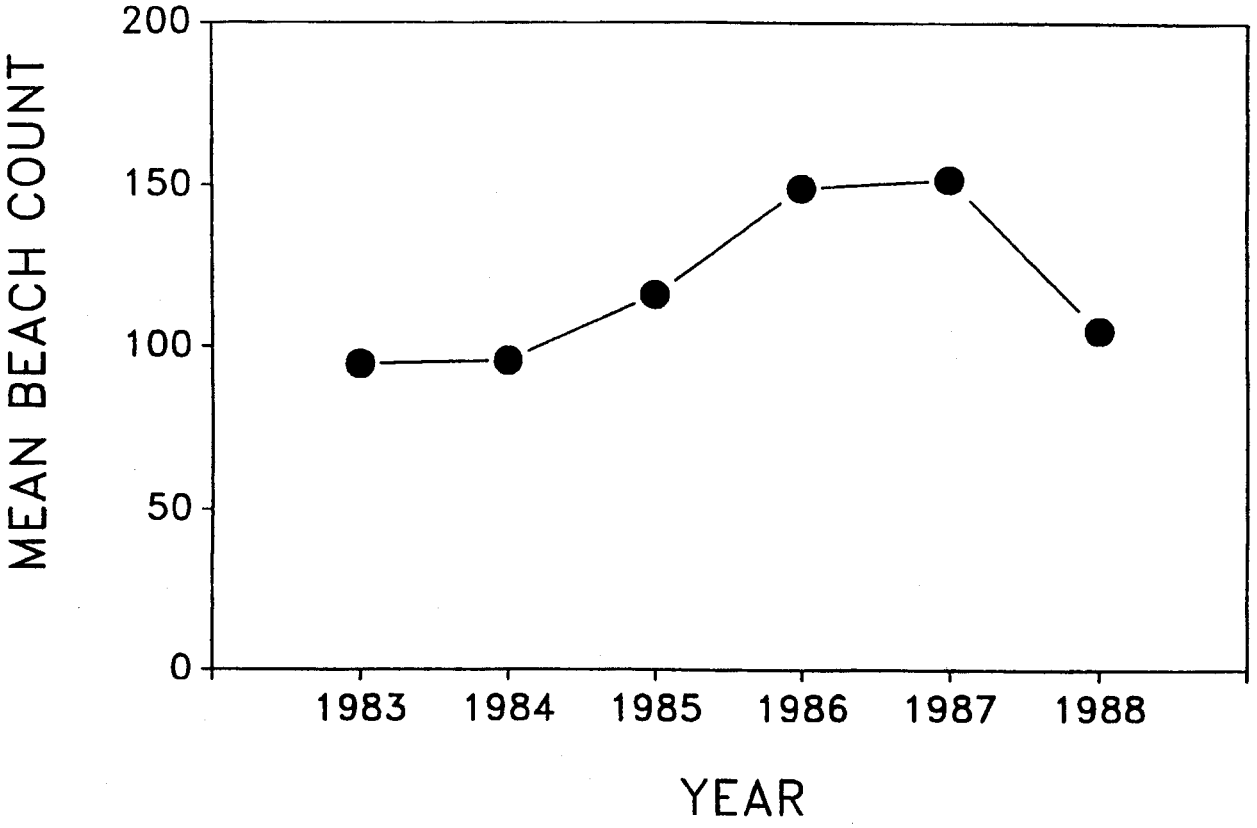

Figure 2.--Mean beach counts at Laysan Island during May and June 1983-88.

Population Structure

A total of 331 individuals (286 excluding pups) were identified by tags, bleach marks, or distinctive natural markings (Table 2). The ratio of identified males to females was very similar in the immature size classes, but was 1.5:1 in the adult class. A total of 135 seals were bleached after molting, with 55% matching a premolt identity.

Since 1985 (the last time bleach marking and identification of nearly all of the population occurred), there was a net increase of 23 identified individuals, excluding pups of the year. Numbers were similar to those in 1985 for all sexes and size classes, except adult females whose total jumped from 55 to 74 identified individuals. Although the 1985 number may be low because females were not bleached that year, most females retained a bleach mark applied post-molt in 1984. Virtually all adult females were marked in 1983 and 1984, totaling 45 and 47 individuals, respectively. Thus, an increase has clearly occurred over the past several years, lowering the observed adult sex ratio (Fig. 3).

Tagged Seals

All weaned pups were tagged in 1988. Table 3 summarizes the number of pups born and tagged at Laysan Island in 1983-88 and resighted each year through 1988. Minimum first-year survival of tagged 1987 pups was high; 86% were resighted in 1988. One Temple

Table 2.--Number of individual Hawaiian monk seals observed, by sex and estimated size class, on Laysan Island, 1988. Sex ratio is the number of males to females.

	No. of seals				
Size	Male	Female	Unknown sex	Total	Sex ratio
Adult	108	74	1	183	1.5:1
Subadults	28	29	0	57	1.0:1
Juveniles	24	22	0	46	1.1:1
Pups	24	19	2	45	1.3:1
Total	184	144	3	331	1.3:1
Total excluding pups	160	125	1	286	1.3:1

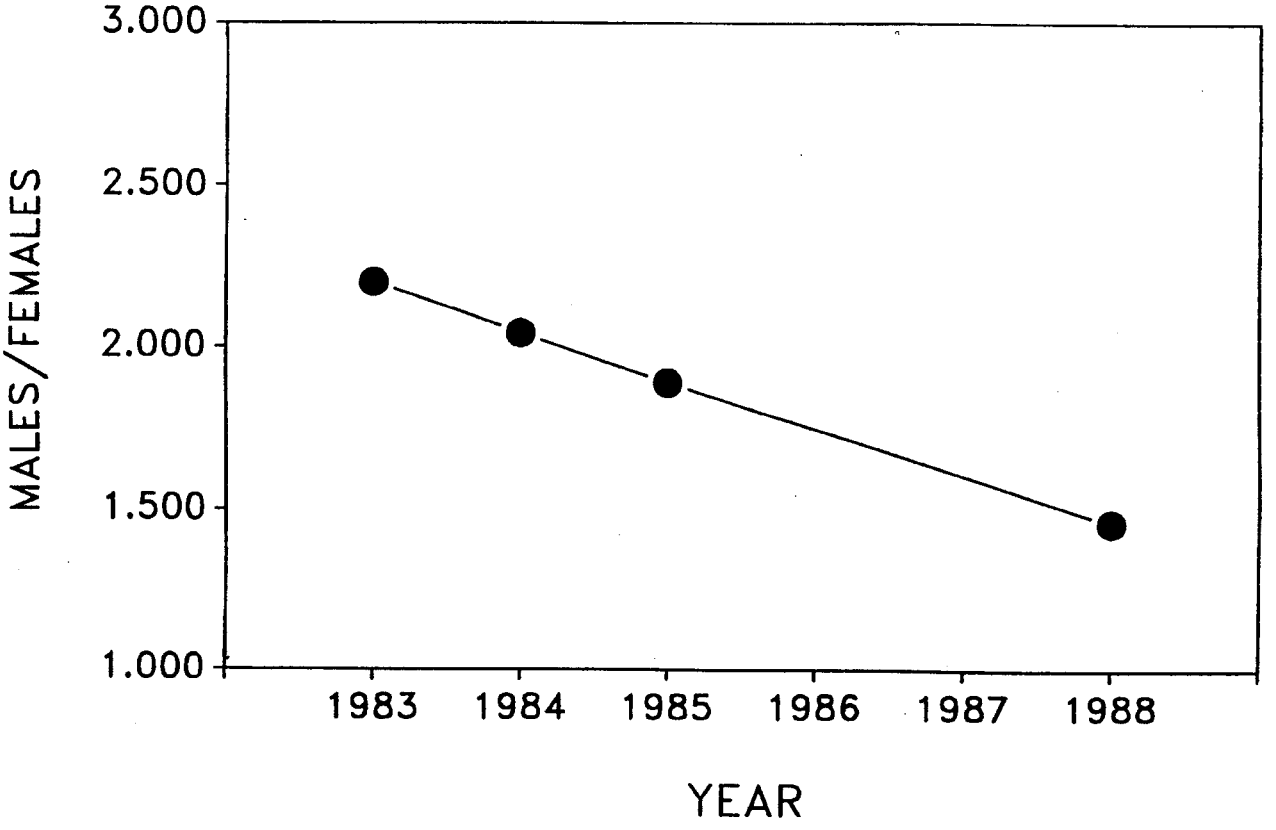

Figure 3.--Sex ratio of identified adults at Laysan Island, 1983-88.

