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Fur Seal Investigations, 1997

by
E. H. Sinclair and B. W. Robson (editors)

U.S. DEPARTMENT OF COMMERCE
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Fur Seal Investigations '97

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ABSTRACT

Researchers from the National Marine Mammal Laboratory (NMML) conduct field investigations on the population health of northern fur seals *(Callorhinus ursinus)* annually on the Pribilof Islands and on Bogoslof Island in the eastern Bering Sea and on San Miguel Island located off the coast of California. The Pribilof Islands (St. Paul and St. George Islands) are home to approximately l,000,000 northern fur seals - 90% of the world population.

Population parameters monitored in 1997 on the Pribilof Islands consisted of direct counts of adult males. A total of 5,064 harem and 8,560 idle adult male seals were counted on St. Paul Island and 910 harem and 1,474 idle adult males were counted on St. George Island. From 1996 to 1997, counts of harem males decreased by 10.3% on St. Paul Island, and decreased by 27.1% on St. George Island. During this same period, the total number of adult males on the Pribilof Islands decreased by 5.4%.

Trends in the mass and length of fur seal pups are used as indicators of population health and have been monitored semi-annually since 1989. Consistent with earlier evaluations of pup mass data the strongest pattern was that the size of pups varied by sex: male pups were heavier and longer than female pups. The mass of female and male pups on St. George Island was greater than pups on St. Paul Island in 1997 and both male and female pups were longer on St. George Island. The proportion of females was not significantly different than 50% for both islands in 1997.

Surveys of northern fur seal entanglement in marine debris indicated that incidence of entanglement among juvenile males on St. Paul (0.19%) and St. George (0.23 %) Islands during 1997 was close to the rate of entanglement observed on St. Paul Island from 1988 to

1992 and in 1995-96. Packing bands comprised the largest proportion of entangling debris among juveniles on St. Paul Island followed by trawl net. Conversely, trawl net was the most frequent debris type observed on St. George Island followed by packing bands and twine.

An analysis conducted to investigate the feasibility of using ratio estimates based on the June bull counts to estimate missing July bull and pup production numbers concluded that estimating the number of breeding males in July from the count of breeding males in June is not likely to produce a reliable estimate. The relationship between the June and July harem male counts is not stable enough to provide an accurate estimate of harem adult males in July. The use of July harem male counts for estimating pup production results in a less biased estimate with a smaller coefficient of variation (CV) than the use of June harem male counts.

The number of pups born on Bogoslof Island in 1997 was estimated using the “shearing-sampling” method currently used in pup production estimates on the Pribilof Islands, Alaska. The estimate for the total number of pups alive at the time of marking was 5,055 (SE = 32.6) and the mortality rate for Bogoslof Island was 0.8%. The 1997 estimate represents a 300.6% increase in the number of pups over the 1995 count. The number of non-pup northern fur seals counted on Bogoslof Island in 1997 was 13,751 (SE = 541.5). This count represents a 272.6% increase over the last count of 3,691 in 1994. The total Bogoslof Island population size is estimated at 22,803 northern fur seals. Foraging studies indicated that female northern fur seals with pups on Bogoslof Island tended to feed close to the island and that foraging trips were shorter in distance and duration than those of females on the Pribilof Islands. Information on tufted puffin *(Frutercula cirrhata)* food habitswas collected and prey was identified as either sablefish *(Anoplopoma fimbria)* or rock greenling *(Hexugrammos lagocephalus).*

Population monitoring studies of northern fur seals on San Miguel Island were based on direct counts of adult males and live and dead pups. The number of territorial bulls increased from 162 bulls in 1996 to 250 in 1997. The total observed pup production during 1997 was 2,133 in Adams Cove and 991 on Castle Rock. Although the number of pups born reached an historical high in 1997, the observed high pup mortality indicates the 1997 El Nino will cause almost total mortality of the 1997 cohort. Additionally, samples of dead fur seal pups in July and October were examined for evidence of hookworm infestation. All dead pups examined during July had hookworm infestations in the intestines; however, by 1 October the fecal and intestine samples were free of hookworm eggs and adults.

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INTRODUCTION

by

Elizabeth H. Sinclair and Bruce W. Robson

Between 1911 and 1984, northern fur *seal (Callorhinus ursinus)* research was carried out by Canada, Japan Russia, and the United States under the Treaty for the Preservation and Protection of Fur Seals and Sea Otters. Since 1984, studies have been carried out independently by cooperating former member nations.

The Pribilof Islands (St. Paul Island and St. George Island) fur seal population of approximately 1 million animals is the largest among U.S. rookeries (Figs. l-3) and comprises approximately 74% of the world's population of northern fur seals. Northern fur seals were designated as depleted in 1988 under the Marine Mammal Protection Act when it was determined that they were below their Optimum Sustainable Population (OSP) level. Commercial harvesting of fur seals was discontinued on St. Paul Island in 1984 and on St. George Island in 1973; however, a subsistence harvest continues on both islands. There is no subsistence or commercial harvest on the remaining U.S. rookeries (Figs. 4 and 5).

Russian names given to rookeries on the Pribilof Islands are translated in Table 1. Terms specific to fur seal research are defined in Appendix A. Research on northern fur seals in 1997 was conducted under Marine Mammal Permit No. 837.

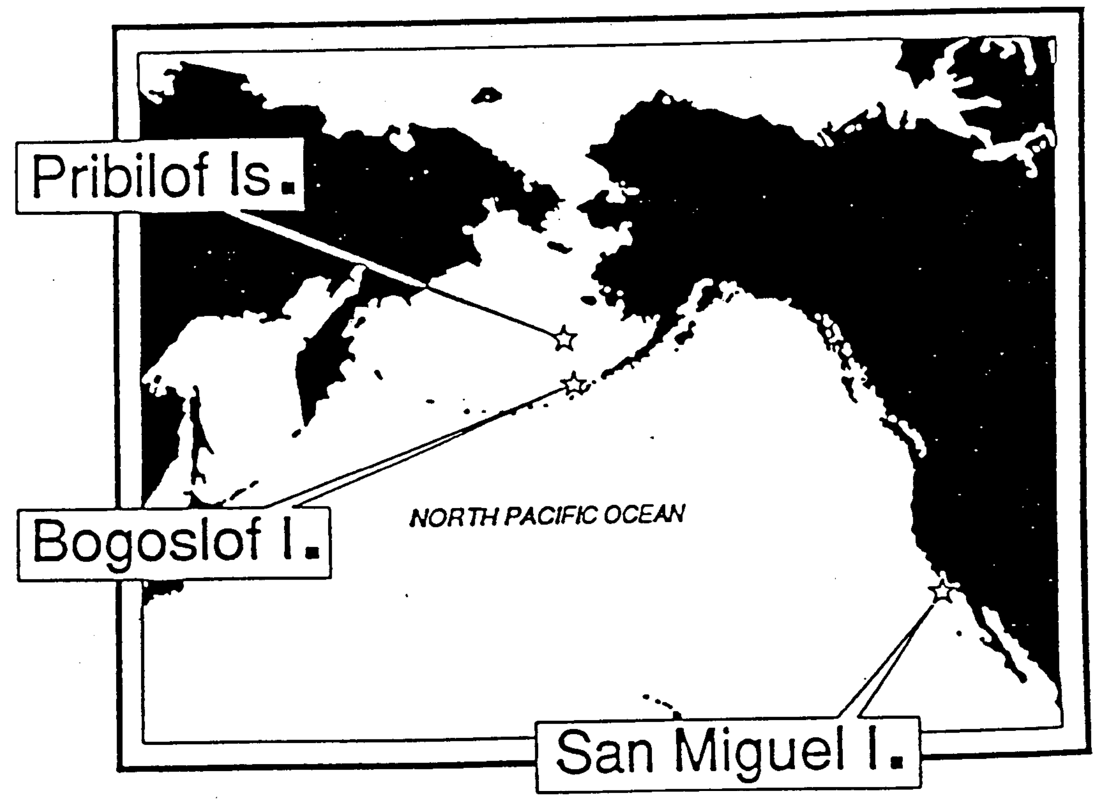

Figure 1 .--Location of the four northern fur seal breeding rookeries within U.S. waters.

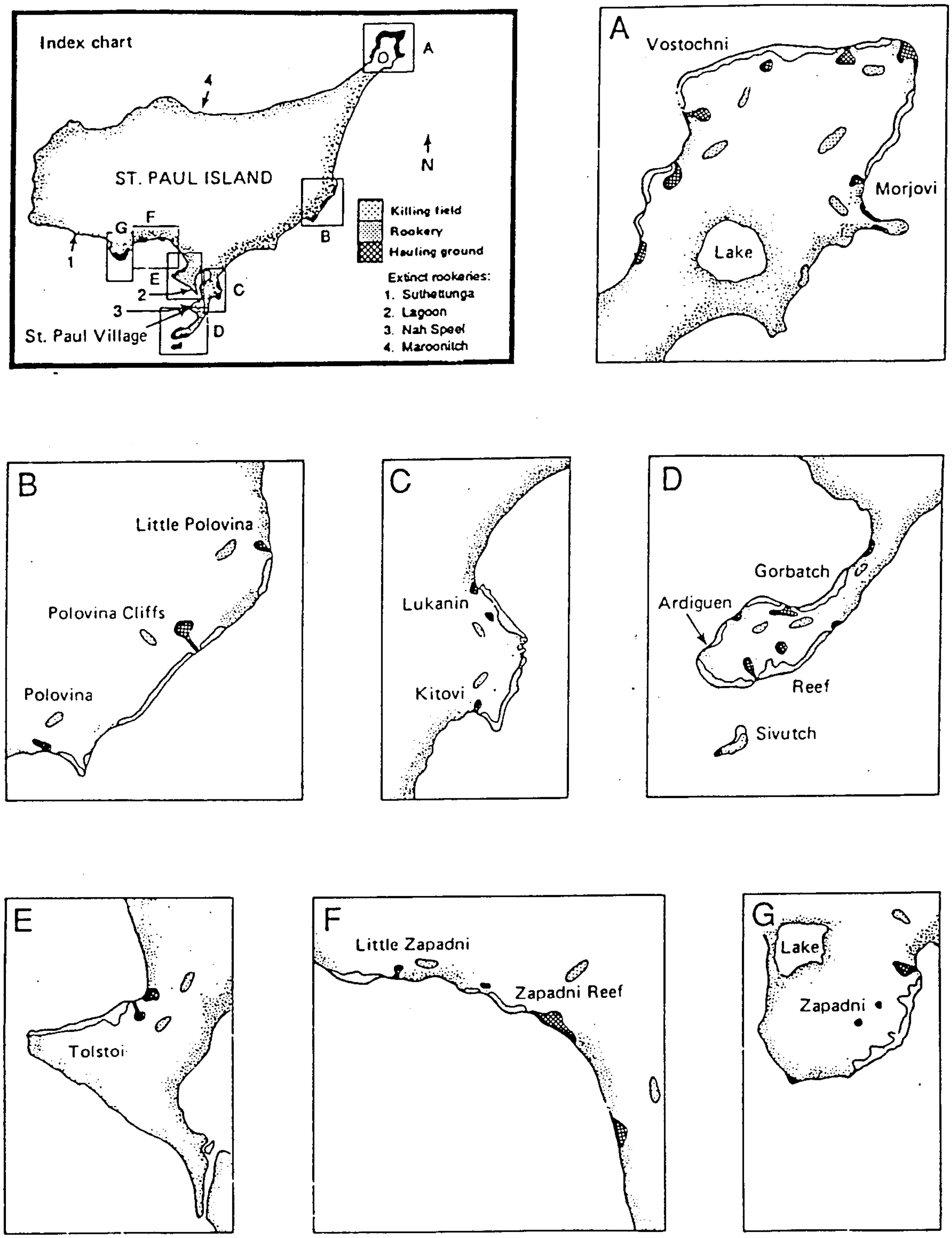

Figure 2.--Location of northern fur seal rookeries (present and extinct), hauling grounds, and harvesting areas, St. Paul Island, Alaska.

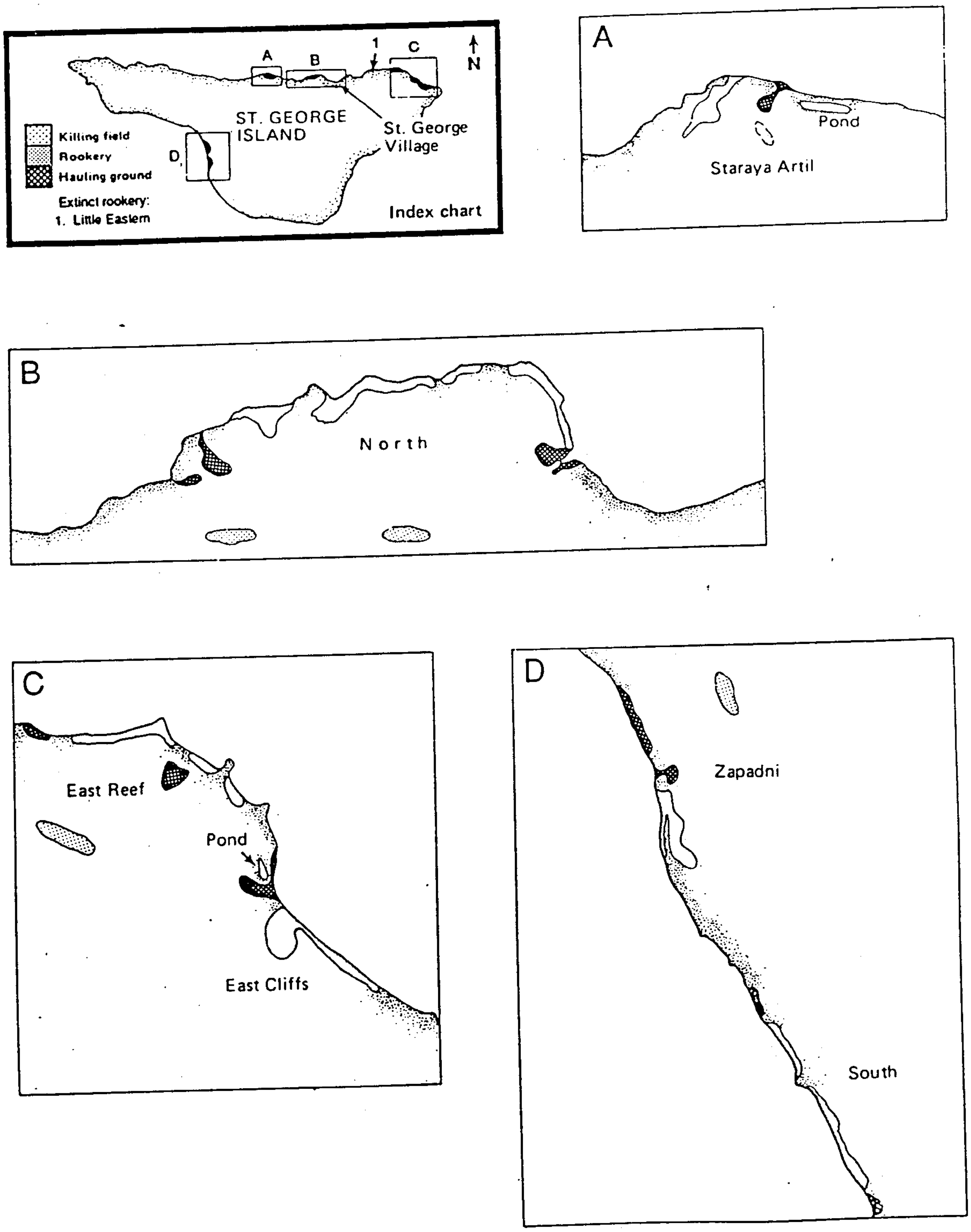

Figure 3.--Location of northern fur seal rookeries (present and extinct), hauling grounds, and harvesting areas, St. George Island, Alaska.

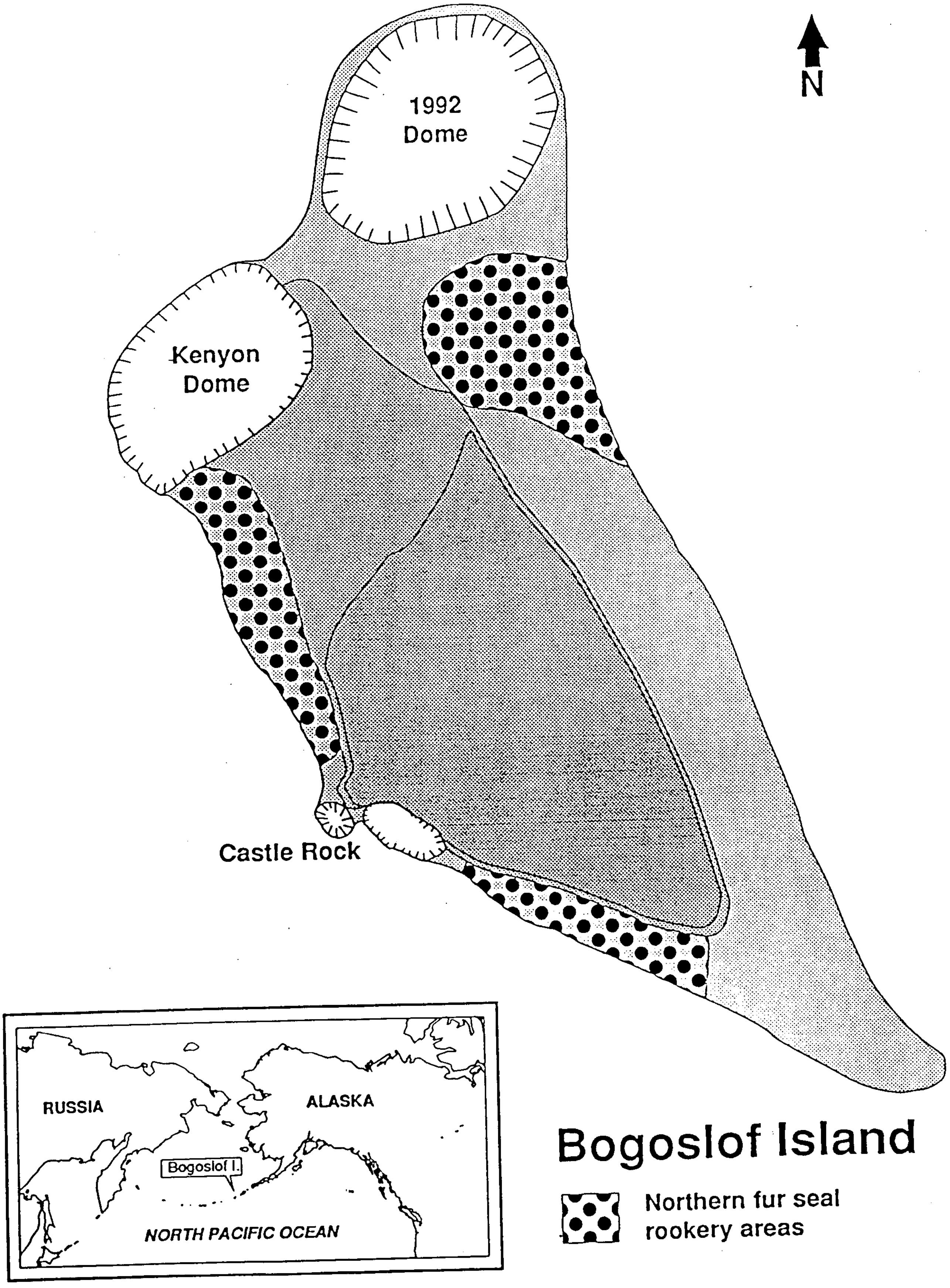

Figure 4.--Fur seal rookeries on *Bogoslof* Island, Alaska.

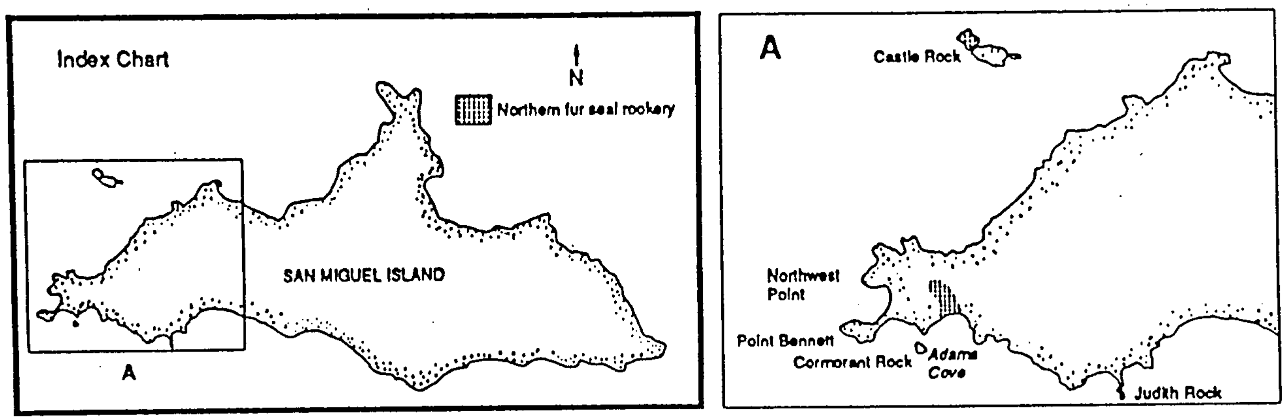

Figure 5.--Location of northern fur seal breeding colonies, San Miguel Island, California.

Table 1.--English translations of Russian names for Pribilof rookeries and hauling grounds.

Island and Russian name	English translation	Comments and derivation of name
St. Paul Island		
Vostochni	---	From "Novoctoshni" meaning "place of recent growth"; applied to Northeast Point, which was apparently at one time an island that has since been connected to St. Paul Island by drifting sand.
Morjovi	Walrus	Historically, walruses hauled out here in summer.
Polovina	Halfway	Halfway to Northeast Point from the village.
Kitovi	Of "kit"	When whaling fleets were active in the Bering Sea between 1849 and 1856, a large right whale killed by some ship's crew drifted ashore here.
Gorbatch	Humpback	Apparently refers to the "hump like" nature of the scoria slope above the rookery.
Tolstoi	Thick	In this case, thick headland on which the rookery is located.
Zapadni	West	Western part of the island.
Lukanin	---	Named after a Russian pioneer sailor who was said to have harvested over 5,000 sea otters from St. Paul Island in 1787.
Zoltoi (hauling ground)	Golden	Named to express the metallic shimmering of the sands.
St. George Island		
Staraya Artil	---	Old settlement or village. There was once a settlement or village adjacent to the rookery.
Sea Lion Rock		
Sivutch	Sea lion	These animals haul out but do not breed here.

POPULATION ASSESSMENT, PRIBILOF ISLANDS, ALASKA

by

Charles W. Fowler, Jason D. Baker, David R. Cormany, and
Rodney G. Towell

In accordance with provisions originally established by the Interim Convention of Conservation of North Pacific Fur Seals, the Alaska Fisheries Science Center's National Marine Mammal Laboratory (NMML) monitors the population status of northern fur seals on the Pribilof Islands (St. Paul and St. George Islands). This species is listed as depleted under terms of the Marine Mammal Protection Act, and any changes in population status are of significance to its management.

METHODS

Data on the number of seals taken in the subsistence harvest and the number of adult males present on both St. Paul and St. George Islands are collected annually. National Marine Fisheries Service personnel monitor the subsistence harvest of juvenile male northern fur seals. A crew is present throughout each harvest operation and the number of seals killed is recorded and maintained as part of a permanent record.

Counts of adult males were obtained each year according to methods established early in the 1900s as documented in Antonelis (1992). In 1997, counts of adult males were obtained from 11 to 16 July. A field crew of 2 to 5 people conducted counts at rookeries from vantage points (natural or constructed tripods or catwalks). Hauling grounds were also visited to count adult males without territories.

Counts included three categories: adult males with territories containing females (Class 3), those occupying territories without females (Class 2), and those without territories (Class 5, see glossary in Appendix A). The last two categories are combined and reported as idle males. The relative location of different classes of adult males is illustrated for a typical fur seal rookery-hauling ground complex on the Pribilof Islands in Figure 6.

RESULTS

Population Parameters

<u>Fur Seals Harvested</u>

The subsistence harvest of northern fur seals involves the killing ofjuvenile males (usually 2 and 3 years of age). Individual harvests are conducted on separate days, usually at only one hauling ground. Twenty-three subsistence harvests of northern fur seals were conducted on St. Paul Island between 28 June and 7 August 1997. Thirteen harvests were conducted on St. George Island between 9 July and 8 August. A total of 1,153 and 227 seals were killed on St. Paul Island and St. George Island, respectively (Table 2). Three female fur seals were accidentally killed in the juvenile male harvest on St. Paul Island.

<u>Living Adult Male Seals Counted</u>

Adult male seals were counted in each section of each rookery (see Appendix A for definition) on St. Paul Island from 11 to 15 July (Table 3). A total of 5,064 harem (Class 3) and 8,560 idle (Classes 2 and 5) adult male seals (also referred to as bulls) were counted on St. Paul Island. On St. George Island a total of 910 harem and 1,474 idle adult males were counted from 11 to 16 July.

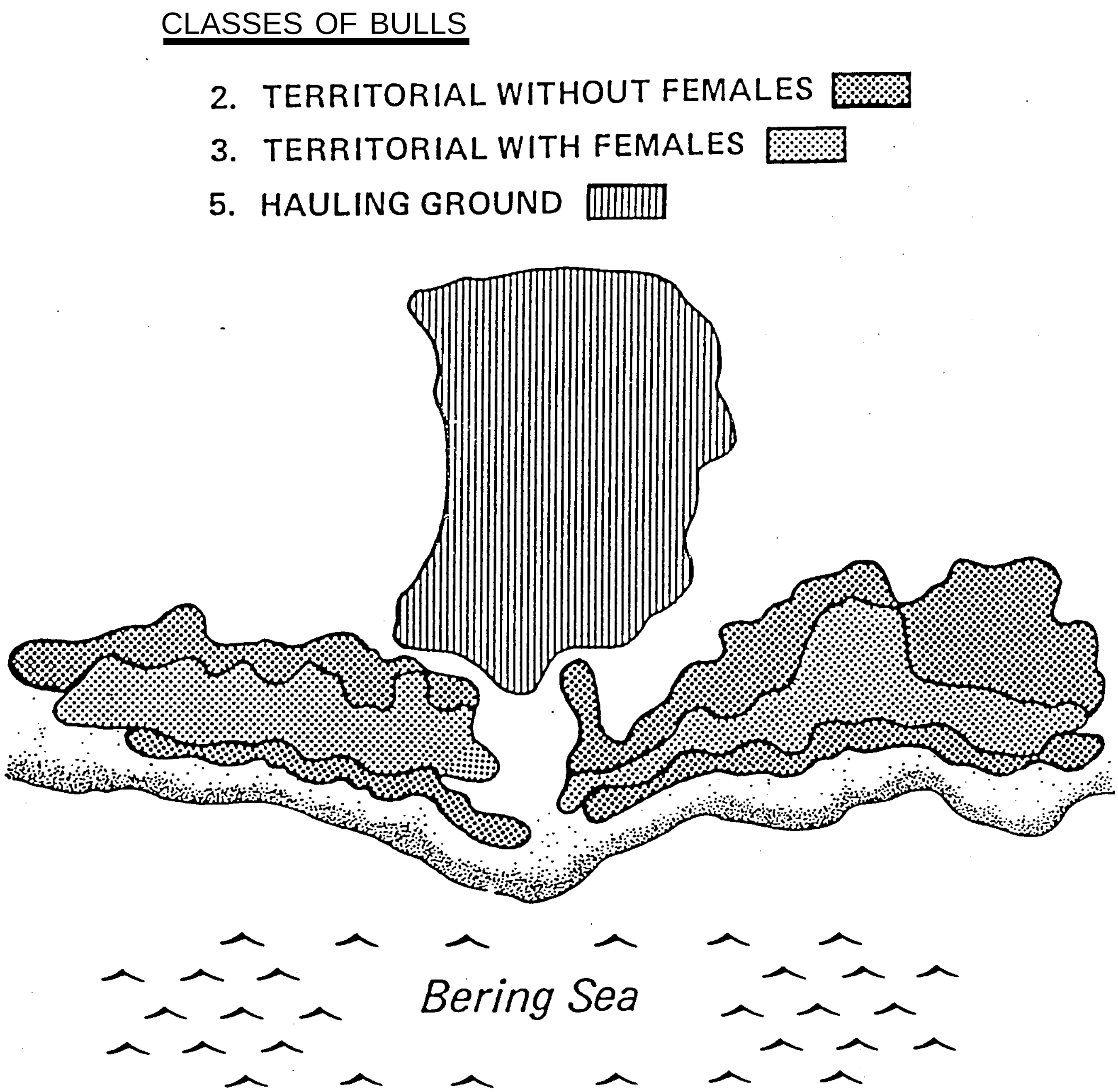

Figure 6.--The relative location of the different classes of adult males for a typical fur seal rookery.

Table 2.--Date, location, and number ofjuvenile male seals killed in subsistence harvests on St, Paul and St. George Islands, Alaska, in 1997.