Table 3.--Number of Hawaiian monk seal pups born, tagged, and resighted at Laysan Island, 1983-88.[a] Numbers in parentheses equal the numbers of males, females, and seals of unknown sex, respectively.

Year tagged	Known births (No.)	Pups tagged (No.)	No. of tags resighted by year				
			1984	1985	1986	1987	1988
1983	24(11,13)	20(10,10)	20(10,10)[b]	20(10,10)[c]	13(4,9)	12(3,9)[d]	12(3,9)
1984	31(16,15)	29(16,13)	--	27(15,12)	25(15,10)[e]	22(12,10)[f]	21(13,8)[g]
1985	32(18,14)	30(16,14)	--	--	23(13,10)	21(12,9)[d]	19(10,9)[c]
1986	34(15,17,2)	32(15,17)	--	--	--	25(13,12)	25(13,12)
1987	34(14,17)	28(13,15)	--	--	--	--	24(11,13)
1988	45(24,19,2)	40(23,17)	--	--	--	--	--

[a]Birth and tag data for 1983-87 are from the following sources: 1983, Alcorn and Buelna (1989); 1984, Johanos et al. (1987); 1985, Johanos and Austin 1988; 1986, Alcorn and Westlake (in prep.); and 1987, Becker and Ching (in prep.).

[b]This figure includes a seal resighted at Lisianski Island and another seal not seen in 1984 but resighted at French Frigate Shoals (FFS) in 1985.

[c]This figure includes a seal resighted at FFS.

[d]This figure includes a seal not seen in 1987 but resighted in 1988 at Laysan Island.

[e]This figure includes a seal resighted at Lisianski Island and another resighted at FFS.

[f]This figure includes a seal resighted at Lisianski Island.

[g]This figure includes a seal resighted at Lisianski Island and two resighted at FFS.

Table 4.--Subadult Hawaiian monk seals retagged with tan Temple Tags on Laysan Island, 1988.

		Left tag		Right tag		
ID No.	Sex[a]	New	Old[b]	New	Old[b]	Date
TL14	F	L65	L14c	--	L15	2 May
TT46	M	T79	T46c	--	T47	3 March
TT52	M	--	T52	T78	T51[c]	16 June

[a]F= female; M = male.

[b]Old tags were not removed unless so noted.

[c]The old, broken tag was removed, and a new tag was inserted into the existing tag hole.

Tag was definitely lost in the period between the end of the 1987 and 1988 field seasons; weaned male pup TF66 was last seen with a left tag on 25 August and lost it by 30 October 1988. In addition, several tags broke, and observers retagged three subadult seals by removing broken tags and inserting new tags into the existing holes (Table 4).

Forty-one adult males were tagged in 1988 (Table 5). Two seals received only 1 Monel tag, 17 seals received only 1 Riese tag, and the rest received 1 Riese tag as well as 1 Monel tag (17 seals), 1 Monel tag and 2 Temple tags (1 seal), or 2 Temple Tags (4 seals). Twelve of those tagged had no previous tag or identifying natural marking. Including previously tagged animals, 74% of the adult male population on Laysan Island had tags by the end of 1988.

Reproduction

Pup Production

At least 45 pups were born in 1988--24 males, 19 females, and 2 of unknown sex (Table 6). This is the highest number of births documented on Laysan Island since extensive research began in 1977: 42 pups were born in 1977, and pup production since the 1978 monk seal die-off has ranged from 29 to 34 pups (Knudtson 1981; Alcorn 1984; Johnson and Johnson 1984; Johanos et al. 1987; Johanos and Austin 1988; Alcorn and Buelna 1989; Alcorn and Westlake in prep.; Becker and Ching in prep.). We found 11 pups (10 nursing and 1 dead) at the beginning of the 1988 field season. The last three pups of the season were born 17-19 July. Of the 45 pups born, 40 survived to weaning. Although all weaned pups were sighted throughout the initial camp that ended in June, seven were not sighted during the fall camp and were not seen in the 1989 and 1990 field seasons (see Disappearances and Probable Deaths).

Table 5.--Adult male Hawaiian monk seals tagged on Laysan Island, 1988.

ID No.	Left tag				Right tag				Date
	Riese[a]	Temple[b]	New metal	Old metal[c]	Riese[a]	Temple[b]	New metal	Old metal[c]	
TH05	PI(HOO)							X108	25 April
TP09				X118	PX(HOW)				6 May
TP67		1AA	X351		MX(HWG)	1AB			14 June
TP81[d]	AR(NRG)			X307			X345		31 May
TY60	BC(NYY)			X168				X269	22 April
TY88				X173	PS(NOG)				18 April
T07M	CD(NBW)		X331						26 April
T17M				X198	PN(NOO)				26 April
T18M				X279	CV(HBO)				9 May
T25M	AK(HRW)			X292				X289	3 May
T30M	PK(HOG)			X326				X288	3 May
T32M			X340		AZ(HRY)				7 May
T33M	HL(HGY)						X333		29 April
T34M			X336		CP(NBW)				3 May
T35M		1AM	X352		CU(HBR)	1 AN			14 June
T36M[d]	AE(NRG)						X337		4 May
T37M	CG(HBB)						X342		7 May
T38M			X339		CN(NBR)				6 May
T39M			X335		CO(NBO)				2 May
T40M			X361						11 June
T41M			X344		CZ(HBY)				23 May
T42M			X334		MT(NWY)				2 May
T43M	CI(HBO)						X350		6 June
T311							X357		3 June
T322					HO(NGY)		X343		11 May
T323		1 AG	X363		CR(NBG)	1AH			16 June

Table 5.--Continued.

ID No.	Left tag				Right tag				Date
	Riese[a]	Temple[b]	New metal	Old metal[c]	Riese[a]	Temple[b]	New metal	Old metal[c]	
T340			X332	X310	AP(NRW)				29 April
T349	MH(NWY)			X298				X145	18 April
T353	AL(HRG)							X246	6 May
T415				X297	CM(NBB)			X137	22 April
T438				X102	AX(HRW)				4 May
T708		1AE		X160	CS(NBY)	1AF		X187	14 June
T734	CF(NBY)			X138				X263	25 April
T735	BI(HYY)							X171	2 June
T741	HC(NGY)						X346		31 May
T742			X338		PZ(HOY)				5 May
T756		1AO	X362		CX(HBW)	1AQ			16 June
T758	CB(NBR)			X251				X126	3 May
T764	CH(HBR)							X146	6 May
T766	CJ(HBW)			X161			X356		6 June
T770	CE(NBG)							X120	5 May

[a]Riese tags can be read by either the unique letter code, listed first, or by a unique hole-letter combination listed in parentheses (H = hole, N = no hole, B = blue, G = green, O = orange, R = red, W = white, and Y = yellow).

[b]Tan colored.

[c]Old tags were not removed.

[d]Same color combination on left Riese tag on both TP81 and T36M. T36M's tag should have gone on the right hind flipper.

Table 6.--Summary of data on Hawaiian monk seal pups born on Laysan Island, 1988.