Date	Rookery	Number killed
28 June	Reef	34
8 July	Zapadni	43
10 July	Polovina [a]	51
14 July	Zapadni Reef Sands	33
15 July	Reef	43
16 July	Lukanin	54
17 July	Polovina	35
21 July	Zapadni	47
22 July	Zapadni Reef Sands	58
23 July	Polovina	64
24 July	Lukanin	44
25 July	Reef	51
26 July	Zapadni	42
28 July	Zapadni Reef Sands	46
29 July	Polovina	32
30 July	Lukanin	32
31 July	Zapadni [b]	59
1 August	Reef [c]	71
2 August	Morjovi	64
4 August	Polovina	45
5 August	Kitovi	41
6 August	Zapadni [d]	85
7 August	Zolotoi [e]	79
St. George Island		
9 July	Zapadni[c]	12
10 July	North	20
13 July	Zapadni	22
16 July	North	11
20 July	Zapadni	21
24 July	North	12
25 July	Zapadni	22
27 July	North	24
30 July	Zapadni	14
31 July	North	15
5 August	Zapadni	14
6 August	North	14
8 August	Zapadni	26

[a] 4 died of heatstroke; 1 not taken for food.

[b] 2 bulls and 1 female accidently struck and killed, not taken for food.

[c] 1 female killed, not taken for food.

[d] 1 bull, 1 female killed, not taken for food.

[e] 1 bull killed, not taken for food.

[f] 1 animal not taken for food (heatstroke)

Table 3.-Number of adult male northern fur seals counted, by class[a] and rookery section, St. Paul Island, Alaska, 11-15 July 1997. A dash indicates no section.

Rookery and class of male	Section 1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total
Lukanin															
2	25	16	-	-	-	-	-	-	-	-	-	-	-	-	41
3	54	57	-	-	-	-	-	-	-	-	-	-	-	-	111
5	90	27	-	-	-	-	-	-	-	-	-	-	-	-	117
Kitovi[b]															
2	12(11)	12	21	24	39	-	-	-	-	-	-	-	-	-	119
3	50(19)	22	64	80	78	-	-	-	-	-	-	-	-	-	313
5	6(37)	9	13	17	124	-	-	-	-	-	-	-	-	-	206
Reef															
2	19	21	19	17	13	19	8	27	17	11	4	-	-	-	175
3	45	66	78	59	56	108	6	87	53	41	6	-	-	-	605
5	20	40	82	11	280	18	91	23	13	43	88	-	-	-	709
Gorbatch															
2	27	24	19	3	28	41	-	-	-	-	-	-	-	-	142
3	85	61	86	4	63	76	-	-	-	-	-	-	-	-	375
5	651	50	91	223	15	36	-	-	-	-	-	-	-	-	1066
Ardiguen															
2	19	-	-	-	-	-	-	-	-	-	-	-	-	-	19
3	87	-	-	-	-	-	-	-	-	-	-	-	-	-	87
5	37	-	-	-	-	-	-	-	-	-	-	-	-	-	37
Morjovi[c]															
2	16(15)	9	19	7	22	12	-	-	-	-	-	-	-	-	100
3	44(28)	68	59	53	93	46	-	-	-	-	-	-	-	-	391
5	281(29)	32	59	40	29	156	-	-	-	-	-	-	-	-	626
Vostochni															
2	11	7	11	20	12	34	16	22	10	6	13	21	48	28	259
3	58	30	46	69	50	131	58	87	44	35	39	87	227	120	1081
5	9	71	12	118	120	61	32	13	47	0	8	144	162	192	989
Little Polovina															
2	4	-	-	-	-	-	-	-	-	-	-	-	-	-	4
3	10	-	-	-	-	-	-	-	-	-	-	-	-	-	10
5	299	-	-	-	-	-	-	-	-	-	-	-	-	-	299
Polovina															
2	21	9	-	-	-	-	-	-	-	-	-	-	-	-	30
3	49	39	-	-	-	-	-	-	-	-	-	-	-	-	88
5	268	28	-	-	-	-	-	-	-	-	-	-	-	-	296
Polovina Cliffs															
2	15	16	11	18	13	27	43	-	-	-	-	-	-	-	143
3	56	35	35	63	63	86	126	-	-	-	-	-	-	-	464
5	64	12	10	17	8	29	46	-	-	-	-	-	-	-	186
Tolstoi															
2	22	16	24	24	37	38	47	37	-	-	-	-	-	-	245
3	61	31	42	77	88	128	70	63	-	-	-	-	-	-	560
5	3	5	19	23	40	30	92	365	-	-	-	-	-	-	577
Zapadni Reef															
2	56	15	-	-	-	-	-	-	-	-	-	-	-	-	71
3	114	40	-	-	-	-	-	-	-	-	-	-	-	-	154
5	120	246	-	-	-	-	-	-	-	-	-	-	-	-	366
Little Zapadni															
2	2	17	24	37	10	15	-	-	-	-	-	-	-	-	105
3	12	45	68	78	39	61	-	-	-	-	-	-	-	-	303
5	26	23	19	40	12	246	-	-	-	-	-	-	-	-	366
Zapadni[d]															
2	25(0)	29	39	37	38	34	39	7	-	-	-	-	-	-	248
3	48(0)	44	97	84	77	73	83	16	-	-	-	-	-	-	522
5	13(135)	48	33	51	61	40	36	602	-	-	-	-	-	-	1019

[a] See Glossary for a description of the classes of adult males seals.
[b] Numbers in parentheses are the adult males counted in Kitovi Amphitheater.
[c] Numbers in parentheses are the adult males counted on the second point south of Sea Lion Neck
[d] Numbers in parentheses are the adult males counted on Zapadni Point Reef.

Total numbers of harem and idle bulls counted since 1986 are shown in Table 4 and the number of adult males counted by rookery for St. Paul and St. George Islands in 1997 is presented in Table 5.

As of 1993, the age structure of male northern fur seals in the Pribilof Island population seemed to have undergone most of the expected change following the termination of the commercial harvest on St. Paul and St. George Islands in 1984 and 1972, respectively. Prior to 1993 increases in Class 3 adult males were observed. Following that date, however, a decline has been observed in the counts of this component of the population. Specifically, from 1996 to 1997, counts of harem males decreased by 10.3% on St. Paul Island, and decreased by 27.1% on St. George Island. During this same period, the total number of adult males on the Pribilof Islands decreased by 5.4%. This follows an increase of 6.4% in the count of total males from 1995 to 1996. Overall, total counts of adult males seem to reflect a decline since 1993. However, due to the variability inherent in these counts, data are needed for another year or two to determine reliable estimates of the rate of change for this apparent trend.

Collection of Teeth

In 1997, tooth samples (usually upper canines) were collected from juvenile males killed in the subsistence harvest on the Pribilof Islands according to methods described in Antonelis (1992). Tooth samples were obtained from 206 and 40 juvenile males on St. Paul and St. George Islands, respectively.

Table 4. --Number of harem and idle male northern fur seals counted in mid-July, Pribilof Islands, Alaska, 1986-97.

	St. Paul Island		St. George Island		Total	
Year	Harem	Idle	Harem	Idle	Harem	Idle
1986	4,603	1,865	1,394	1,342	5,997	3,207
1987	3,636	1,892	1,303	1,283	4,939	3,175
1988	3,585	3,201	1,259	1,258	4,844	4,459
1989	4,297	6,400	1,241	1,163	5,538	7,563
1990	4,430	7,632	909	1,666	5,339	9,298
1991	4,729	9,543	736	1,271	5,465	10,814
1992	5,460	10,940	1,028	1,834	6,488	12,774
1993	6,405	9,301	1,123	1,422	7,528	10,723
1994	5,715	10,014	1,174	1,590	6,889	11,436
1995	5,154	8,459	1,242	1,054	6,396	9,513
1996	5,643	9,239	1,248	790	6,891	10,029
1997	5,064	8,560	910	1,474	5,974	10,034

Table 5.--Number of adult male northern fur seals counted by rookery on St. Paul and St. George Islands, Alaska, in July 1997.

Rookery	Date (July)	Class of adult male*			Total
		2	3	5	
St. Paul Island					
Lukanin	11	41	111	117	269
Kitovi	11	119	313	206	638
Reef	14	175	605	709	1,489
Gorbatch	14	142	375	1,066	1,583
Ardiguin	14	19	87	37	143
Morjovi	15	100	391	626	1,117
Vostochni	15	259	1,081	989	2,329
Little Polovina	13	4	10	299	313
Polovina	13	30	88	296	414
Polovina Cliffs	13	143	464	186	793
Tolstoi	11	245	560	577	1,382
Zapadni Reef	12	71	154	366	591
Little Zapadni	12	105	303	366	774
Zapadni	12	248	522	1,019	1,789
Island total		1,701	5,064	6,859	13,624
St. George Island					
South	11	108	184	154	446
North	16	201	342	351	894
East Reef	14	22	49	66	137
East Cliffs	14	88	177	163	428
Staraya Artil	16	62	38	96	196
Zapadni	11	58	120	105	283
Island total		539	910	935	2,384

* See glossary for a description of the classes of adult male seals.

MASS, LENGTH, AND SEX RATIOS OF NORTHERN FUR SEAL PUPS ON ST. PAUL AND ST. GEORGE ISLANDS, 1997

by

Rodney G. Towell, Anne E. York, Jason D. Baker,
and Rolf R. Ream

Mass and length measurements of fur seal pups on St. Paul and St. George Islands have been recorded in late August and serve as an indicator of population health. Here we report average mass, average lengths, and sex ratios for male and female pups from Tolstoi, Vostochni, Polovina Cliffs, and Reef rookeries on St. Paul Island and all rookeries on St. George Island in 1997. We also report on comparisons of mass, length, and sex ratios between islands.

METHODS

Pups were randomly sampled in mid-to late August using the techniques described for tagging, sexing and weighing (Antonelis 1992), and length measuring (Robson et al. 1994). A Pesola spring scale was used to weigh pups. Mass was recorded to the nearest 0.2 kg and lengths to the nearest centimeter. Variations of mass and length of pups on St. Paul and St. George Islands were analyzed using an analysis of variance on sex and rookery location. We limited statistical comparisons to an analysis of variance of mass and length data by island, sex and rookery variables.

Significant differences in mass and length by sex between islands were compared using a two-sample t-test for samples with variances not significantly different from one another or a Welch modified two-sample t-test (Snedecor and Cochran 1980) for samples with significantly different variances.

An analysis of the sex ratios by rookery was limited to an exact binomial test for each rookery and island. The exact binomial test was used to analyze whether the proportion of female pups was significantly different than 50%.

RESULTS AND DISCUSSION

Pun Mass and Length

Pup mass (Table 6, Fig. 7) varied significantly ($P < 0.001$) by sex and rookery for St. Paul Island. Male and female pups were analyzed separately since the variance for males was greater than that for females and again rookery was significant ($P = 0.053$ for males, $P = 0.002$ for females; Table 7). Similarly pup lengths (Table 8, Fig. 8) were significantly different ($P < 0.001$) by sex and rookery on St. Paul Island in 1997. Male and female pups were again analyzed separately and there was a significant difference in pup lengths between rookeries for males and females ($P = 0.006$ for females, $P = 0.018$ for males; Table 9).

On St. George Island, pup mass (Fig. 7, Table 10) was also significantly different ($P < 0.001$) by sex and rookery. Again, male and female pups were analyzed separately due to the difference in the variances for each sex. Rookery was a significant factor in the analysis of male mass ($P = 0.010$, Table 11) but was not significant in the analysis of the female mass ($P = 0.164$). The analysis of variance for lengths (Table 12, Fig. 8) also indicated significant differences by sex ($P < 0.00l$), but when separate analyses were conducted by sex, there were no significant differences between rookeries for males ($P = 0.550$, Table 13) or females ($P = 0.545$, Table 13).

Table 6.--Sample sizes (n), mean mass (kg), and standard deviation (SD) of male and female northern fur seal pups weighed on St. Paul Island, Alaska, 24-26 August 1997.

Rookery		Females	Males	Combined
Reef	kg	8.70	9.85	9.31
27 August	SD	1.42	1.70	1.67
	n	121	135	256
Vostochni	kg	7.97	9.35	8.70
26 August	SD	1.56	1.67	1.76
	n	117	133	250
Pol. Cliffs	kg	8.25	9.82	9.07
25 August	SD	1.36	1.59	1.68
	n	126	137	263
Tolstoi	kg	8.31	9.67	8.96
25 August	SD	1.48	1.59	1.68
	n	131	120	251
Combined	kg	8.31	9.67	9.01
	SD	1.47	1.66	1.71
	n	495	525	1020

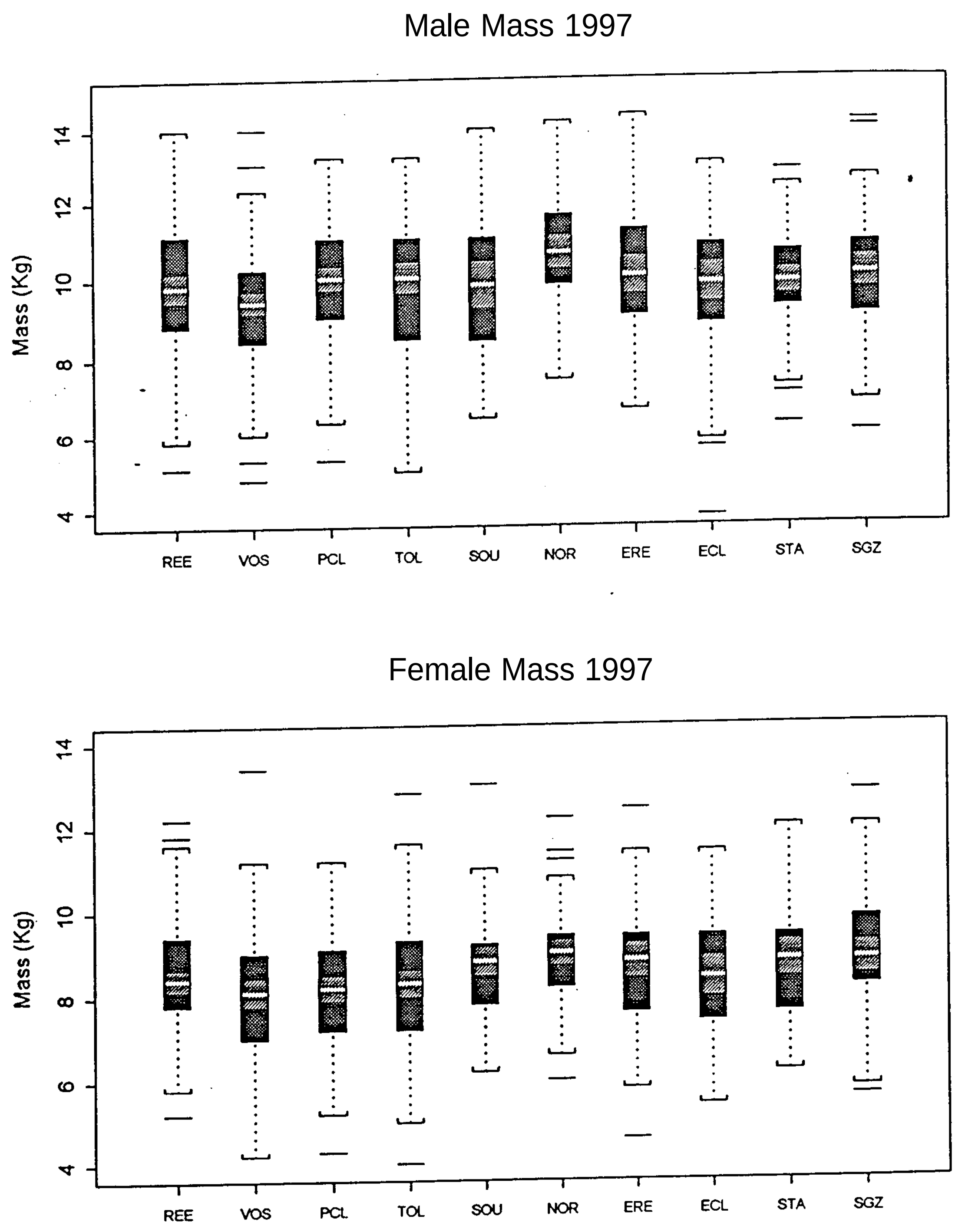

Figure 7.--Boxplots of the median mass (white line), 95% confidence intervals of the median mass (light hatch) of northern fur seal pups on St. Paul Island and St George Island, Alaska, August 1997: Reef (REE), Vostochni (VOS), Polovina Cliffs (PCL), Tolstoi (TOL), South (SOU), North (NOR), East Reef (ERE), East Cliffs (ECL), Staraya Artil (STA), and St. George Zapadni (SGZ). Lines outside of the whiskers are outliers to the data.