Tag No.[a]		ID		Birth		Weaning		Nursing period	Tagging	Measurement[c] (cm)		Mother
L	R	No.	Sex[b]	Date	Sector	Date	Sector	(days)	date	AG	SL	ID
F00	F01	TF00	M	--	--	3/3-4	11	--	3/7	110	125	TP52
F02	F03	TF02	M	--	--	3/7	4	--	3/12	103	119	248
F04	F05	TF04[d]	M	--	--	3/17	3	--	3/21	99	130	532
F06	F07	TF06	M	--	--	3/28	2	--	3/29	116	138	T65F
F08	F09	TF08	F	--	--	3/27-28	7	--	3/29	115	140	T44F
F10	F11	TF10	F	3/1-2	11	4/5	10	34-35	4/5	109	141	T64F
F13	F12	TF12[e]	M	--	--	4/4	4	--	4/5	96	116	T374
F15	F14	TF14	M	--	--	3/30-31	10	--	4/9	102	127	520
F16	F17	TF16[f]	F	--	--	4/8	2	--	4/9	130	132	T63F
F18	F19	TF18	M	3/1	3	4/5	2	35	4/11	106	121	527
F21	F20	TF20	M	--	--	4/8	4	--	4/12	120	135	T51F
F22	F23	TF22	M	--	--	3/27	11	--	4/13	121	148	T53F
F24	F25	TF24	M	3/3-4	10	4/12	11	39-40	4/13	104	123	T38F
F26	F27	TF26	F	3/10	3	4/17	2	38	4/19	101	126	L18
F28	F29	TF28[g]	M	3/6	4	4/14	4	39	4/21	99	112	TA26
F30	F33	TF30	M	3/12	2-3	4/26	3	45	4/27	115	130	T37F
F31	F32	TF32	M	3/10	4	4/25	3	46	4/27	91	115	T68F
F34	F35	TF34	M	3/13	3	4/23	3	41	4/27	116	135	T368
F36	F37	TF36	F	3/22	20	5/2	20	41	5/2	110	141	GA10
F38	F39	TF38	F	3/15	3	4/30	3	46	5/5	125	147	T66F
F40	F41	TF40[h]	M	4/5	3	5/6	4	31	5/7	97	118	299
F42	F43	TF42	F	4/1	2	5/4	3	33	5/7	107	127	T56F
F44	F45	TF44	M	3/26	2	5/9	2	44	5/13	105	118	T15F
F46	F47	TF46[i]	F	4/3	3	5/12	4	39	5/13	114	125	TA04
F48	F49	TF48	M	4/2	2	5/11	4	39	5/13	110	130	T391
F50	F51	TF50	F	4/5	11	5/11	9	36	5/16	114	136	T69F
F52	F53	TF52	M	3/29	11	5/15-16	12	47-48	5/16	121	131	T14F
F54	F55	TF54	F	4/11	11	5/15-16	12	34-35	5/16	96	122	TA32
F56	F57	TF56	M	4/17	12	5/28	12	41	5/29	117	130	229
F58	F59	TF58	F	4/23	2	5/30	2	37	6/7	110	125	GJ31
F60	F61	TF60	F	4/24	3	6/5	3	42	6/7	120	132	T09F
F62	F63	TF62	M	4/29	4	6/4	1	36	6/10	112	132	T362
F64	F65	TF64	M	5/28	20	7/4	20	37	7/4	--	107	T22F
F66	F67	TF66	M	5/26	20	7/6	20	41	7/6	103	121	T12F
F68	F69	TF68	M	5/18	20	6/29-7/3	19	42- 46	7/6	119	124	139
F70	F71	TF70	F	6/4	11	7/13-21	11	39-47	7/22	117	127	T06F
F72	F73	TF72	F	6/12	1	7/21	20	39	7/27	117	128	T03F
F74	F75	TF74	F	7/17-19	20	8/24-25	20	36-39	8/25	119	125	--
F76	F77	TF76	F	7/17-19	6	8/26-30	6	38-44	8/30	115	138	T27F
F78	F79	TF78	F	7/17-19	5	--	--	--	11/8	81	125	T24F
--	--	TFX1[j]	U	--	--	--	--	--	--	--	--	--
--	--	TFX2[k]	F	2/29-3/1	2	--	--	--	--	--	--	169

Table 6.--Continued.

Tag No.[a] L	Tag No.[a] R	ID No.	Sex[b]	Birth Date	Birth Sector	Weaning Date	Weaning Sector	Nursing period (days)	Tagging date	Measurement[c] (cm) AG	Measurement[c] (cm) SL	Mother ID
--	--	TFX3[l]	F	3/6	3-4	--	--	--	--	--	--	151
--	--	TFX4[m]	M	3/7	3	--	--	--	--	--	--	T31F
--	--	TFX5[n]	U	5/20	20	--	--	--	--	--	--	T11F

[a]Tan Temple Tags; L = left hind flipper and R = right hind flipper.
[b]F = female, M = male, and U = unknown.
[c]AG = axillary girth; SL = straight length.
[d]Pup exchange. Mom 532 ends parental investment on 15 March, TF04 weans from T63F on 17 March.
[e]Pup exchange. Mom T374 end parental investment on 8 April; TF12 weans from T63F on 4 April.
[f]Pup exchange. Mom T63F ends parental investment on 4 April; TF16 weans from T374 on 8 April.
[g]Pup exchange. Mom TA26 ends parental investment on 7 March; TF28 weans from 151 on 14 April.
[h]Pup exchange. Mom 299 ends parental investment on 12 May; TF40 weans from TA04 on 6 May.
[i]Pup exchange. Mom TA04 ends parental investment on 6 May; TF46 weans from 299 on 12 May.
[j]Died before field camp was established. Remains found on 2 March in sector 12.
[k]Perinatal pup death.
[l]Died 7 March in sector 4 after being abandoned in pup exchange.
[m]Died 15 March in sector 3.
[n]Pup lost 31 May-1 June in sector 20 and is presumed dead.

The major pupping areas were similar to previous years; 62% of the known pupping sites occurred along the midwest (sector 20) and northwest (sectors 2-3) portions of the island.

Complete nursing periods were observed for 29 mother-pup pairs in 1988. Average nursing period was 39-40 days (range, 31 to 47-48 days).

Pup Exchanges

Pup exchanges were observed 17 times between 14 nursing females. This is the greatest number of pup exchanges ever observed on Laysan Island. The observed increase may be partially due to a higher density of nursing mothers in sectors 2-3 in 1988, but is probably also due to the increased observation effort and marking of nursing mother-pup pairs during a concurrent study conducted by Boness (1990) on Laysan Island. All but one of the pup exchanges were observed during this separate study and are described in Boness (1990). Details of the remaining pup exchange follow.

Seal GJ31 gave birth on 23 April in sector 2, and T09F gave birth the following day in sector 3. The mothers were observed in their parturition sectors throughout the pup exchange. Although both pups were female, T09F's pup could be distinguished by an applied bleach mark. On 25 May, the marked pup was with its mother at 1005, but by 1636, the pups had switched. The pups were back with their respective mothers on 26 May; the marked pup was with a mother (probably T09F) in sector 3 at 0906 and confirmed to be

with T09F at 1618. Subsequently, both pups remained with their mothers until weaning. The unmarked pup of GJ31 weaned on 30 May in sector 2; the marked pup of T09F weaned on 5 June in sector 3.

Parturient Females

The 1988 reproductive rate was similar to previous years on Laysan Island; at least 61% of the adult females in the population gave birth. Thirty-one of the 45 parturient females had been identified in previous years. Parturition dates were known for 7 of the 10 adult females that pupped in both 1987 and 1988, and the average time between births in successive years was 382 days (range, 374-393 days). Three females (TA04, TA26, and TA32), born and tagged on Laysan Island in 1983 (Alcorn and Buelna 1989), gave birth in 1988 and were the youngest parturient Hawaiian monk seals ever documented. Previously, the youngest parturient females on record gave birth at Kure Atoll in 1987 at 6 years of age (Reddy 1989).

Seal T27F, tagged as a yearling at French Frigate Shoals (FFS) in 1967, gave birth on Laysan Island in 1988. At least 22 years old, she is the oldest known parturient female. She has been sighted at Laysan Island since 1982 and has pupped each year since 1984 (Johanos and Austin 1988; Alcorn and Westlake in prep.; Becker and Ching in prep.).

Births

A seal was observed giving birth, and two were observed immediately following parturition. Two of these events were observed by Smithsonian personnel (L. Honigman, Nature Conservancy, 1116 Smith St., Honolulu, HI 96817, pers. commun., August 1990), and the unpublished field notes are on file at the NMFS Honolulu Laboratory. Female T56F gave birth at 1228 on 1 April, and female T15F gave birth between 1100 and 1104 on 26 March, although the actual parturition of T15F was not observed. The third female (bleach No. 139) gave birth at approximately 1812 on 18 May in sector 20. The latter seal lay on her left side at midbeach with her hind flippers toward the ocean. She rolled onto her ventrum, and a wet pup hauled up the mother's left side toward her nose. The mother nudged and vocalized to her pup. The pup was partially hidden from view, and observers could not determine whether the placenta was still attached. The mother was still on her ventrum, and the pup had not nursed, when observations ended at approximately 1820.

Interisland Movement

In 1988, interatoll movement was documented for 11 seals which moved between Laysan Island and Lisianski Island or French Frigate Shoals (Table 7). Subadult male GL16 and female BT10 moved from Lisianski Island to Laysan Island, and juvenile male YL11 moved from FFS to Laysan Island. Subadult males TK25 and TT08 and adult males T45M and T46M moved from Laysan Island to FFS. In addition, three seals made round trips: subadult male TT34 and adult female T08F traveled from Laysan Island to Lisianski Island and returned, whereas subadult female GO54 made the opposite trip. Subadult male Y322 traveled from FFS to Laysan Island and then to Lisianski Island.

Table 7.--Interisland movement of monk seals to and from Laysan Island, 1988 (A = adult, S = subadult, and J = juvenile; M = male and F = female).

ID No.	Tag No. L	Tag No. R	Tag color[a]	Size	Sex	Movement from Location	Movement from Date last seen	Movement to Location	Movement to Date first seen
YL11	L11	L111	Y	J	M	FFS[b]	6/23/87	Laysan	3/12/88
TK25	K25	K24	T	S	M	Laysan	7/13/87	FFS[b]	8/19/88
GL16	L16	L17	G	S	M	Lisianski	5/18/88	Laysan	10/27/88
TT08	T08	T07	T	S	M	Laysan	8/2/86	FFS[b]	9/15/88
BT10	T11	T10	B	S	F	Lisianski	8/20/87	Laysan	3/12/88
Y322	T33	T33	Y	S	M	FFS[b] Laysan	7/06/87 4/13/88	Laysan Lisianski	3/7/88 8/29/88
TT34	T34	T33	T	S	M	Laysan Lisianski	6/13/88 8/29/88	Lisianski Laysan	8/29/88 8/30/88
G054	A15	A16	G	S	F	Lisianski Laysan	8/24/87 4/21/88	Laysan Lisianski	3/18/88 5/16/88
T08F	--	--	--	A	F	Laysan Lisianski	5/9/88 5/18/88	Lisianski Laysan	5/17/88 6/2/88
T45M	--	--	--	A	M	Laysan	4/21/88	FFS[b]	5/23/88
T46M	--	--	--	A	M	Laysan	3/15/88	FFS[b]	9/15/88

[a]French Frigate Shoals.
[b]Tag colors: B = blue, G = green, T = tan, and Y = yellow.

Factors Affecting Survival

Injuries

Ninety-two injuries were observed during the 1988 field season. In order by frequency, adult male mating attempts, seal bites, shark attacks, or contact with reef or debris probably injured most seals (Table 8). Of the 52 injuries (57% of total) thought to be caused by seals, adult male mating attempts probably caused 35 (38% of the total), and bites inflicted during jousts probably caused 17 (18% of the total). Of the 15 injuries (16% of total) apparently inflicted by sharks, 9 were circular wounds typically inflicted by the cookiecutter shark, *Isistius brasiliensi*, and 6 were more severe, clean lacerations or gaping wounds, probably inflicted by the tiger shark, *Galeocerdo cuvieri*. Contact with reef or debris probably caused eight wounds (9% of the total), seven of which were minor, but one seal had a severe neck wound from entanglement in netting. A pulled flipper tag (still attached) bloodied a seal's tag hole. In addition, 16 injuries (17% of the total) were from unknown sources. Further analysis of these injuries will be reported elsewhere.

Adult Male Aggression

A mobbing and a similar act of aggression by a single male were observed (see Disappearances and Probable Deaths). Other mobbings clearly occurred at Laysan Island in 1988, as evidenced by massive back wounds found on both live and dead seals (see Injuries, Disappearances and Probable Deaths, and Deaths). Prolonged adult male harassments of immature seals, nursing female-pup pairs, and injured seals also were observed. The aftermath of a mobbing and a potential mobbing interrupted by the observer are described below.

Case 1.--On 26 April at approximately 1830, adult female T63F was observed on the high beach in sector 14 accompanied by four adult males (T764, TY60, and two unidentified seals). The female had fresh lacerations over three- fourths of her back (see injury No. 41). She was fleeing inland; the males followed in single file. Defending male T764 periodically turned and challenged the male behind him. The female entered the vegetation and then traveled east, parallel to the beach. Observation ended at approximately 1845.

The following day, the female and T764 were alone on the high beach at 0848, having traveled approximately 200 m toward the border of sectors 13-14. No additional injuries were apparent; she was sighted alone in sector 15 on 28 April.

Case 2.--On 17 June, adult female T37F hauled down the beach in sector 1 at 0740. Adult male T16M arrived by 0755. He vocalized and bit her, and the pair hauled up to the beach crest. By 0815, two other adult males (T766 and T760) had arrived. The attending male attempted to chase them off, but they remained and positioned themselves between the pair and the water. Single adult males were repulsed at 0857 and 0918, but adult male T726 arrived at 0928 and also stayed. Additional adult males were repulsed at 0953 and 1125. Adult male T460 arrived, jousted with the attending male, and displaced male T16M

Table 8.--Injuries of Hawaiian monk seals at Laysan Island, 1988 (A = adult, S = subadult, J = juvenile, and W = weaned pup; M = male, F = female, and U = unknown; P = probable cause, and K = known cause).

Injury No.	Date	Size	Sex	ID No.	Description of injury					
					Type	Location	Depth (cm)	Dimension (cm) (l x w or diam.)	Cause	P or K
1	2/29	S	F	GK24	Gaping wound	Neck	3.75[a]	42.5 x 3.75	Entanglement with net	K
2	3/3	S	M	TT46	Other-4th toenail ripped off	Left foreflipper	--	--	Unknown	--
3	3/3	A	F	T68F	Circular	Left lateral	1.25x1.8[b]	7.5 x 6.25	Shark	P
4	3/14	S	F	TK55	Laceration	Head--left cheek	0.5[c]	5.0 x 2.0	Unknown	--
6	3/15	S	F	TK51	Laceration	Dorsal	0.2[c]	7.5 x 0.63	Seal bite	P
7	3/12	A	M	T349	Circular	Ventral	3.75[d]	7.5 diam.	Shark	P
8	3/18	A	M	Bleach 265	Circular	Ventral	2.5[a]	6.0 diam.	Shark	P
9	3/21	A	F	T39F	Numerous gaping wounds	Dorsal	1.0[c]	Largest, 3x2; total area covers 3/4 back	Adult male	P
10	3/27	A	F	TA04	Circular	Dorsal	2.5[b]	6.25 diam.	Shark	P
11	3/31	S	M	TT54	Gaping wound lacera-tion	Right lateral	5.0 cm[a]	17.5 x 10.0 (wound); 10.0 x 1.25 (laceration)	Shark	P

Table 8.--Continued.

Injury No.	Date	Size	Sex	ID No.	Description of injury					P or K
					Type	Location	Depth (cm)	Dimension (cm) (l x w or diam.)	Cause	
12	4/2	A	M	T719	Two lacerations	Right hind flipper	0.2[c]	3 x 0.1; 1.5 x 0.1	Reef/debris	P
13	4/4	A	F	TA40	Laceration	Right lateral	0.3[d]	5.0 x 0.1	Unknown	--
14	4/4	S	F	BT10	Numerous lacerations	Dorsal	0.2[e]	Longest, 8.75; total area covers 3/4 back	Adult male	P
15	4/7	A	M	TP41	Laceration	Lower lip	0.2[c]	1.5 x 0.1	Unknown	--
17	4/11	S	M	TK07	Several abrasions	Right lateral and dorsal	0.2[e]	6.0-10.0 x 0.3	Seal bites	P
18	4/12	A	M	T04M	Three gaping wounds	Head--muzzle	1.25[a]	2.5 x 2.5	Seal bites	P
19	4/14	A	F	T11F	Gaping wound	Dorsal	1.25[d]	21.5 x 15.0	Adult male	P
20	4/14	A	M	T23M	Three gaping wounds	Left lateral	4.0-5.0[a]	20 x 30, 8 x 25, 6 x 25	Shark	P
22	4/15	A	M	TP87	Laceration	Left lateral	0.63[d]	3.75 x 0.63	Seal bite	P
23	4/15	S	F	TK51	Circular wound	Ventral	--[c]	6.25 diam.	Shark	P
24	4/15	A	M	T446	Laceration	Right hind flipper	0.3[c]	1.8 x 0.6	Unknown	--

Table 8.--Continued.

Injury No.	Date	Size	Sex	ID No.	Description of injury: Type	Location	Depth (cm)	Dimension (cm) (l x w or diam.)	Cause	P or K
25	4/16	A	F	T31F	Numerous lacerations and gaping wound	Dorsal and left hind flipper	0.63[d]	Largest laceration, 5.0 x 1.25; total area covers 3/4 back	Adult male	P
26	4/14	A	F	TP71	Laceration	Left hind flipper	0.5[d]	2.5 x 1.25	Reef/debris	P
27	4/17	A	F	T53F	Several abrasions	Dorsal	--[c]	Longest, 15.0 x 0.1	Adult male	P
28	4/18	A	F	T64F	Several abrasions	Dorsal	--[c]	Total area covers 3/4 back	Adult male	P
29	4/18	A	M	TY60	Abrasion	Ventral	--[c]	7.5 x 5.0	Seal bite	P
30	4/18	S	M	TT34	Numerous lacerations	Dorsal	1.5[c]	Largest, 5.0 x 0.5; total area covers 3/4 back	Adult male	P
32[f]	4/20	S/A	U	--	Gaping wound	Dorsal	7.5[a]	Covers entire back	Adult male	P
33	4/15	A	F	T63F	Numerous lacerations	Dorsal	--[c]	Total area covers 1/3 back	Adult male	P

Table 8.--Continued.