Table 7. --Analysis of variance of mass of northern fur seal pups on St. Paul Island, Alaska, August 1997, by sex on rookery.

Factor	df	SS due to factor	MSS*	Residual	df	F	P
Females							
Rookery	3	32.6	10.9	1039	491	5.1	0.002
Males							
Rookery	3	20.8	6.9	1401	521	2.6	0.053

*MSS = SS divided by df

Table 8.--Sample sizes (n), mean length (cm), and standard deviation (SD) of male and female northern fur seal pups weighed on St. Paul Island, Alaska, 24-26 August 1997.

Rookery		Females	Males	Combined
Reef	cm	75.11	77.91	76.59
27 August	SD	3.83	4.41	4.37
	n	121	135	256
Vostochni	cm	73.40	77.09	75.36
26 August	SD	4.75	5.02	5.22
	n	117	133	250
Pol. Cliffs	cm	73.41	76.42	74.98
25 August	SD	4.29	3.87	4.34
	n	126	136	262
Tolstoi	cm	74.16	77.59	75.80
25 August	SD	4.37	4.64	4.81
	n	131	120	251
Combined	cm	74.02	77.24	75.67
	SD	4.36	4.52	4.72
	n	495	524	1019

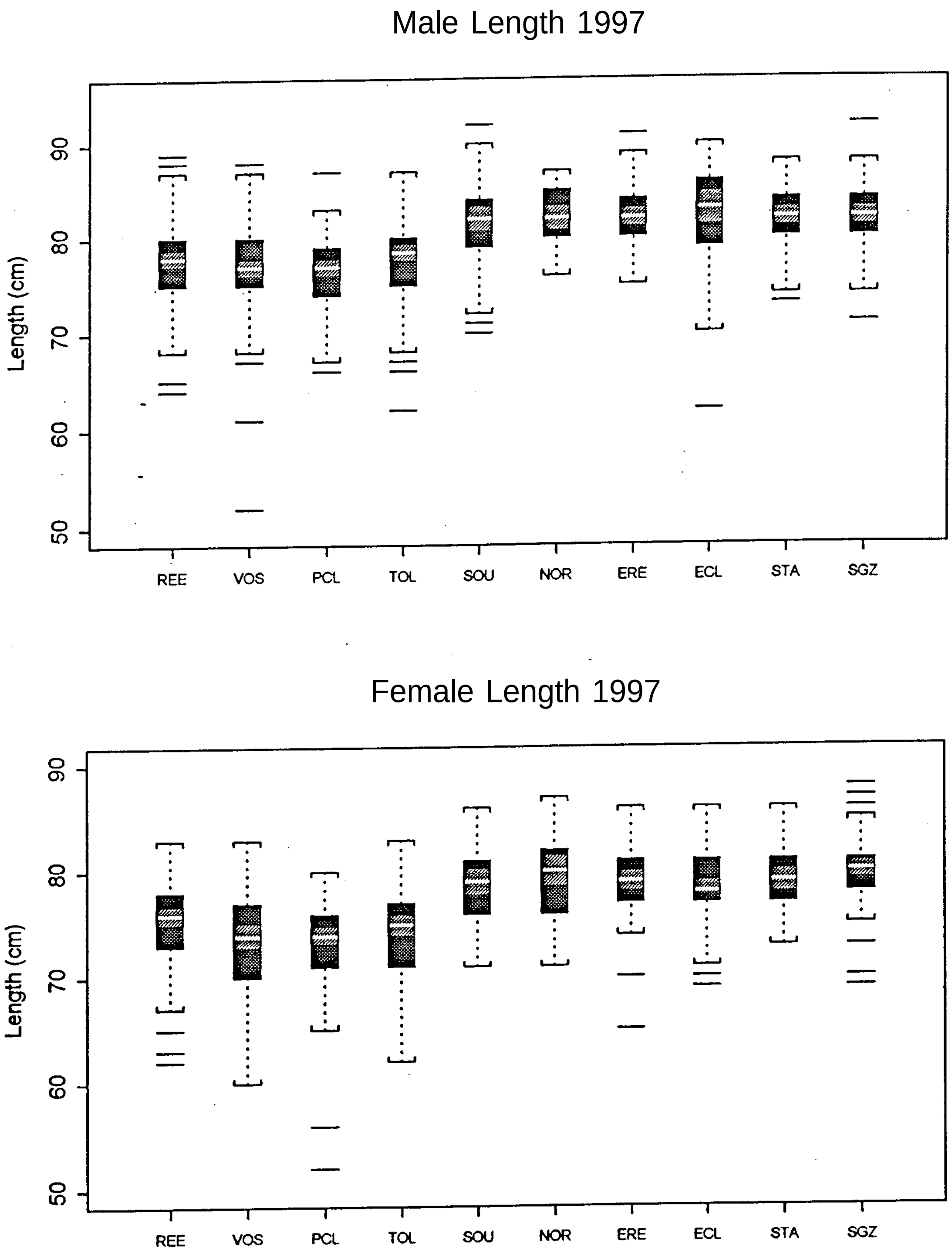

Figure 8.--Boxplots of the median length (white line), 95% confidence intervals of the median length (light hatch) of northern fur seal pups on St. Paul Island and St George Island, Alaska, August 1997: Reef (REE), Vostochni (VOS), Polovina Cliffs (PCL), Tolstoi (TOL), South (SOU), North (NOR), East Reef (ERE), East Cliffs (ECL), Staraya Artil (STA), and St. George Zapadni (SGZ). Lines outside of the whiskers are outliers to the data.

Table 9.--Analysis of variance of length of northern fur seal pups on St. Paul Island, Alaska, August 1997, by sex on rookery.

Factor	df	SS due to factor	MSS*	Residual	df	F	P
Females							
Rookery	3	236.9	79.0	9162	491	4.2	0.006
Males							
Rookery	3	348.1	116.0	17759	521	3.4	0.018

*MSS = SS divided by df

Table l0.-- Sample sizes (n), mean mass (kg), and standard deviation (SD) of male and female northern fur seal pups weighed on St. George Island, Alaska, 5-28 August 1997.

Rookery		Females	Males	Combined
South	kg	8.66	9.69	9.19
24 August	SD	1.23	1.84	1.65
	n	50	53	103
North	kg	9.03	10.68	9.85
27 August	SD	1.31	1.45	1.60
	n	53	53	106
East Reef	kg	8.66	10.13	9.43
26 August	SD	1.42	1.56	1.66
	n	55	61	116
East Cliffs	kg	8.38	9.66	9.00
26 August	SD	1.47	1.87	1.79
	n	53	49	102
Staraya Artil	kg	8.73	9.82	9.30
27 August	SD	1.35	1.42	1.48
	n	49	54	103
Zapadni	kg	8.99	9.96	9.51
25 August	SD	1.47	1.56	1.59
	n	51	57	108
Combined	kg	8.74	10.00	9.38
	SD	1.38	1.64	1.65
	n	311	327	638

Table Il.--Analysis of variance of mass of northern fur seal pups on St. George Island, Alaska, August 1997, by sex on rookery.

Factor	df	SS due to factor	MSS*	Residual	df	F	P
Females							
Rookery	5	15.0	3.0	579	305	1.5	0.164
Males							
Rookery	5	56.3	18.8	1184	322	3.1	0.010

*MSS = SS divided by df

Table 12.-- Sample sizes (n), mean length (cm), and standard deviation (SD) of male and female northern fur seal pups weighed on St. George Island, Alaska, 25-28 August 1997.

Rookery		Females	Males	Combined
South	cm	78.88	81.21	80.08
24 August	SD	3.48	4.96	4.44
	n	50	53	103
North	cm	79.45	82.64	81.05
27 August	SD	3.83	2.92	3.75
	n	53	53	106
East Reef	cm	78.95	82.08	80.59
26 August	SD	3.98	3.41	4.00
	n	55	61	116
East Cliffs	cm	78.28	82.14	80.16
26 August	SD	3.90	5.39	5.05
	n	53	50	103
Staraya Artil	cm	79.45	81.87	80.72
27 August	SD	3.08	3.26	3.39
	n	49	54	103
Zapadni	cm	79.41	81.61	80.57
25 August	SD	3.99	3.62	3.94
	n	51	57	108
Combined	cm	79.06	81.92	80.53
	SD	3.73	3.99	4.19
	n	311	328	639

Table 13.--Analysis of variance of length of northern fur seal pups on St. George Island, Alaska, August 1997, by sex on rookery.

Factor	df	SS due to factor	MSS*	Residual	df	F	P
Females							
Rookery	5	56.2	11.2	4250	305	0.8	0.550
Males							
Rookery	5	64.0	12.8	5147	322	0.8	0.545

*MSS = SS divided by df

Mass and length were compared between islands by sex. The variances of the mass for males between islands were significantly different (P = 0.00l), but the variances for the mass of females between islands were not significantly different (P = 0.233). Male and female mass were significantly greater on St. George Island than on St. Paul Island (males, P = 0.021 and females, P < 0.001). The variances of the lengths for each sex by island were significantly different (males, P < 0.001 and females, P = 0.003). Male and female pups were longer on St. George Island than St. Paul Island (males, P < 0.001 and females, P < 0.001).

Sex Ratios

The fraction of females (Table 14) for each rookery and island was tested using an exact binomial test. The fraction of females was not significantly different than 50% (P < 0.05) for any sampled rookery or island in 1997. The overall fraction of females (48.6%) was not significantly different than 50% (P = 0.741).

SUMMARY

Consistent with earlier evaluations of pup mass data (York and Antonelis 1990, York and Towell 1993, Towell et al. 1996, and Towel1 et al. 1997), the strongest pattern was that the size of pups varied by sex: male pups were heavier and longer than female pups. The mass of female and male pups on St. George Island were significantly greater than pups on St. Paul Island in 1997. Both males and female pups were significantly longer (P < 0.001) on St. George Island than on St. Paul Island in 1997. The proportion of females was not significantly different (P > 0.05) than 50%, (48.5% on St. Paul Island and 48.7% on St. George Island; Table 15) for both islands in 1997.

Table 14.--Numbers of female pups, total number of pups, and fraction (that are female) of northern fur seal pups sampled during pup weighing on St. Paul Island, Alaska, August 1997.

Rookery	Females	Total	Fraction
Reef	121	256	0.473
Vostochni	117	250	0.468
Pol. Cliffs	126	263	0.479
Tolstoi	131	251	0.522
Total	495	1020	0.485
East Reef	55	116	0.474
East Cliffs	53	103	0.515
Staraya Artil	49	103	0.476
North	53	106	0.500
Zapadni	51	108	0.472
South	50	103	0.485
Total	311	639	0.487

Table 15.--Numbers of female pups, total number of pups, and fraction (that are female) of live northern fur seals pups captured during weighing operations on St. Paul Island and separate samples on St. George Island, Alaska, for the years 1992-97.

Year	St. Paul			St. George		
	Females	Total	Fraction	Females	Total	Fraction
1992	494	1118	0.442	291	634	0.459
1994	926	1926	0.481	430	886	0.485
1995	939	2040	0.460	294	653	0.450
1996	520	1149	0.453	331	749	0.442
1997	495	1020	0.485	311	639	0.487

These differences in mass and length may reflect the influence of environmental variability on the condition of pups and their mothers. Undetected biases in sampling techniques may also be responsible for the differences detected in this study. Future studies will be designed to minimize possible sources of biases due to methodology and explore the combined use of length and mass to create condition indices of pups.

NORTHERN FUR SEAL ENTANGLEMENT STUDIES: ST. PAUL AND ST. GEORGE ISLANDS, 1997

by

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Candace M. Stepetin, and Gary E. Merculief

Entanglement of northern fur seals *(Callorhinus ursinus)* in marine debris has been studied since the late 1960s. Surveys of entanglement among subadult male fur seals were conducted in conjunction with the commercial harvest from 1967 through 1985 (Scordino and Fisher 1983, Scordino 1985) and using research roundups after the cessation of the commercial harvest (Bengtson et al. 1988, Fowler 1987, Fowler and Baba 1991, Fowler et al. 1992). Adult female entanglement has been studied by Bigg (1979), Scordino and Fisher (1983), Scordino (1985), Delong et al. (1988), and Kiyota and Fowler (1994). Mortality resulting from entanglement in marine debris has been implicated as a contributing factor in the decline observed in the Pribilof Islands northern fur seal population during the 1970s and early 1980s (Fowler 1987, Trites and Larkin 1989).

During 1997, in cooperation with the Tribal Governments of St. Paul and St. George Islands and the Pribilof Islands Stewardship Program, the NMFS continued a study of juvenile and adult male fur seal entanglement using a combination of research roundups and surveys during the subsistence harvest. Surveys conducted in conjunction with the subsistence harvest were initiated in 1995 to reduce the number of times seals are disturbed by eliminating the need for research roundups on the same haulouts during July and early August.

The objective of this study was to determine current trends in the entanglement rate of northern fur seals in marine debris on St. Paul and St. George Islands. This information is used to provide 1) a continuing index of entanglement rates, 2) a comparison of entanglement rates on St. Paul Island and St. George Island, 3) a means of indirectly assessing the relative amount of entangling debris within the habitat of the fur seal, and 4) an assessment of the debris types associated with different fisheries that may have an impact upon fur seals. In addition to the juvenile male entanglement studies, researchers collected information on seasonal and annual (1991-97) rates of entanglement among adult female fur seals. As in previous years, researchers captured and removed debris from entangled seals encountered during other research projects.

METHODS

Harvest Surveys and Roundups of Adult and Juvenile Males

Male fur seals on hauling grounds located on St. George and St. Paul Islands were surveyed for entanglement in July and August 1997. Harvest surveys were conducted in conjunction with the Aleut subsistence harvest while non-harvest surveys followed the methods described in Bengtson et al. (1988), Fowler and Ragen (1990), and Fowler et al. (1992). The harvest sampling protocol was adjusted as described by Robson et al. (1997a). During each survey, separate counts were made by different observers of the total number of male seals (all age groups) and the number of juvenile male seals judged to be of the appearance and age (2-4 years old) historically taken in the commercial harvest (Bengtson et al. 1988, Fowler et al. 1992). Criteria for selection of juvenile males was based on overall size, pelage characteristics (color and thickness of mane, sagittal crest, and chest patch), and vibrissae color and length (Scheffer 1962). During subsistence harvest surveys, harvested seals were examined for evidence of entanglement and added to the final count. The count of adult seals (ages 5 and older) was derived by subtracting the number of juveniles from the total count of all seals during surveys where both total and juvenile counts were made.

When an entangled seal was sighted, the flow of seals to the water was stopped and the entangled seal was captured and the entangling debris removed. Information on the type of entangling debris, the extent of the wound, and the estimated age of the seal was recorded. Debris removed from entangled seals was examined to determine the type, color, weight, and size (stretched mesh and twine size for net fragments; length and width of the entangling loop for other materials such as packing bands or ropes) and saved for future analysis.

When entangled juvenile seals could be physically restrained, shear marks indicating island of capture and type of survey were made on the shoulder pelage of the seal. Marking enabled observers to resight previously entangled seals during subsequent surveys (Bengtson et al. 1988, Fowler and Ragen 1990). During the study period, juvenile male seals captured and disentangled during other research activities were also marked to indicate previous entanglement. In situations where the logistics of a capture or the safety of the crew made it necessary to remove the debris without completely restraining a seal (through the use of a cutting hook mounted on a pole), it was not possible to shear mark juvenile seals. Due to the difficulty involved with handling and restraining adult male fur seals, they were not marked for resighting. Observations of unsheared, scarred seals (juvenile or adult) were not used in calculations of the incidence of entanglement described below.

In contrast to tagging, shear marks do not allow detection of seals released from debris in previous years. Therefore, current methods will slightly underestimate the entanglement rate in comparison with previous methods (Fowler and Baba 1991) and may be better understood as an index of the minimum rate of entanglement among juvenile male fur seals. In addition, shear marking does not allow for the determination of the type of debris which was previously removed from the seal and therefore data on the composition of entangling debris is based only on the initial removal of debris and does not include resighted seals.

The rate of entanglement is estimated by the ratio of all (both initial and subsequent) entanglement sightings to the total of number of seals examined (Bengtson et al. 1988, Fowler et al. 1992). This estimate is subject to a slight upward bias due to the assumption that seals from which debris was removed would not have lost their debris independently (Scordino 1985, Fowler et al. 1993). Because some seals on haulouts are observed more than once (Fowler and Ragen 1990, Raker et al. 1995), surveys sampled seals with replacement.

Statistical analysis of entanglement data was performed using a general linear model assuming a binomial response. Factors were considered statistically significant if the deviance accounted for by that factor was greater than $X^2_{df,0.85}$ (where df is the number of levels of the factor -1). Factors examined in the analysis of the entanglement rate were age (adult vs. juvenile), island (St. Paul vs. St. George), sample type (harvest vs. roundup sample), and the interaction between age, island, and sample type in the rate of entanglement.

Entanglement Surveys of Adult Females

In 1997, island-wide surveys of entangled adult female fur seals were conducted on St. Paul Island using the techniques described by Kiyota and Fowler (1994). All rookeries were surveyed in conjunction with the counts of adult males from 12 to 17 July. Locations of entangled females were recorded and attempts were made to locate and disentangle these seals when possible, with minimal disturbance to the rookeries.

RESULTS AND DISCUSSION

Entanglement Surveys and Roundups of Adult and Juvenile Males

Twenty-two subsistence harvest surveys and 33 roundups were conducted on St. Paul Island (55 total) and 18 roundups and 8 harvest surveys (26 total) were conducted on St. George Island during July and early August of 1997 (Table 16). Observers sampled 37,105 and 6,754 seals of all age groups combined on St. Paul and St. George Islands, respectively. Samples included 19,265 juveniles (2-4 years old) on St. Paul Island and 2,987 juveniles on St. George Island. Sixty-one entangled male seals were observed during harvest surveys and roundups and included in the calculation of the entanglement rate below. Of these, fifty-seven were captured, examined, and the debris was removed (49 on St. Paul Island and 8 on St. George Island). Crews were unable to capture 4 entangled seals (1 juvenile and 1 adult on St. Paul and 2 adult males on St. George Island). Sixty-six seals with scars indicating evidence of previous entanglement were also observed, however they were not used in subsequent calculations of the incidence of entanglement (Table 16). Twenty-five of the entangled seals were adult males, some of which had fresh, open wounds indicating that their debris was probably removed or lost during 1997.

Resights of Previously Entangled Seals

Twenty-five of 33 entangled juveniles were shear marked on St. Paul Island. Six of the 8 seals not sheared were captured on the last visit to a survey area. Debris was removed from most of the seals captured on St. George Island using a cutting hook, therefore only two of the 7 entangled juvenile seals captured during surveys were shear marked during the 1997 season. An additional 5 entangled juveniles on St. Paul were sheared during other research activities.

Table 16.--Summary of harvest surveys and roundups of juvenile and adult northern fur seal males conducted on St. Paul and St. George Islands during July and August 1997 including the number of observations of seals entangled, resighted, and observed with scars (* indicates surveys in which no total counts were made).

Date	Survey Type	Location	Total count	Juvenile count	Juveniles entangled	Sheared juveniles resighted	Juveniles scarred	Adults entangled	Adults scarred
St. Paul Island									
01-Jul-97	R	Zapadni Reef Sands	648	149	1	0	0	0	0
02-Jul-97	R	Tolstoi Sands	206*	206	0	0	1	--	--
02-Jul-97	R	Tolstoi Hill	541	90	0	0	0	0	0
05-Jul-97	R	Vostochni Sec.14	563	293	0	0	1	1	0
02-Jul-97	R	Vostochni Sec.10	708	209	0	0	0	1	0
05-Jul-97	R	Vostochni Sec.1	357	95	0	0	0	0	0
06-Jul-97	R	Zolotoi	1697	310	0	0	0	0	2
06-Jul-97	R	Morjovi Sec.1	1426	455	0	0	0	2	1
08-Jul-97	H	Zapadni	930	438	1	0	1	0	0
10-Jul-97	H	Polovina	438	279	0	0	0	0	0
11-Jul-97	R	Tosltoi Hill	145	43	0	0	0	0	0
12-Jul-97	R	Zapadni	1000	492	0	0	1	0	0
12-Jul-97	R	Zapadni Reef Sands	955	516	0	0	2	1	0
13-Jul-97	R	Little Polovina	641	241	0	0	0	0	2
14-Jul-97	H	Zapadni Reef Sands	599	376	1	0	0	1	0
15-Jul-97	H	Reef	364	263	0	0	0	0	0
15-Jul-97	R	Vostochni Sands	456	300	0	0	2	0	1
16-Jul-97	H	Lukanin	225	126	0	0	1	1	0
17-Jul-97	H	Polovina	202	131	0	0	0	0	1

Table 16.--continued.

Date	Survey Type	Location	Total count	Juvenile count	Juveniles entangled	Sheared juveniles resighted	Juveniles scarred	Adults entangled	Adults scarred
17-Jul-97	R	Tolstoi Sands	722	425	0	0	2	0	0
17-Jul-97	R	Tolstoi Hill	386	137	0	0	0	0	0
21-Jul-97	H	Zapadni	771	509	1	0	1	0	1
21-Jul-97	R	Vostochni Sec.14	321	190	2	0	0	0	0
21-Jul-97	R	Vostochni Sec.12	209	124	0	0	0	0	0
21-Jul-97	R	Vostochni Sec.10	840	602	2	0	0	0	0
22-Jul-97	H	Zapadni Reef Sands	893	657	0	0	0	1	1
23-Jul-97	H	Polovina	656	427	0	1	2	2	0
23-Jul-97	R	Morjovi Sec.1	659*	659	1	0	1	--	--
23-Jul-97	R	Vostochni Sec.1	236	111	0	0	0	0	0
23-Jul-97	R	Northeast Point	389	189	0	0	0	0	0
24-Jul-97	H	Lukanin	257	186	0	0	0	0	0
24-Jul-97	R	Zolotoi	1228	471	2	0	2	1	0
24-Jul-97	R	Little Zapadni	577	321	0	1	2	0	1
25-Jul-97	H	Reef	799	531	0	0	1	0	0
25-Jul-97	R	Little Polovina	1149	430	1	0	1	2	1
26-Jul-97	H	Big Zapadni	384	343	0	0	2	0	0
28-Jul-97	H	Zapadni Reef Sands	371	252	0	0	0	0	0
29-Jul-97	H	Polovina	509	281	0	0	3	0	1
30-Jul-97	H	Lukanin	108	75	0	0	0	0	0
31-Jul-97	H	Zapadni	898	587	1	0	2	0	0
31-Jul-97	R	Morjovi Sec.1	1588	1116	1	0	1	0	0

Table 16.--continued.

Date	Survey Type	Location	Total count	Juvenile count	Juveniles entangled	Sheared juveniles resighted	Juveniles scarred	Adults entangled	Adults scarred
01-Aug-97	H	Reef	441	329	2	0	0	0	0
02-Aug-97	H	Morjovi Sec.1	926	777	3	0	1	0	1
02-Aug-97	R	Zolotoi	1642	657	1	0	1	3	2
04-Aug-97	R	Little Zapadni	664	203	1	0	0	0	0
04-Aug-97	R	Tolstoi Sands	709	227	1	0	1	2	0
04-Aug-97	R	Tolstoi Hill	1093	326	0	0	1	0	0
04-Aug-97	H	Polovina	671	459	2	0	0	0	1
05-Aug-97	H	Kitovi	741	437	0	0	0	0	0
06-Aug-97	H	Zapadni	1007	560	3	1	2	0	2
07-Aug-97	H	Zolotoi	1400	520	0	0	0	0	0
09-Aug-97	R	Vostochni Sec.14	111	111	0	0	1	0	0
09-Aug-97	R	Vostochni13/14	474	330	2	0	0	0	0
09-Aug-97	R	Vostochni 12	700	539	3	0	1	0	1
10-Aug-97	R	Little Polovina	475	155	1	0	0	0	1
St. Paul Totals			37105	19265	33	3	37	18	20
St. George Island									
07-Jul-97	R	Northcentral	102	31	0	0	0	0	0
07-Jul-97	R	Northwest	272	74	0	0	0	0	0

Table 16.--continued.

Date	Survey Type	Location	Total count	Juvenile count	Juveniles entangled	Sheared juveniles resighted	Juveniles scarred	Adults entangled	Adults scarred
10-Jul-97	R	East Reef	218	72	0	0	0	0	0
10-Jul-97	R	East Cliffs	933	287	0	0	0	0	0
10-Jul-97	R	Staraya Artil	206	33	0	0	0	1	0
14-Jul-97	R	Northcentral	143	25	0	0	0	0	0
14-Jul-97	R	Northwest	124	66	0	0	0	0	0
18-Jul-97	R	East Reef	187	58	0	0	0	0	0
18-Jul-97	R	East Cliffs	758	389	2	0	0	1	0
18-Jul-97	R	Staraya Artil	141	33	0	0	0	0	1
24-Jul-97	H	Northeast	469	167	0	0	1	0	1
25-Jul-97	R	East Reef	245	93	0	0	0	0	0
25-Jul-97	R	East Cliffs	753	386	1	0	2	0	0
25-Jul-97	R	Northcentral	201	24	0	0	0	0	0
25-Jul-97	R	Northwest	175	87	0	0	0	0	0
25-Jul-97	R	Staraya Artil	216	57	0	0	1	1	0
25-Jul-97	H	Zapadni	104*	104	0	0	0	--	--
30-Jul-97	H	Zapadni	177*	177	0	0	0	--	--
31-Jul-97	H	Northeast	177*	177	0	0	0	--	--
31-Jul-97	R	Northcentral	134	35	0	0	0	0	0
31-Jul-97	R	Northwest	117	33	0	0	0	0	0
01-Aug-97	R	East Cliffs	517	194	1	0	0	0	1
05-Aug-97	H	Zapadni	186*	186	2	0	0	--	--
06-Aug-97	H	Northeast	132*	132	1	0	0	--	--

Date	Survey Type	Location	Total count	Juvenile count	Juveniles entangled	Sheared juveniles resighted	Juveniles scarred	Adults entangled	Adults scarred
08-Aug-97	H	Zapadni	67*	67	0	0	0	--	--
St. George Totals			6754	2987	7	0	4	3	3

Three juvenile males on St. Paul Island and no seals on St. George Island were observed with shear marks indicating prior removal of entangling debris during 1997. During 1997, the resight rate for sheared, previously entangled juvenile seals on both islands combined was 9.4% (3 out of the total of 32 sheared), down from 29.0% in 1996 and 31.5% in 1995. Data collected during entanglement studies conducted from 1985 to 1992 on St. Paul Island showed a within-year resight rate for both control and entangled seals of approximately 25%, with a minimum of 17.5% in 1992 (Fowler et al. 1993). Considering St. Paul Island individually, where research crews were able to consistently shear entangled juvenile seals during 1997, the resight rate of 10.0% is still lower than previous levels.

Incidence of Entanglement

During subsistence harvest surveys and roundups on St. Paul Island, 33 juvenile and 18 adult entangled fur seals were observed and the type of debris was determined. Seven juvenile and 3 adult male entangled seals were observed on St. George Island. In situations where an entangled seal was not captured, age and debris information was recorded when possible. Seventeen juvenile male seals and 11 adult male seals captured and disentangled during other research activities on both islands from late June through early August 1997 are not included in the calculations of the entanglement rate.

The rate of entanglement for juvenile males was 0.19% (36/19,265) on St. Paul Island and 0.23% (7/2,987) on St. George Island. Among adult males, the rate of entanglement was 0.10% (18/17,840) on St. Paul Island and 0.08% (3/3,767) on St. George Island. The overall rate of entanglement for males was 0.15% (54/37,105) and 0.10% (7/6,754) for St. Paul and St. George Islands, respectively.

Under the full linear model, only the age of a seal (juvenile vs. adult) had a significant effect on the rate of entanglement (P = 0.03) (Table 17). No significant difference in the entanglement rate was observed between islands (P = 0.84) or sample type (P = 0.91) for either juvenile or adult male fur seals during 1997. The combined results of surveys conducted from 1995 to 1997 also show a highly significant effect of age on the rate of entanglement (P < 0.01) reflecting the higher rate of entanglement among juveniles, and a marginally significant (P = 0.06) interaction between age and island. The age/island effect is due to the higher rate of entanglement observed among juvenile males on St. George Island during 1995. This was probably due to a lack of an organized capture effort prior to the initiation of this study in 1995 (Robson et al. 1997b). When 1995 is removed from the model, neither island (P = 0.69) or age vs. island (P = 0.30) have a significant effect on the rate of entanglement, indicating that the entanglement rate is not significantly different between male fur seals on the two islands.