Injury No.	Date	Size	Sex	ID No.	Description of injury					P or K
					Type	Location	Depth (cm)	Dimension (cm) (l x w or diam.)	Cause	
35	4/22	A	M	T726	Gaping wound	Head	0.63[d]	2.5 x 1.0	Seal bite	P
38	4/25	A	M	T719	Gaping wound	Right lateral	1.8[b]	7.5 x 5.0	Seal bite	P
39	4/25	A	M	TP84	Gaping wound	Left lateral	0.63[d]	2.5 x 1.25	Unknown	--
40	4/14	A	M	T20M	Lacerations	Neck	0.2	Largest, 5.0 x 0.2	Seal bites	P
41	4/26	A	F	T63F	Numerous lacerations	Head, dorsal, left hind flipper	0.2[c]	Largest, 10.0 x 0.2; total area covers 3/4 back	Adult male	P
42	4/27	A	M	T764	At least five lacerations	Left lateral, head, neck, right foreflipper	0.2[c]	Largest, 15.0 x 0.2	Seal bites	P
43	4/20	A	M	T42M	Abrasion	Left hind flipper	--[c]	--	Unknown	--
44[f]	4/27	S	F	TT30	Numerous lacerations	Dorsal	--[c]	Largest, 5.0 x 1.25; total area covers 3/4 back	Adult male	P
45	4/27	A	M	T803	Laceration	Right lateral	--[c]	8.75 x 0.2	Unknown	--

Table 8.--Continued.

Injury No.	Date	Size	Sex	ID No.	Description of injury					P or K
					Type	Location	Depth (cm)	Dimension (cm) (l x w or diam.)	Cause	
46	4/29	J	M	TN00	Numerous lacerations	Dorsal	--[c]	Total area covers 1/2 back	Adult male	P
47[f]	4/30	J	M	TL06	Numerous abrasions, one gaping wound	Dorsal and ventral	--[d]	Total area covers 1/2 back	Adult male	P
48	4/30	S	M	TL46	Numerous abrasions	Dorsal	--[e]	Total area covers 1/2 back	Adult male	P
49	5/2	S	F	TL14	Numerous abrasions	Dorsal and left lateral	--[c]	Total area covers 1/5 back	Adult male	P
50	5/2	A	F	TA26	Abrasion	Dorsal	--[d]	5.0 x 1.25	Reef/debris	P
51	4/30	A	F	T374	Abrasions and puncture	Dorsal	--[d]	2.5 diam.	Adult male	P
52	5/3	A	F	--	Numerous lacerations	Dorsal	--[c]	Total area covers 2/3 back	Adult male	P
53	5/3	A	M	T080	Numerous lacerations	Dorsal and ventral	--[c]	--	Seal bites	P
54	5/3	J	M	TN21	Abscess	Lower dorsum	Raised 0.6	Widest point, 27.5 x 15.0	Adult male	P

Table 8.--Continued.

Injury No.	Date	Size	Sex	ID No.	Description of injury				Cause	P or K
					Type	Location	Depth (cm)	Dimension (cm) (l x w or diam.)		
55	4/28	A	M	Bleach 265	Abrasion	Above right foreflipper	--[e]	7.5 x 5.0	Unknown	--
56	4/27	S	M	TA23	Other	Left hind flipper	--	--	Pulling tag	P
57	5/5	A	F	Bleach 520	Abrasion	Dorsal	--[e]	Total area covers 1/4 back	Adult male	P
58	5/6	S	F	TK51	Gaping wound	Dorsal	--[d]	10.0 x 1.25	Adult male	P
59	5/6	A	M	T42M	Circular	Ventral	--[c]	4.0 diam.	Shark	P
60	5/4	A	M	T766	Laceration	Ventral	--[c]	3.0 x 0.1	Reef/debris	P
61	5/9	J	M	TL48	Gaping wound	Ventral	--[c]	4.2 x 2	Unknown	--
62[f]	5/18	S	M	TK07	Gaping wound	Dorsal	2.5[a,b]	70 x 25; total area covers 2/3 back	Adult male	P
63	5/20	A	F	T374	Gaping wound	Dorsal[c]	--	Various scratches; largest, 5.0 x 7.5	Adult male	P
64	5/23	A	F	T63F	Laceration	Dorsal	--[c]	--	Adult male	P

Table 8.--Continued.

Injury No.	Date	Size	Sex	ID No.	Description of injury: Type	Location	Depth (cm)	Dimension (cm) (l x w or diam.)	Cause	P or K
66	5/24	S	M	TK23	Numerous abrasions and one abscess	Dorsal	--[c]	Abscess, 7.5 diam.	Adult male	P
68	5/25	A	M	T44M	Gaping wound	Right lateral	10.0[g]	30 x 30	Shark	P
69	5/24	A		Bleach 239	Lacerations	Dorsal	--[c]	3.75 x 1.25	Adult male	F P
70	5/28	A	F	T302	Puncture and lacerations	Right lateral and dorsal	--[c]	10.0-15.0 x 0.6	Adult male	P
71	5/29	A	M	T35M	Gaping wound	Right lateral	--[d]	1.25 x 1.25; total length, 30.0	Shark	P
72	5/17	W	F	TF42	Lacerations	Left lateral	--[c]	Length, ca. 7.5	Reef/debris	P
73	5/17	A	M	TP81	Abrasion	Left hind flipper	--[c]	--	Reef/debris	P
74	5/16	W	M	TF32	Lacerations	Right lateral	--[c]	6.25 x 0.63	Reef/debris	P
75	5/31[h]	A	F	T29F	Abscesses and two parasites	Right and left lateral	--[c]	--	Unknown	--
76	5/31	A	F	T56F	Lacerations	Ventral and left hind flipper	--[c]	ca. 2.5 x 0.6	Unknown	--

Table 8.--Continued.

Injury No.	Date	Size	Sex	ID No.	Description of injury: Type	Location	Depth (cm)	Dimension (cm) (l x w or diam.)	Cause	P or K
77	5/31	A	F	Temp. ID-L18	Laceration	Left hind flipper	--[a]	ca. 2.5 x 0.6	Unknown	--
78	5/31	W	M	TF00	Punctures	Dorsal	--[d]	Largest, 2.0 x 1.0	Seal bites	P
79	6/1	A	F	T15F	Lacerations	Dorsal	--[c]	Total area covers 2/3 back	Adult male	P
80	5/26	A	M	TY75	Amputation	Right hind flipper	--	--	Shark	P
81	5/22	J	M	TN16	Laceration	Left hind flipper	--[a]	2.0 x 8.0	Unknown	--
82	6/5	A	F	T15F	Gaping wound	Right lateral	--[d]	5.0 x 1.25	Seal bite	P
83	6/9	W	M	TF24	Two punctures	Left lateral	--[d]	1.0 x 0.5	Seal bites	P
84	6/10	A	F	TA32	Punctures and abrasions	Dorsal and lateral	--[c]	Total area covers entire back and sides	Adult male	P
85	6/8	A	M	T308	Lacerations	Head--left side	1.25[c]	10.0 x 1.0	Seal bites	P
86	6/9	S	M	TT38	Punctures	Left side over left foreflipper	--[c]	15 x 15	Shark	P

Table 8.--Continued.

Injury No.	Date	Size	Sex	ID No.	Description of injury					P or K
					Type	Location	Depth (cm)	Dimension (cm) (l x w or diam.)	Cause	
87	6/10	A	M	T080	Lacerations	Head--right upper eyelid	--[c]	1.25 x 0.6	Seal bites	P
88	6/11	A	F	T37F	Gaping wound	Dorsal	--[c]	7.5 x 1.25	Adult male	P
89	6/13	A	M	T25M	Lacerations/abrasion	Hind flippers and muzzle	--[c]	--	Seal bites	P
90	6/12	A	M	T42M	Laceration,gaping wound	Head--right side	--[a]	10 x 8	Seal bites	P
93	10/27	S	M	TK23	Abscess	Left lateral, 1/3 from tail	2.0 raised	20.0 x 2.5	Unknown	--
94	10/28	W	F	TF60	Circular wound	Dorsal near tail	3.0[a]	7.0 diam.	Shark	P
95	11/1	J	F	TL34	Circular wound	Ventral right hind flipper	1.25	10.0 x 2.5	Shark	P
96	10/30	S	F	TL14	Puncture	Chest-ventrum	1.25	ca. 7.5	Unknown	--
97	5/9	J	M	TL06	Gaping wound	Dorsal and right lateral	--[d]	7.5	Adult male	P
98	5/12	A	F	T374	Gaping wound, abrasions, laceration	Dorsal, right lateral, left foreflipper	1.25[d]	7.5 x 1.5	Adult male	P

Table 8.--Continued.

Injury No.	Date	Size	Sex	ID No.	Description of injury				Cause	P or K
					Type	Location	Depth (cm)	Dimension (cm) (l x w or diam.)		
99	6/11	A	F	TA32	Gaping wound	Dorsal and right lateral	--[d]	15 x 15	Adult male	
100	11/1	S	F	TL14	Circular wound	Dorsal between shoulders	0.1	3.0 diam.	Shark	P
101	7/19	W	F	TF54	Gaping wound	Lower dorsal	--	--	Adult male	P
102	7/26	W	M	TF32	Gaping wound	Lower dorsal	--[a]	--	Adult male	P
103	8/17	U	U	--	Gaping wound	Lower dorsal	--	--	Adult male	P

[a]Muscle layer.

[b]Fat layer.

[c]Skin broken.

[d]Blubber layer.

[e]Surface scratch.

[f]Disappeared.

[g]Body cavity.

[h]One of the unidentified parasites was attached to a lump that was first noted on 31 March 1988.

Table 9.--Hawaiian monk seal entanglements[a] in debris at Laysan Island, 1988 (A = adult, S = subadult, and J = juvenile; M = male, F = female, and U = unknown).

Field No.	Date	Size	Sex	ID No.	Location of seal: Sector	Location of seal: Beach position[b]	Type of debris	Part of body entangled
1	2/29	J	M	TN44	01	2	Plastic ring	Neck
2	3/1	S	F	GK24	05	3	Net	Neck[c]
3	3/11	S	M	TT48	07	2	Net	Body, left foreflipper
4	3/14	S	M	TT06	19	2	Line	Torso
5	3/15	A	F	Y156	08	2	Net	Snout
6	3/18	A	F	--	07	2	Net	Midtorso
7	4/4	J	F	TN48	07	1	Net	Neck

[a]Movement was not restricted in any of these entanglements.
[b]1 = wet sand, 2 = midbeach, and 3 = beach crest.
[c]See injury No. 1 in Table 8.

at 1149. Displaced male T16M was approached by the other three lone males, and then all four males rushed toward the new pair. The observer intervened between the pair and the four advancing males at 1151, as the new attending male jousted with and bit the female. Adult male T760 left at 1153, followed by T726 and T16M at 1155 and 1158, respectively. The original attending male returned at 1240, displaced T460, and then chased away T766. By 1253, only the original pair remained. Observations ended at 1317.

Entanglement and Net Accumulation

Seven seals were found entangled in debris and were released by observers (Table 9). Three of these entanglements (cases 3, 5, and 6) involved the same large trawl net that was pulled up the beach by observers attempting to minimize entanglement and left at the border of sectors 7 and 8. In all, 485 pieces of potentially dangerous debris (including the large trawl net) were inventoried and destroyed before the end of the field season. Details of the entanglements follow.

Case 1.--On 29 February at 1130, juvenile male TN44 was observed at midbeach in sector 1 with a tight plastic ring around his neck. He apparently was not injured, and his movement was not restricted, but the band could not be slipped over his neck. Observers restrained the seal and cut off and collected the band.

Case 2.--On 1 March at 0936, subadult female GK24 was observed at high beach in sector 5 with a net fragment encircling her neck. Although not restricting movement, the net was cutting deeply into the sides and back of the neck, and the wound was closing over the strands (injury No. 1). Observers restrained the seal and removed and collected all segments of the net from the wound. After release, the seal rested for several minutes in the wave wash before swimming away. The neck wound healed during the field season.

Case 3.--On 11 March at 0957, subadult male TT48 was at midbeach in sector 7, entangled in the loose loops of a trawl net. The seal had two strands of netting around his body, and a loop of mesh on his left foreflipper. Observers cut the two strands of net, though the loops were probably loose enough for the seal to have freed himself. The seal woke, disengaged himself from the net, and then fell asleep again in the same general vicinity. The net was pulled farther up the beach after the seal left.

Case 4.--On 14 March at 0825, subadult male TT06 was entangled in a line at midbeach in sector 19. The observer removed the line from around the seal's torso.

Case 5.--On 15 March, adult female Y156 was entangled in a net at midbeach in sector 8. The net was removed from around her snout, though she probably could have freed herself.

Case 6.--On 18 March, an unidentified adult female was entangled in a net at midbeach in sector 7. The net was removed from around her midtorso.

Case 7.--On 4 April at 1705, juvenile female TN48 was entangled on the wet sand in sector 7. Netting was loosely wrapped around her neck, and she probably could have freed herself. The net was removed and taken to the beach crest.

Disappearances and Probable Deaths

At least 17 seals disappeared during the 1988 field season: 5 of the seals disappeared during the initial 1988 field camp that ended in June, and 12 of the seals seen throughout the initial camp were not sighted in the fall and were not seen in the 1989 and 1990 field seasons. A juvenile male sighted in 1989 with both tags ripped out probably accounts for one of these disappearances. Nothing unusual was noted before 12 of these disappearances; juvenile male TL52 and subadult male TK33 were last seen 31 and 30 March, respectively, and 7 weaned pups (males TF04, TF24, TF28, and TF48; females TF26, TF54, and TF70) and 3 juvenile seals (males TN11 and TN34 and female TL42) were seen throughout the initial camp and appeared to be in good health when last seen. The other five disappearances were probably deaths based on circumstantial evidence (Table 10); details relating to these probable deaths follow.

Case 1.--A large subadult or adult seal of unknown sex (injury No. 32) was seen with a severe dorsal wound on 20 April in sector 6 at 1846. The seal was approximately 50 m offshore, floating at the surface and only lifting its head to breathe. The wound, extending into the muscle layer over three-fourths of the back, leached fluids, creating a large slick

Table 10.--Probable Hawaiian monk seal deaths at Laysan Island, 1988.

Injury No.[a]	Date last observed	ID No.	Size class[b]	Sex[c]	Probable cause of death
32	4/20/88	--	S/A	U	Adult male
44	4/29/88	TT30	S	F	Adult male
47	6/13/88	TL06	J	M	Adult male
62	5/23/88	TK07	S	M	Adult male
90	6/13/88	T42M	A	M	Unknown

[a]See Table 8 for further information.

[b]A = adult, S = subadult, and J = juvenile.

[c]M = male, F = female, and U = unknown.

on the surrounding water. This seal was never resighted and presumably died as the result of adult male-inflicted injuries.

Case 2.--Subadult female TT30 (injury No. 44) was seen with numerous lacerations covering three-fourths of her back on 27 April in sector 17 at 0916. She appeared alert and interacted aggressively with attending males, but had some difficulty moving. Adult males contested frequently over her. She was initially with adult male T758, but he was displaced at 0926 by another adult male (bleach No. 265). Observations ended at 0933. When observations resumed at 1545, she was with another adult male (T33M), but he was also displaced at 1623 by adult male T415. Observations ended at 1745.

An unidentified subadult female (probably TT30) was mobbed on 28 April in sector 18. Two seals were observed at 1257, about 70 m offshore over shallow reef. The pair vocalized, rolled, and splashed. Another seal approached at 1255, and a fourth, at 1256. The three adult males (TY75 and two unidentified seals) rolled and jousted around the subadult female. One male bit and attempted to mount her at 1253, but was too low on her body. He rolled off; his erection was visible. The three males continued to joust, resting at intervals. The group moved toward the edge of the reef, and one or more males left at 1305. The group swam north toward sector 19, still jousting and vocalizing. Only two seals remained by 1308. They swam north and disappeared from view at 1310. Subadult female TT30 was seen later that day in sector 19 at about 1500 and again at 1742 with adult male T710.

Subadult female TT30 was resighted on 29 April in the same general area with yet another adult male (bleach No. 197) at 0811. The pair was at the water's edge. She was alert but made few movements. She gulped repeatedly at the male and slapped the water with her right foreflipper whenever he approached. The pair jousted at 1020, and the male chased away lone adult males at 0930 and 1028 and two males at 1048. Observations ended at 1121.