As in previous years, entangling debris consisted primarily of pieces of trawl net, plastic packing bands, or loops of synthetic or natural twine. On St. Paul Island, 7 (41.2%) adult males were entangled in packing bands, 7 in trawl net (41.2%), and the remaining 3 were entangled in twine (17.6 %). On St. George Island, only 1 adult male entangled in a synthetic string was observed during entanglement surveys (debris type was not determined for 2 entangled adult males observed but not captured). Packing bands comprised the largest proportion of entangling debris among juveniles on St. Paul Island (50.0%, n = 16) followed

Table 17.-- Results of statistical analysis of adult and juvenile male northern fur seal entanglement rates on St. Paul and St. George Islands.

Factor	df	Deviance	Residual df	Residual deviance	P (X^2)
1997 Survey					
Null			150	132.34	
Age	1	7.10	149	125.24	0.03
Island	1	0.04	148	125.20	0.84
Sample type	1	0.01	147	125.19	0.91
Age × Island	1	0.39	146	124.80	0.53
Age × Sample type	1	0.06	145	124.73	0.80
Island × Sample type	1	0.06	144	124.67	0.80
Age × Island × Sample	1	0.61	143	124.06	0.43
1995-97 Surveys					
Null			485	470.33	
Age	1	28.52	484	441.80	<0.01
Island	1	0.62	483	441.18	0.43
Sample type	1	0.26	482	440.92	0.61
Age × Island	1	3.51	481	437.40	0.06
Age × Sample type	1	0.01	480	437.39	0.91
Island × Sample type	1	1.84	479	435.55	0.18
Age × Island × Sample	1	1.74	478	433.81	0.19
1996-97 Surveys					
Null			324	296.62	
Age	1	17.11	323	279.51	<0.01
Island	1	0.16	322	279.35	0.69
Sample type	1	0.35	321	279.00	0.55
Age × Island	1	1.10	320	277.90	0.30
Age × Sample type	1	0.40	319	277.50	0.53
Island × Sample type	1	0.30	318	277.20	0.59
Age × Island × Sample	1	1.71	317	275.49	0.19

by trawl net (31.3%, n = 10). Conversely, trawl net was the most frequent debris type (71.4%, n = 5) observed on St. George Island followed by packing bands (14.3%, n = 1) and twine (14.3%, n = 1). As in 1995 and 1996, more entanglement in packing bands was observed on St. Paul Island (46.9%, n = 23) relative to St. George Island (12.5%, n = 1) for all age groups combined

The proportion of entangling debris in each category during 1997 is relatively consistent with the previous two years on St. George Island, where the incidence of trawl debris on juvenile males is higher than on St. Paul Island (Table 18). Differences in the occurrence of debris types between the two islands may reflect the prevalence of a given material in the nearshore environment of each island. While the occurrence of trawl net observed on entangled seals has decreased in recent years, the consistent numbers of seals entangled in packing bands on St. Paul Island may reflect the disposal of these materials by vessels in proximity to the island. Recent data from satellite-tracked drifters deployed in the Bering Sea suggests a "trapped" clockwise circulation pattern around the Pribilof Islands (Stabeno et al. In press) which might act to retain marine debris in the nearshore environment. An increase in the number of Antarctic fur seals *(Arctocephalus gazella)* entangled in polypropylene packing bands was observed at Bird Island, South Georgia, in the late 1980s as these materials came into common usage by at-sea processing vessels (Croxall et al. 1990).

The incidence of entanglement among juvenile males on St. Paul Island is the lowest observed since 1968 (Table 19, Fig. 9); however, it is still close to the entanglement rates observed from 1988 to 1992 and in 1995-96 (Robson et al. 1997a, Robson et al. 1997b). Fowler et al. (1993) attributed a decline in the rate of entanglement on St. Paul Island from a

Table 18.-- Debris found on juvenile male northern fur seals from St. Paul and St. George Islands, Alaska, 1981-97, expressed as the incidence of entanglement (observed percent) among juvenile males entangled by debris category (data for 1981-91 from Fowler and Ragen 1990, Fowler and Baba 1991, and Fowler et al. 1992). Sample sizes shown are the number of entangled juveniles for which debris type could be determined and do not include sheared resights or seals which were not captured or examined closely. Observed percent values are calculated as the overall entanglement rate for juveniles on each island multiplied by the percentage of seals in a debris category.

Year	Trawl net fragments	Packing bands	Cord, rope, and string	Monofilament net fragments	Misc. items	Entanglement rate	Sample size
St. Paul Island							
1981	0.29	0.08	0.04	-	0.03	0.43	102
1982	0.24	0.10	0.04	0.01	0.01	0.41	102
1983	0.30	0.07	0.02	0.01	0.03	0.43	112
1984	0.22	0.09	0.05	0.02	0.01	0.39	87
1985	0.31	0.05	0.07	0.01	0.01	0.45	76
1986	0.27	0.06	0.07	0.01	0.01	0.42	70
1988	0.15	0.07	0.05	-	0.01	0.28	53
1989	0.12	0.10	0.06	0.02	0.01	0.29	47
1990	0.11	0.11	0.07	0.01	0.03	0.32	71
1991	0.06	0.08	0.06	0.01	0.00	0.21	38
1992	0.14	0.07	0.05	0.01	0.03	0.29	40
1995	0.11	0.08	0.02	-	0.01	0.22	22
1996	0.10	0.07	0.03	-	0.02	0.23	37

Table 18.--continued.

Year	Trawl net fragments	Packing bands	Cord, rope, and string	Monofilament net fragments	Misc. items	Entanglement rate	Sample size
1997	0.06	0.09	0.01	-	0.03	0.19	32
St. George Island							
1995	0.18	0.05	0.11	-	0.05	0.39	17
1996	0.11	0.05	0.04	-	0.02	0.21	12
1997	0.17	0.03	-	-	0.03	0.23	7

Table 19 .--The percentage ofjuvenile male northern fur seals from St. Paul Island, Alaska, entangled in marine debris as recorded from 1967 to 1984 during the commercial harvest (data from Kozloff et al. 1986); from 1985 to 1992 during roundups (data updated from Fowler et al. 1993) and from 1995 to 1997.

Year	Percent entangled	
	St. Paul Island	St. George Island
1967	0.15	–
1968	0.16	–
1969	0.20	–
1970	0.28	–
1971	0.41	–
1972	0.43	–
1973	0.48	–
1974	0.58	–
1975	0.71	–
1976	0.42	–
1977	0.35	–
1978	0.46	–
1979	0.40	–
1980	0.49	–
1981	0.43	–
1982	0.41	–
1983	0.43	–
1984	0.39	–
1985	0.45	–
1986	0.42	–
1987	–	–
1988	0.28	–
1989	0.29	–
1990	0.32	–
1991	0.21	–
1992	0.29	–
1993	–	–
1994	–	–
1995	0.22	0.39
1996	0.23	0.21
1997	0.19	0.23

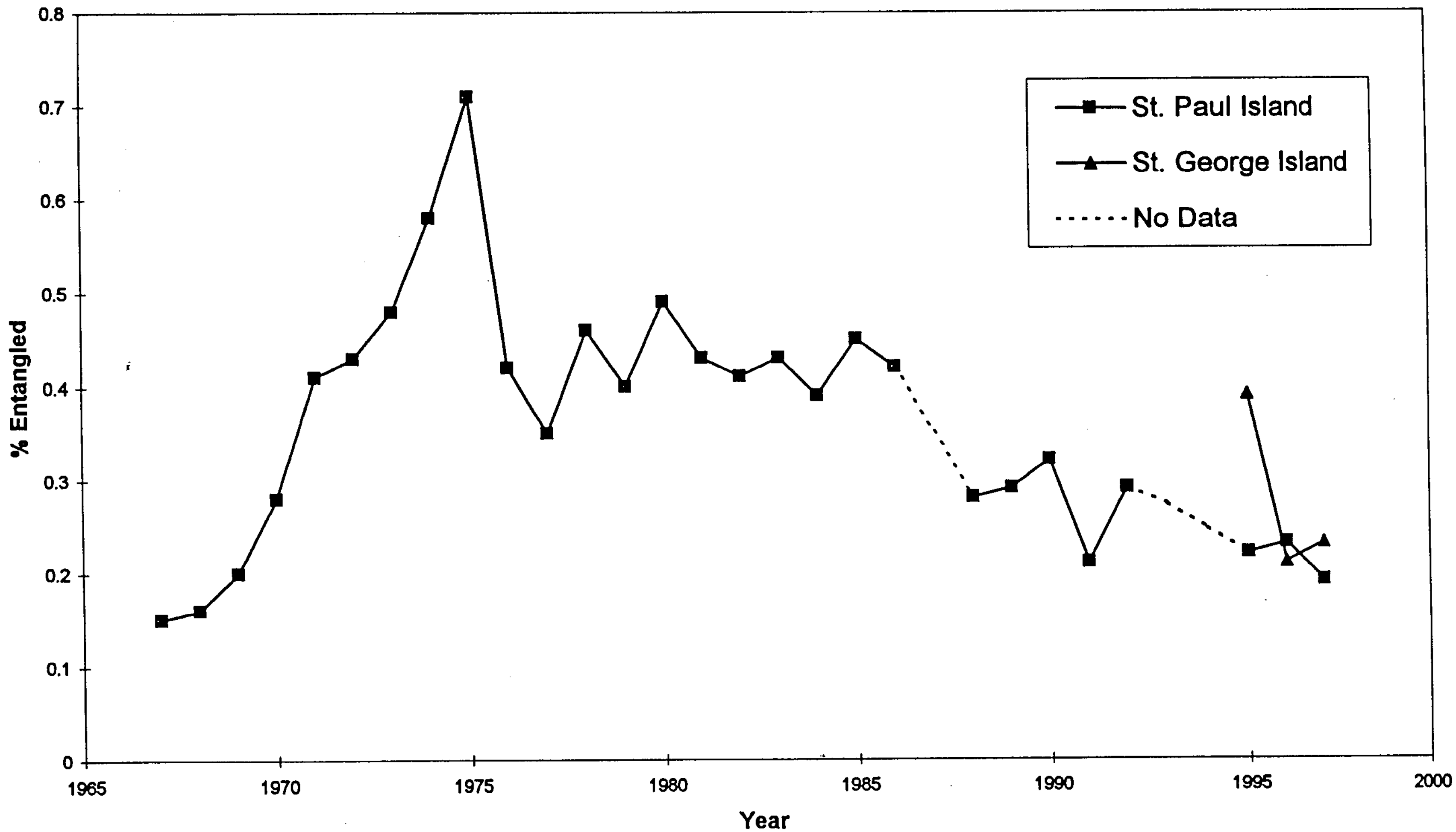

Figure 9.-- The percentage of juvenile male northern fur seals from St. Paul and St. George Island, Alaska, entangled in marine debris recorded during the commercial harvest (1967-84) and entanglement surveys (1985-97).

mean rate of 0.4% between 1976 and 1985 to the approximately 0.2% level observed from 1988-92 and 1995-97 to a reduction in the fraction of seals entangled in trawl net fragments. this decline coincides with a decrease in the amount of trawl debris observed in beach debrissurveys in the Gulf of Alaska since the implementation of MARPOL Annex V legislation in 1998 (Johnson et al.1994).

Adult Female Entanglement

Two entangled and 9 scarred (evidence of previous entanglement) adult female fur seals were observed during female entanglement surveys on St. Paul Island (Table 20). The rate of entanglement among females was calculated at 0.007 % for entangled females, 0.029 % for scarred females, and 0.036% for the two categories combined. The 1997 data are comparable to the observed rate of entangled, and entangled and scarred females combined in 1995-96, and to that observed in 1992 and 1993 (Table 21) (Kiyota and Fowler 1992, Kiyota pers. comm).

SUMMARY

1. The incidence of entanglement among juvenile males on St. Paul (0.19%) and St. George (0.23%) Islands is close to the rate of entanglement observed from 1988 to 1992 and in 1995-96.

2. No significant difference in the entanglement rate was observed between islands for either juvenile or adult male fur seals during 1996 or 1997 indicating that the entanglement rate is similar between male fur seals on the two islands.

3. The decline in the rate of entanglement on St. Paul Island from a mean rate of 0.4 %

between 1976 and 1985 to current levels of approximately 0.2% indicates a reduction in the relative amount of entangling debris in the marine environment.

4. The consistency in the proportion of seals entangled in packing bands on St. Paul Island during the 199Os, relative to a decrease in the amount of trawl netting, may reflect the use and disposal of these materials in the marine environment.

Table 20.--Surveys of female entanglement conducted during July 1997.

Date	Rookery	No. counted	Females entangled	Females scarred	Females entangled and scarred
7/12/97	Big Zapadni	3,769	0	1	1
7/12/97	Little Zapadni	2,234	0	1	1
7/12/97	Zapadni Reef	788	0	0	0
7/11/97	Tolstoi	4,219	0	1	1
7/17/96	Gorbatch	2,852	1	1	2
7/17/96	Ardiguen	542	0	0	0
7/17/96	Reef	3,694	1	2	3
7/11/97	Kitovi	979	0	0	0
7/11/97	Lukanin	739	0	0	0
7/13/97	Polovina	486	0	0	0
7/13/97	Polovina Cliffs	3,612	0	1	1
7/13/97	Little Polovina	45	0	0	0
7/14/97	Morjovi	2,064	0	0	0
7/14/97	Vostochni	4,383	0	2	2
Total		30,406	2	9	11
Rate (%)			0.0066	0.0296	0.0362

Table 21.-- Observed incidence and rate of female entanglement on St. Paul Island based on surveys of all major rookeries.

Year	Number			Rate (%)		
	Counted	Entangled	Scarred	Entangled	Scarred	Total
1991	16009	3	7	0.019	0.044	0.062
1992	25089	3	6	0.012	0.024	0.036
1993	31638	3	11	0.009	0.035	0.044
1994	30269	7	10	0.023	0.033	0.056
1995	29109	3	8	0.010	0.028	0.038
1996	30426	4	7	0.013	0.023	0.036
1997	30406	2	9	0.007	0.029	0.036

CAN WE ESTIMATE PUP PRODUCTION AND JULY ADULT MALE NUMBERS FROM THE JUNE COUNTS OF ADULT MALE NORTHERN FUR SEALS, *Callorhinus ursinus?*

by

Rodney G. Towell and Anne E. York

INTRODUCTION

The number of adult male northern fur seals have been counted on St. Paul Island, Alaska, in July nearly annually since 1909. Estimates of pup production have been made less often. During 1912-16, pups were counted on all rookeries and in 1924, they were counted on sample rookeries. Since 1961, numbers of pups have been estimated using the shearing-sampling method (York and Kozloff 1987). When shearing-sampling estimates are not made on all rookeries, counts of breeding males made during July are important for estimating pup production and ultimately population trends. The proportion of adult breeding males contributed to the yearly total by a single rookery is closely correlated with proportion of total pups born on that rookery (Fig. 10). It is due to this relationship that we are able to use the number of adult breeding males counted in July to estimate pup production when pup counts (or estimates) are available from sample rookeries and adult male counts are available from all the rookeries. The total number of pups is estimated by multiplying the ratio of pups to adult males with females on the sampled rookeries by the total count of adult males with females (York and Kozloff 1987).

Adult males were counted in June between 1966 and 1980; for some years during that period, there were no July counts of adult males or pup production estimates (Tables 24 and 25). In this paper, we investigate the feasibility of using ratio estimates based on the June bull counts

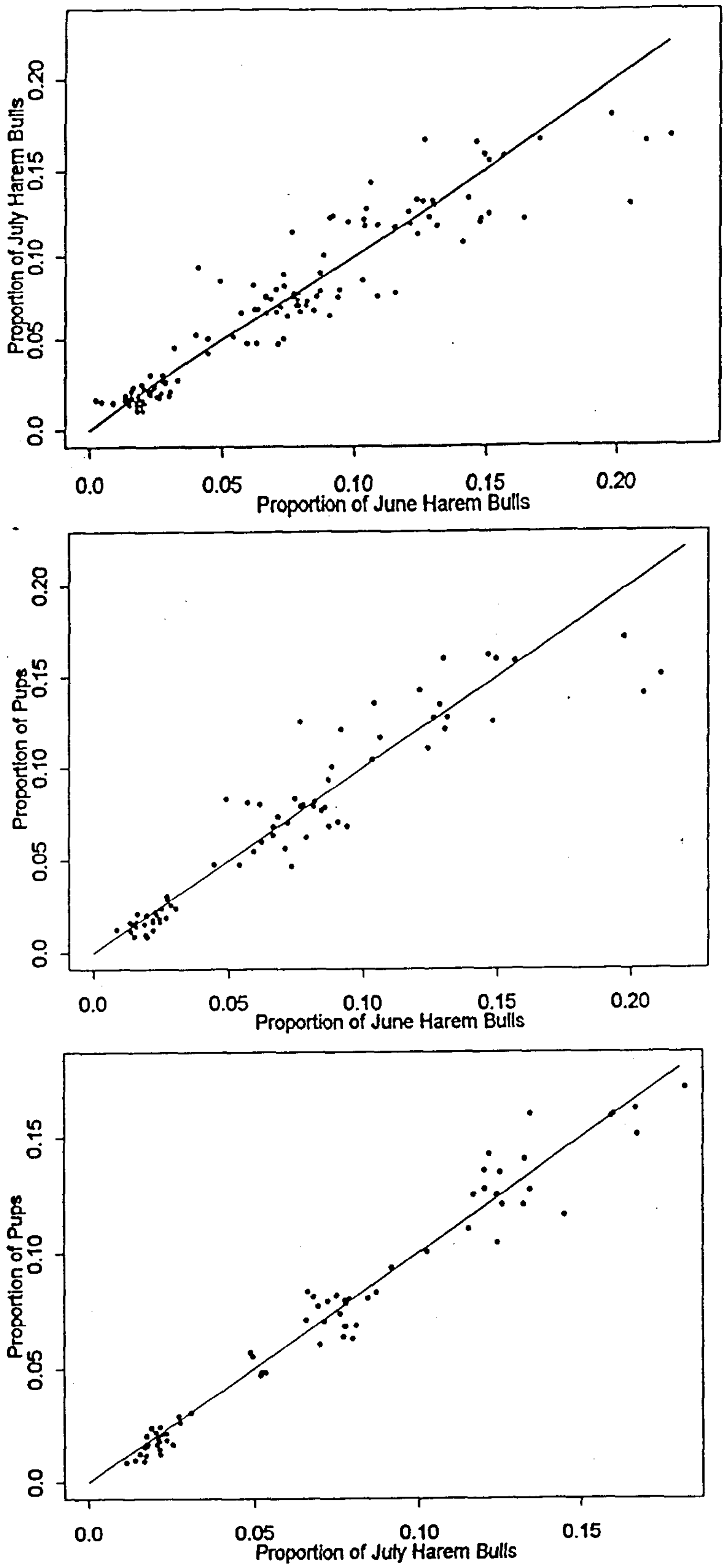

Figure l0.-The proportion contribution by each rookery to the yearly island total of June harem bulls, July harem bulls, and pup production. The superimposed line is of intercept 0 and slope of I. Plots are to illustrate the relationship of June bulls to pup production, bulls to pup production, July bulls to pup production, and June bulls to July bulls by rookery.

Table 24.--June harem adult male counts, July harem adult male counts and pup production estimates for the rookeries on St. Paul Island, Alaska. Only the years with all three counts for all rookeries are included. Rookeries are Vostochni (Vos), Tolstoi (Tol), Zapadni (Zap), Reef (Ree), Mojovi (Mor), Polovina Cliffs (Pcl), Little Zapadni (Lza), Gorbatch (Gor), Ardiguen (Ard), Lukanin (Luk), Zapadni Reef (Zar), Polovina (Pal), and Little Polovina (Lpo).

	1966			1969			1970			1975			1979		
Rookery	June	July	Pup	June	July	Pup	June	July	Pup	June	July	Pup	June	July	Pup
Large															
Vos	522	1,449	51,619	360	913	35,457	289	791	37,139	348	799	44,615	203	1,040	40,239
Tol	233	819	30,433	130	638	29,507	240	570	25,774	329	621	35,249	284	828	34,929
Zap	275	957	40,932	219	683	31,727	251	664	37,227	269	610	40,068	182	749	31,758
Ree	333	1,070	38,480	222	723	28,460	206	716	27,128	230	622	29,398	127	785	30,059
Medium															
Mor	230	645	20,852	160	423	16,213	139	352	16,512	182	376	23,049	109	498	15,741
Pcl	202	619	24,075	105	463	19,000	150	390	18,728	193	461	26,399	68	544	20,725
Lza	150	542	24,632	127	361	19,671	175	325	16,626	181	363	22,372	117	433	19,221
Kit	193	413	14,430	76	285	11,524	137	241	13,392	120	267	13,752	82	309	13,865
Gor	180	607	22,401	146	426	18,504	128	385	16,002	147	387	18,063	86	436	15,166
Small															
Ard	53	92	2,936	27	118	3,691	43	108	3,181	34	85	2,916	27	89	2,725
Luk	67	152	7,619	34	96	5,120	59	107	5,909	52	112	6,209	32	127	5,768
Zar	65	203	5,393	46	115	4,751	43	106	4,499	64	139	7,731	38	194	7,890
Pol	65	188	5,982	25	94	3,954	31	87	4,183	42	88	4,773	19	112	4,409
Lpo	73	218	9,147	28	129	5,291	43	103	4,185	31	88	3,667	12	98	3,437

Table 25.--June harem adult male counts and July harem adult male counts for the rookeries of St. Paul Island, Alaska. Listed below are the years without pup production estimates on all rookeries. Rookeries are Vostochni (Vos), Tolstoi (Tol), Zapadni (Zap), Reef (Ree), Mojovi (Mor), Polovina Cliffs (Pcl), Little Zapadni (Lza), Gorbatch (Gor), Ardiguen (Ard), Lukanin (Luk), Zapadni Reef (Zar), Polovina (Pal), and Little Polovina (Lpo).

	1976		1977		1978		1980	
Rookery	June	July	June	July	June	July	June	July
Large								
Vos	522	1,449	360	913	289	791	348	799
Tol	233	819	130	638	240	570	329	621
Zap	275	957	219	683	251	664	269	610
Ree	333	1,070	222	723	206	716	230	622
Medium								
Mor	230	645	160	423	139	352	182	376
Pcl	202	619	105	463	150	390	193	461
Lza	150	542	127	361	175	325	181	363
Kit	193	413	76	285	137	241	120	267
Gor	180	607	146	426	128	385	147	387
Small								
Ard	53	92	27	118	43	108	34	85
Luk	67	152	34	96	59	107	52	112
Zar	65	203	46	115	43	106	64	139
Pol	65	188	25	94	31	87	42	88
Lpo	73	218	28	129	43	103	31	88

to estimate the missing July bull and pup production numbers. Pup production estimates breeding male counts estimated from the June counts are compared to actual counts.

METHODS AND AVAILABLE DATA

Counts of adult males are categorized as territorial males with females (breeding males or harem males), territorial males without females and adult males on the fringes of breeding areas (Antonelis, 1992). Territorial males with females, or harem males, are the only classification of adult males used throughout the analysis. We assumed that the shear-sampling estimate of live pups was the correct or "true" number of live pups for those years in which data were available. We also assumed that the sum of the July harem adult male counts were the true number of breeding males in July when trying to estimate July harem adult male counts from June harem adult male counts. Data available for this report included counts of breeding adult males in June, breeding adult males in July, and pup production estimates on all 14 rookeries of St. Paul Island for the years 1966, 1969, 1970, 1975, and 1979 (Table 24). Also available were adult male counts in June and July for all rookeries of St. Paul Island for the years 1976, 1977, 1978, and 1980 (Table 25).

Estimating July Harem Male Counts from June Harem Male Counts

Preliminary analysis of a basic regression of July harem male counts on June harem male counts showed a strong, significant ($P < 0.01$) relationship of June to July harem males (Fig. 10), and suggested the possibility of estimating July harem male counts from June harem male counts. By testing the procedure using data from years which we have counts for all rookeries (St. Paul), we can see how well the procedure performs and potentially use the limited data from other years to estimate any missing counts in those years.

Similar to York and Kozloff 1987 and York and Towel1 1997, seven of the sampling schemes calculated using June adult breeding male counts are compared to those determined from July adult breeding male counts or to shear-sampling estimates where complete data is available. July rookeries and two estimation procedures were examined to determine how well the number of breeding males in July could be estimated from the counts of the number of breeding males in June. A simple ratio estimate was not used since there is no variance associated with the adult male counts; hence, a variance could not be calculated for the estimates (see simple ratio formula in the estimating pups born section). We investigated three schemes using random sampling (of four, five, and six rookeries) and four stratified random sampling schemes, with strata being small, medium, and large rookery classes. Two rookeries from one class and one from each of the other classes provided us with three of the stratified random sampling schemes, and the fourth used three rookeries, one from each strata. We used a sample (described above) of the harem male count data from the 14 rookeries to estimate the July male count for all rookeries on St. Paul Island. Regression and jackknife (Mosteller and Tukey 1977) estimates were compared under both simple random and stratified random sampling schemes.

For each sampling scheme, all combinations of rookeries were used to produce estimates of July harem adult males and a variance. Jackknife methods were used to calculate a ratio estimate and its variance from which the total number of breeding males on all rookeries in July is calculated. Let (B_1,B_2, . . . B_n) be the counts of breeding males in June and let (J_1,J_2, . ..J_n) be the counts of breeding males in July counted on *n* sample rookeries. Then $\bar{B}$ is the mean count of

June breeding males on n sample rookeries and $\bar{J}$ is the mean count of July breeding males on n sample rookeries. B is the total number of breeding males counted in June on all rookeries. Let r be the ratio of July breeding males to June breeding males on all the sample rookeries and r_{-i} be the ratio of July breeding males to June breeding males on all but the ith sample rookery. Then the ratio of July breeding males to June breeding males on all rookeries is

$$r_{-i} = \frac{\sum_{i=1}^{n} (n\bar{J} - J_i)}{\sum_{i=1}^{n} (n\bar{B} - B_i)}.$$

The ith psuedovalue is $r_i^* = nr - (n - l)r^{-i}$ Then the jackknife estimate of the ratio, r^*, is

$$r^* = \frac{\sum_{i=1}^{n} r_i}{n}$$

and the variance of r^* is (Mosteller and Tukey 1977):

$$Var(r^*) = \frac{\sum_{i=1}^{n} (r_i^* - r^*)^2}{n\,(n - 1)}.$$

The jackknife estimate of the total number of breeding males on all rookeries in July, T,, is

$$T_J = r^* * B, \text{ and } Var(T_J) = B^2 * Var(r^*).$$

Another estimate of the ratio of July harem adult male numbers to June harem adult male numbers is an ordinary regression estimate with no intercept. The estimate of the ratio of July to June breeding males is

$$s = \frac{\sum_{i=1}^{n} J_i B_i}{\sum_{i=1}^{n} (B_i)^2}.$$

The estimate of the variance of s is calculated from the mean square residual of the regression equation

$$Var(s) = \frac{\sum_{i=1}^{n} \left(\frac{J_i B_i}{B_i^2} - s\right)^2}{n-1}.$$

The regression estimator of the total number of breeding males in July, T_{Rg}, is

$$T_{Rg} = s * B, \text{ and } Var(T_{Rg}) = B^2 * Var(s).$$

Estimating Pups Born from June Adult Harem Male Counts.

The same sampling schemes and estimation procedures used above were investigated to estimate pup numbers from June breeding male numbers; in addition, we used a simple ratio estimate. These estimates were compared to estimates calculated from July breeding male numbers. Sampling schemes are the same as described in the section above. Ratio, regression, and jackknife estimates were compared under both simple and stratified random sampling schemes. A simple ratio estimate and a ratio estimate with jackknife methods applied were compared to regression estimates.

Again, all combinations of rookeries were used to produce an estimate for pup production and a variance. Let $(P_1, P_2, \ldots P_n)$ be the estimate of the number of pups on the *n* sample rookeries. The jackknife and regression estimates are obtained by substituting the P_is for the J_is in the formulas listed above to estimate pup production from June breeding male counts. After substituting P_is for the J_is in the formula above, substitute J_is for B_is to get the estimate of pup production from July breeding male counts. The estimate of the simple ratio of pups to June (for July use J_is in place of B_is) breeding males is

$$t = \frac{\sum_{i=1}^{n} P_i}{\sum_{i=1}^{n} (B_i)}.$$

The estimate of the variance of this ratio estimator is

$$Var(t) = \frac{\sum_{i=1}^{n} Var(P_i)}{(\sum_{i=1}^{n} B_i)^2}.$$

The ratio estimate and variance of the number of pups is then

$$T_R = B * t \text{ and } Var(T_R) = B^2 * Var(t).$$

All combinations of rookeries were evaluated for each sampling scheme and method to produce bootstrap estimates for both July adult male counts from June adult male counts, pups born from June adult male counts, and pups born from July adult male counts. Pup production from July adult male counts were included for comparison purposes. Once all estimates were calculated, a relative bias for each estimate was calculated as the value of the difference between the estimate and the "true", divided by the "true". A coefficient of variation (CV) was also calculated for each estimate as the standard error divided by the -estimate. A 95% confidence interval about the estimate was calculated as the estimate plus or minus the standard error of each estimate multiplied by the t-value at a = 0.025 and n-l degrees of freedom, where n is the number of rookeries sampled.