When observations resumed at 1327, she was with adult male T41M, floating approximately 100 m offshore in shallow water over the reef. The pair periodically raised their heads to breathe and, at 1332, splashed and rolled around each other. The pair moved approximately 10 m farther offshore, and the male swam back and forth near the female. The male mounted and bit the female at 1413. The female lay on her left side while mounted. She periodically raised her head to breathe and attempted to swim toward shore, towing the male. The male did not breathe while mounted on the female. When the pair broke apart and then rolled, the male's erection was observed and the female slapped the water with her foreflippers. By 1417, the seals floated at least 5 m apart. The male approached and nudged the female at 1537, and both seals rolled. The male mounted the female briefly at 1830, and she rolled, threatened, and attempted to flee. The pair floated apart. At 1919, the male mounted and bit the female for approximately 3 minutes. The female rolled and vocalized. She floated on her back, arched, with the male underneath, his hind flippers pressed tightly against her vestibule. When the pair rolled onto their sides and broke apart at 1922, the male's erection was observed again. Several seals and a shark passed through the general area during the second observation period, but did not appear to notice the floating pair. Observations ended at 2003. She was never resighted and presumably died as a result of adult male-inflicted injuries.

Case 3.--Subadult male TK07 (injury No. 62) was seen with a fresh dorsal wound covering two-thirds of his back on 18 May in sector 4 at 1000. The fat and muscle layers were visible. The wound appeared unchanged on 20 May but looked larger when the seal was resighted in the same general location on 22 May at 1923. He was resighted again at 0800 on 23 May in the same area, but disappeared by 1444 and presumably died of adult male-inflicted injuries.

Case 4.--Juvenile male TL06 (injury No. 47) was seen with a gaping wound and numerous abrasions covering half of his back on 30 April in sector 19 at 0843. He developed several abscesses during the last 2 weeks of the initial camp and grew steadily weaker and thinner. He was last sighted on 13 June in sector 18 at 1338, lethargic and floating in the wave wash. He presumably died of adult male-inflicted injuries.

Case 5.--Adult male T42M (injury No. 90) was seen with a large, gaping head wound on 12 June in sector 5 at 1128. His skin was peeled back, exposing muscle, and his right eye was cut. The injury was very fresh, and blood flowed into the water as he jousted with adult male TY55. Male T42M attempted to defend himself and submissively rolled, exposed his ventrum, and slapped the water with his foreflipper. He was resighted the next day in sector 8 at 1110. He appeared lethargic, was floating in shallow water, and was attended by adult male T803, which repeatedly bit and rolled over the injured male until he finally reached the shoreline and rolled in the surf. The injured male disappeared by 1600 and presumably died of unknown causes.

Table 11.--Hawaiian monk seal deaths at Laysan Island, 1988.

Necropsy No.	Date[a]	ID No.	Size class[b]	Sex[c]	Probable cause of death
01LA88	--	TFX1	P	U	Unknown
02LA88	3/1	TFX2	P	F	Unknown
03LA88	3/7	TFX3	P	F	Unknown
04LA88	3/15	TFX4	P	M	Starvation
05LA88	4/20	TT46	S	M	Unknown
06LA88	4/22	TP52	A	F	Adult male
07LA88	4/28	W37[d]	A	F	Adult male
08LA88	5/2	TK15	S	F	Adult male
09LA88	5/22	TK29	S	F	Adult male/shark
10LA88	6/1[e]	TFX5	P	U	Unknown
11LA88	6/14	TN44	J	M	Adult male
12LA88	6/23	--	A	F	Adult male
13LA88	7/26	TK27	S	M	Adult male
14LA88	8/9	--	A	F	Unknown

[a]Date found dead.
[b]A = adult, S = subadult, J = juvenile, and P = nursing pup.
[c]F = female, M = male, and U = unknown.
[d]Temporary number.
[e]Body not found; last seen 30 May. Confirmed as gone on 1 June.

Deaths

At least 14 seals died during the 1988 field season (Table 11). Tissue samples and skulls were collected from eight dead seals. Necropsy reports are on file at the NMFS Honolulu Laboratory. Details relating to the deaths follow.

Case 1.--On 2 March, the carcass of neonatal pup TFX1 of unknown sex was found at the waterline in sector 12. The body was in a state of advanced decomposition and flattened. The cause of this stillbirth or death was unknown.

Case 2.--On 1 March, the carcass of neonatal female pup TFX2 was found on a rock ledge in sector 2 at 0914. The umbilical cord was still attached, and a 2- to 3-day-old placenta was 3 m away. The mother (bleach No. 169) was in attendance and remained near the dead pup until 4 March. The carcass was not recovered because of the proximity of the mother and other mother- pup pairs. The cause of this stillbirth or death was unknown.

Case 3.--On 7 March, a mother (bleach No. 151) and 1-day-old female pup TFX3 were at the beach crest in sector 4. The mother left the pup at 1350 to investigate another mother-pup pair (TA26 and 1-day-old pup TF28) approximately 30 m away near the water.

The pup did not follow, and the mother did not return to her pup. Within 40 minutes, the mother had contested for the other pup and displaced its mother. The resulting lone mother searched for a pup, but pup TFX3 headed inland 30-40 m away from the mothers. At approximately 1430, the observer picked up the pup and carried it within approximately 20 m of the two mothers. Again, the pup turned away from the direction of the mothers and headed inland. At this point, the observer moved the pup within 10 m of the mother without a pup. The pup again moved inland, although it turned its head in the direction of the mothers who were vocalizing and contesting over the other pup. The pup stopped moving 15 to 30 minutes later, but seemed alert.

The mother and foster pup moved within 15 m of the motionless pup at approximately 1500, but did not appear to notice it. The pup appeared to convulse as a rain cloud passed overhead and a gust of wind blew, then lay motionless again. The lone mother moved within 25 m of the pup but did not appear to notice it. After she was asleep, the observer moved the pup within 5 m of her. The pup was gasping sharply at this time. The mother eventually noticed the pup, moved to it, and presented her ventrum, but the pup was not alert. By 1700, the pup stopped gasping and was presumed dead. A necropsy was performed on 9 March, when observers were able to retrieve the pup. The cause of death was unknown.

Case 4.--On 15 March, 8-day-old male pup TFX4 was dead at 1000 at high beach in sector 3. Mother T31F was still in the vicinity but had hauled down to the wet sand. While alive, the pup did not concentrate on the nipple area when it attempted to nurse, and never appeared to successfully nurse. On the evening before he died, the pup moved very slowly and stopped to rest often as he followed the mother to the beach crest. The probable cause of death was starvation.

Case 5.--Subadult male TT46 was dead on 20 April in sector 19. The carcass had washed up against rocks and had a broken neck. The cause of death was unknown.

Case 6.--Adult female TP52 was dead on 22 April at 0930 in sector 2. She was first sighted alert with lacerations over much of her back on 10 April at 1344 in sector 20, hauled up with adult male TP84. The largest wound was to the muscle layer, but most were surface scratches. She had a new wound to the blubber layer and appeared lethargic when resighted on 12 April at 0952 in sector 7, accompanied by adult male T06M. The male had two fresh wounds on his muzzle, apparently received during jousting. She was resighted 20 April at 1111, lying lethargically in the wave wash in sector 6. The blubber hung from her side, movement appeared painful, and fluids leached from the wounds. She entered the water at 1501 and floated as far as approximately 50 m offshore. When observation ended at 1845, she was floating near the border of sectors 6-7. The seal was last seen alive at 1453 on 21 April in sector 5 and was found dead on 22 April at 0930 in sector 2. The probable cause of death was from adult male-inflicted injuries.

Case 7.--An unbleached adult female (temporary No. W37) was dead on 28 April in sector 17. She was first sighted 25 April at 0846 in sector 19 with many dorsal surface scratches and six lacerations through the skin. She appeared fairly alert, rolling in the water accompanied by adult male T41M. She was last seen alive on 27 April at 1800 and was

found dead at 0850 the following morning, accompanied by male T717. The probable cause of death was from adult male-inflicted injuries.

Case 8.--Subadult female TK15 was dead on 2 May at 0927 in sector 18, lying on the wet sand with eight dorsal lacerations to or through the blubber layer. The probable cause of death was from adult male-inflicted injuries.

Case 9.--Subadult female TK29 was dead on 22 May at 1030 in sector 6, lying in the wave wash. She was last seen alive on 21 May at 1746 in sector 7 with many fresh dorsal lacerations through the pelage. She was lethargic and rolled motionless in the wave wash, accompanied by adult male T16M. By morning, the carcass had two large shark bites that had removed a portion of the mid-right side and the left shoulder and foreflipper. Internal examination revealed an apparent bruise in the ventral left side. The probable cause of death was from adult male-inflicted injuries, shark attack, or both.

Case 10.--Pup TFX5 of unknown sex had a very weak vocalization when last seen on 30 May in sector 20 at approximately 1530. Neither the pup nor its mother T11F was seen the following day; however, the mother was alone on 1 June in sector 20, searching for her pup. When the pup disappeared, it was 11-12 days old. It was presumed dead.

Case 11.--Juvenile male TN44 was dead on 14 June at 0900, lying at midbeach in sector 7. When last seen the previous day, nothing unusual was noted. When found dead, he had numerous dorsal wounds through the skin, three fresh lacerations on the ventrum, and possible shark bites above and also through the right foreflipper. The shark bites were not severe. The probable cause of death was from adult male-inflicted injuries.

Case 12.--A recently dead, unmarked adult female was found on 23 June in sector 2. She had two large wounds and several smaller puncture wounds on her back. The probable cause of death was from adult male-inflicted injuries.

Case 13.--Subadult male TK27 probably died more than a week before he was found dead on 26 July in sector 4. The carcass was floating at the water's edge with three dorsal wounds. The probable cause of death was from adult male-inflicted injuries.

Case 14.--A recently dead, unmarked adult female was found in the wave wash with no apparent wounds on 9 August in sector 8, accompanied by adult male T27M. The cause of death was unknown.

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APPENDIXES

Appendix A.--Itinerary of the fieldwork conducted on Laysan Islnd in 1988 by the National Marine Fisheries Service.

Date	Event
2/27	NOAA ship *Townsend Cromwell* arrives at Laysan Island.
2/28	*Townsend Cromwell* disembarks B. Becker, M. Brown, B. Choy, L. Hiruki, T. Johanos, and two cooperating Smithsonian scientists; and departs. Field camp is established.
2/29	Incidental patrols and bleach marking begin.
3/4	Censuses begin.
3/10	Behavior patrols begin.
4/13	Fishing vessel *Feresa* arrives.
4/15	The fishing vessel *Feresa* arrives at Laysan Island and disembarks two cooperating U.S. Fish and Wildlife Service (USFWS) scientists.
4/17	Fishing vessel *Feresa* departs.
5/14	*Townsend Cromwell* arrives; disembarks L. Dean, M. Wilcox, B. Warren and a cooperating USFWS scientist; embarks B. Becker, M. Brown, B. Choy, L. Hiruki, and two cooperating USFWS scientists; and departs for Lisianski Island.
5/15	*Townsend Cromwell* returns for additional field supplies and departs again for Lisianski Island.
5/19	*Townsend Cromwell* arrives and disembarks B. Becker, R. Brainard, M. Brown, R. Westlake, and two cooperating USFWS scientists. Embarks L. Dean, T. Johanos, B. Warren, M. Wilcox, and two cooperating Smithsonian scientists and departs.
6/13	Censuses end.
6/15	Behavior patrols end.
6/18	*Feresa* arrives. Disembarks five cooperating USFWS scientists.
6/20	*Townsend Cromwell* arrives.
6/21	*Townsend Cromwell* embarks B. Becker, M. Brown, R. Brainard, and R. Westlake and departs from Laysan Island.
10/24	*Townsend Cromwell* arrives, disembarks B. Becker and L. Honigman, and departs.

Appendix A.--Continued.

Date	Event
10/25	Incidental patrols begin.
10/28	Censuses begin.
11/09	Censuses end.
11/11	Incidental patrols end.
11/12	*Townsend Cromwell* arrives.
11/13	Field camp disbanded. *Townsend Cromwell* embarks B. Becker, L. Honigman, and two cooperating USFWS scientists and departs.

Appendix B.--Data type summary, typical daily schedule, and additional codes for Hawaiian monk seal research at Laysan Island, 1988.

DATA TYPE

1. C:
   - Census data: 4 March-13 June, 28 October-9 November
   - Data: Standard census
   - Area: Total island
   - Frequency: Every fourth day (4 March-13 June)
     Every second day (28 October-9 November)
   - Time: 1300-1600
   - Observers: 2

2. P: Behavior patrol: 10 March-15 June

   a) Patrol type A
   - Data: All A or S4 seals and their associations, sectors 1-8 (traveling north)
   - Frequency: Every noncensus day except day off
   - Time: 0800-1200
   - Observer: 1

   b) Patrol type B
   - Data: All A or S4 seals and their associations
   - Area: Sectors 20-9 (traveling south)
   - Frequency: Every noncensus day except day off
   - Time: 0800-1200
   - Observer: 1

   c) Patrol type C
   - Data: All A or S4 seals and their associations
   - Area: Entire island
   - Frequency: On the day off (once a week)
   - Time: 0800-1500
   - Observer: 1

Appendix B.--Continued.

d) Patrol type D

Data:	All A or S4 seals and their associations
Area:	Sectors 18-8 (traveling north) until 23 May. Sectors 17-8 (traveling north) after 23 May
Frequency:	Census days
Observers:	1 or 2

e) Patrol type E (PM mob)

Data:	All A or S4 seals and their associations
Area:	Sectors 18-8 (traveling north) until 23 May. Sectors 17-8 (traveling north) after 23 May.
Frequency:	On every noncensus day except day off
Time:	1500-1800 until 30 May. 1400-1700 after 30 May
Observers:	1 or 2

3. I: Incidental (no criteria)

TYPICAL SCHEDULE[a]

1. Census day (every fourth day)

0800-1200	patrol type D
1300-1600	census

2. Every noncensus day except day off

0800-1200	patrol types A and B
1500-1800	patrol type E

3. Day off

0800-1500	patrol type C

ADDITIONAL CODES[b]

1. Behavior codes:

A1	Approach $\leq$2 body lengths
A2	Approach >2 body lengths
V	Vocalizations indistinguishable or undefined
G	Gulp vocalization
U	Rolling growl vocalization
S	Snort vocalization
H	Head raise
H1	Looks around

Appendix B.--Continued.

H2	Lifts head and looks around
T	Open-mouthed threat
K	Nudge
KV	Ventral nudge
KS	Side nudge
KM	Muzzle nudge
KB	Back nudge
KF	Foreflipper nudge
KH	Hind flipper nudge
KC	Chest nudge
KN	Nipple nudge
DG	Dig or wallow
SN	Sneeze
SC	Scratch
ST	Stretch
SP	Spew
EP	Erectile projection
FS	Flip sand, flipper slap

2. Distance codes

3	$>5 \leq 10$ m
4	>10 m

3. Associated line number

IN = 94 Inland
OC = 95 Ocean
Z = 96 Nonseal association
X = 97 Undirected behaviors

[a]Focal animal and focal group observations (Altmann 1973) were also conducted but are not included in this schedule because the methods and results will be presented elsewhere.

[b]All data types except C can use the additional codes developed for specific use on Laysan Island in 1988.

Appendix C.--Mobbings and prolonged harassments by adult male Hawaiian monk seals observed on Laysan Island, 1988.

Date	Field No.	Sector No.	Time		Initial beach position[a]	Victim			No. of adult males	Type of interaction[d]
			Begin	End		Size[b]	Sex[c]	ID		
3/14	1	4	1000	>1039	1	S	M	TT40	2	H
3/19	2	2	0928	1109	0	A	F	T65F	3	H
3/24	3	17	1355	1402	0	S	M	--	2	H
4/26	7	14	1830	>1845	3	A	F	T63F	4	H[e]
4/26	8	20	1930	--	3	A	F	GA10	1	H
4/28	4	18	1253	1310	0	S	F	TT30?	3	M
4/29	--	19	<1327	>2003	0	S	F	TT30	1	S[e,f]
5/05	6	20	0833	0835	0	W	F	TF36	1	H
5/11	9	20	1321	>1340	0	W	U	--	1	H
6/17	--	1	0755	1253	1	A	F	T37F	5	H

[a]0 = in the water, 1 = on wet sand, and 3 = beach crest.

[b]A = adult, S = subadult, and W = weaned pup.

[c]M = male, F = female, and U = unknown.

[d]H = harassment, M = mobbing, and S = single male aggression.

[e]The victim was injured at the time of the incident.

[f]The victim disappeared following this incident and probably died.

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