RESULTS

Adult Males

Plotting and the analysis of variance were used for comparing the bias of the estimate of July harem male counts from June harem male counts between method and scheme over years (Pig. 11). Yearly differences in relative bias were large and overwhelmed the effect of sampling scheme and estimation method. Estimates of July harem males from June harem males tended to be negatively biased. The median relative bias calculated from each year, method, and sampling scheme combination ranged from -15.4% to 4.7% (Pig. 11). The 25th and 75th percentile of the relative bias (for each year, method and sampling scheme combination) were between -22.9% and 23.7%, resulting in a biased estimate for July adult males. Clearly, the more rookeries sampled

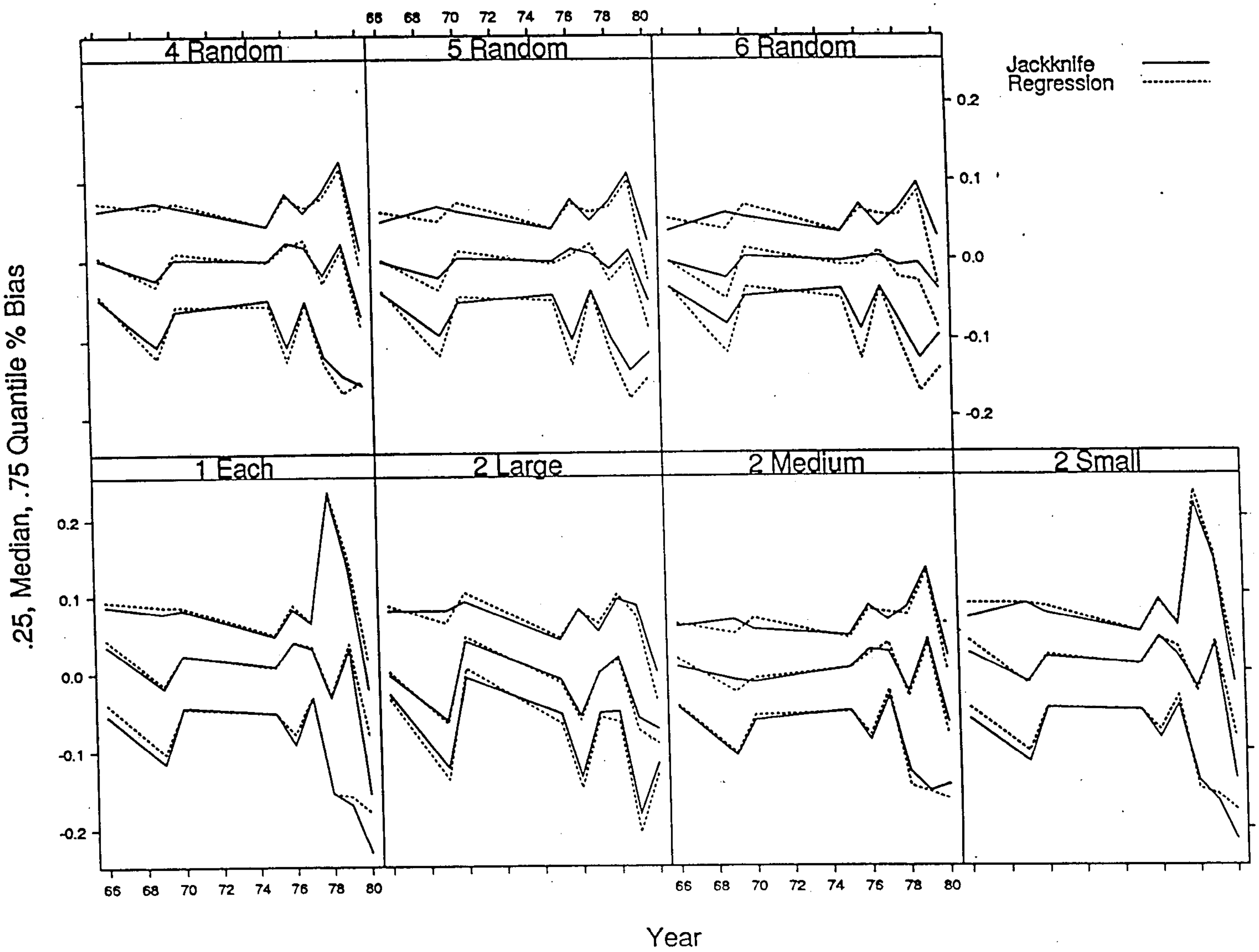

Figure 11.--The .25 quantile (lower), median (middle), and .75 quantile (upper) of the percent bias of the estimate of July harem male counts from June harem male counts by method. Each panel represents a different sampling scheme; 1 rookery from each strata, 2 large, 1 medium, and 1 small rookery, 1 large, 2 medium, and 1 small rookery; 1 large, 1 medium, and 2 small rookeries, 4 randomly sampled rookeries, 5 randomly sampled rookeries, and 6 randomly sampledrookeries.

the less the bias, but the magnitude of the bias was still substantial. There was little difference between the jackknife and regression estimates (Fig. 11).

Confidence interval coverage was also examined. A nominal 95% confidence interval was calculated for each bootstrap estimate for each year, method, and sampling scheme combination. A percentage of intervals for each year, method, and sampling scheme that contained the actual July count, was calculated. For all year and sampling scheme combinations of the jackknife method, over 90% of the bootstrap confidence intervals contained the true July count. For the regression method, less than one-third of the year and sampling scheme combinations had 90% of the bootstrap confidence intervals containing the true July harem male count.

The estimated CVs from the regression method were typically smaller than CVs from the jackknife estimates (Fig. 12). The percentage of bootstraps that had a CV of 10% or less was calculated for each year, method, and sampling scheme combination. The results were too erratic to make any generalizations about low CVs for a particular method or sampling scheme. However, the CVs were much greater for the years 1978-80. The sampling scheme of 6 random rookeries using the regression method resulted in CVs less than 14% for 75% of the cases. For all year and sampling scheme combinations, 79% or more of all regression bootstrap estimates had a CV of 20% or less.

Pup Estimates

Once all bootstrap calculations were complete, results were plotted to compare bias between methods and schemes over years and months. Pup estimate calculations from the July harem male counts were less biased than estimates calculated from June adult male counts. For estimates calculated from the July harem male counts, the 25th and 75th percentile of the relative

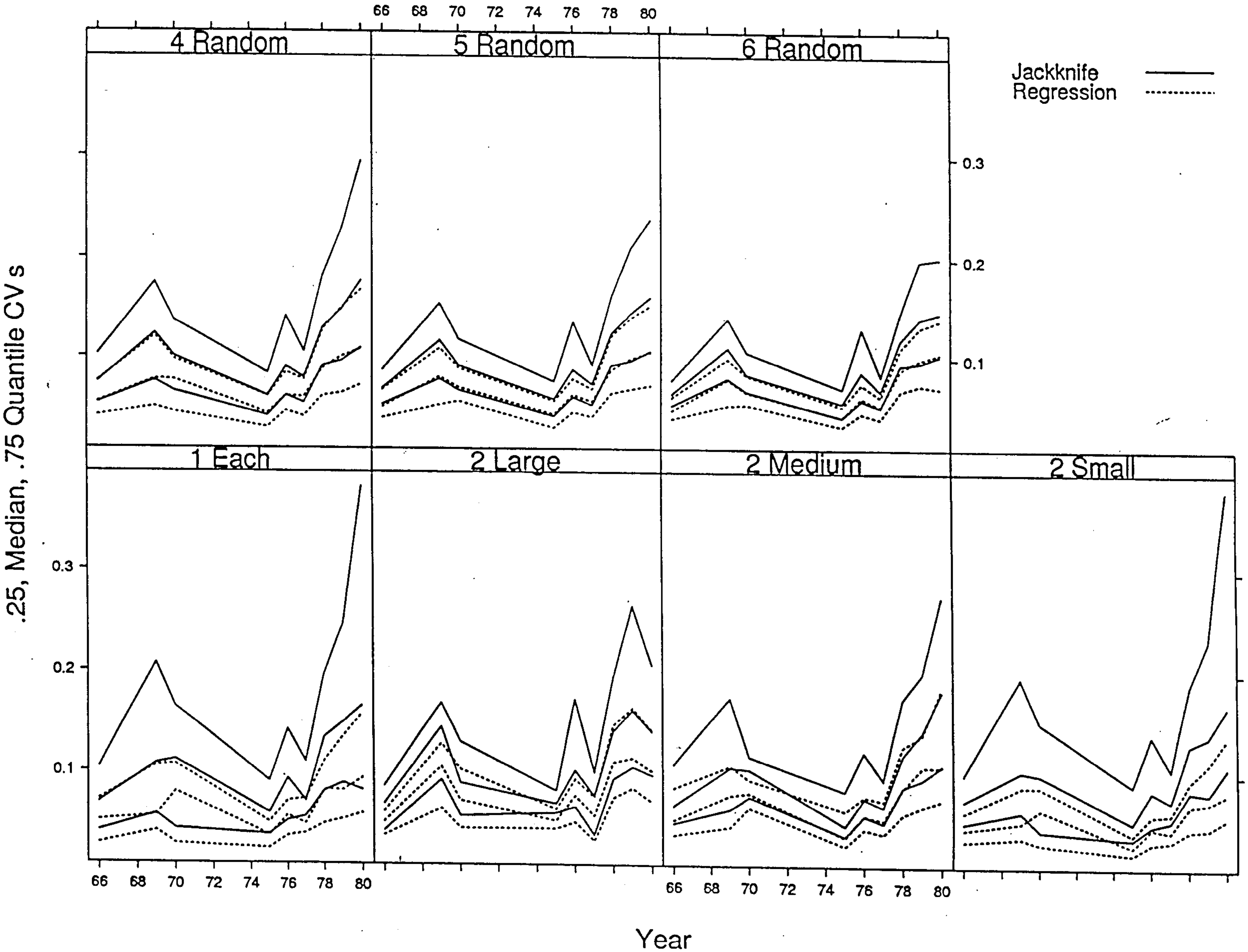

Figure 12.--The .25 quantile (lower), median (middle), and .75 quantile (upper) of the coefficient of variation (CV) for the estimate of July harem male counts from June harem male counts by method. Each panel represents a different sampling scheme; 1 rookery from each strata, 2 large, l medium, and 1 small rookery, 1 large, 2 medium, and 1 small rookery, 1 large, 1 medium, and 2 small rookeries, 4 randomly sampled rookeries, 5 randomly sampled rookeries, and 6 randomly sampled rookeries.

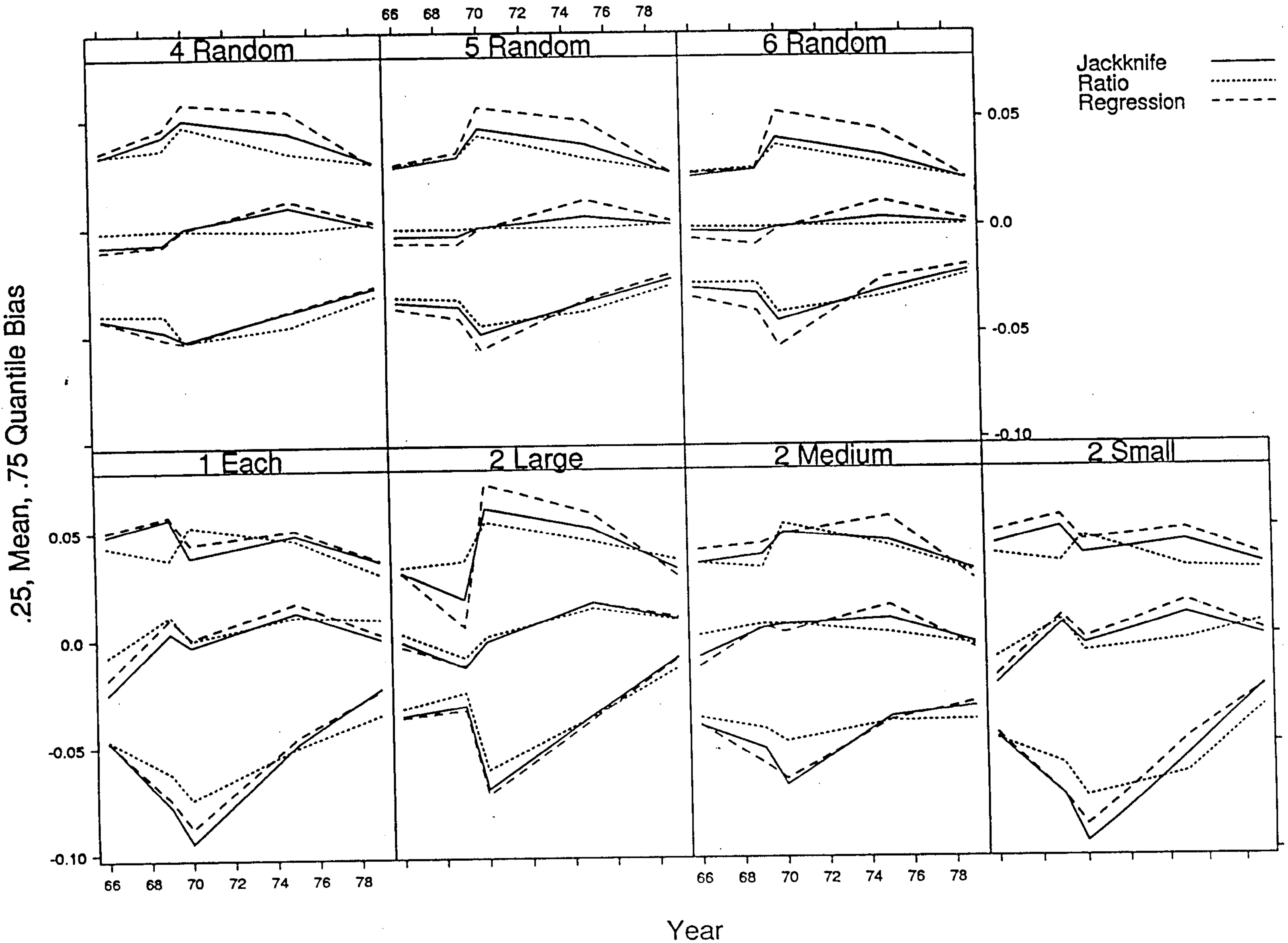

Figure 13.--The .25 quantile (lower), mean (middle), and .75 quantile (upper) of the percent bias of the estimate of pup production from July harem male counts by method. Each panel represents a different sampling scheme; 1 rookery from each strata, 2 large, 1 medium, and 1 small rookery, 1 large, 2 medium, and 1 small rookery, 1 large, 1 medium, and 2 small rookeries, 4 randomly sampled rookeries, 5 randomly sampled rookeries, and 6 randomly sampled rookeries.

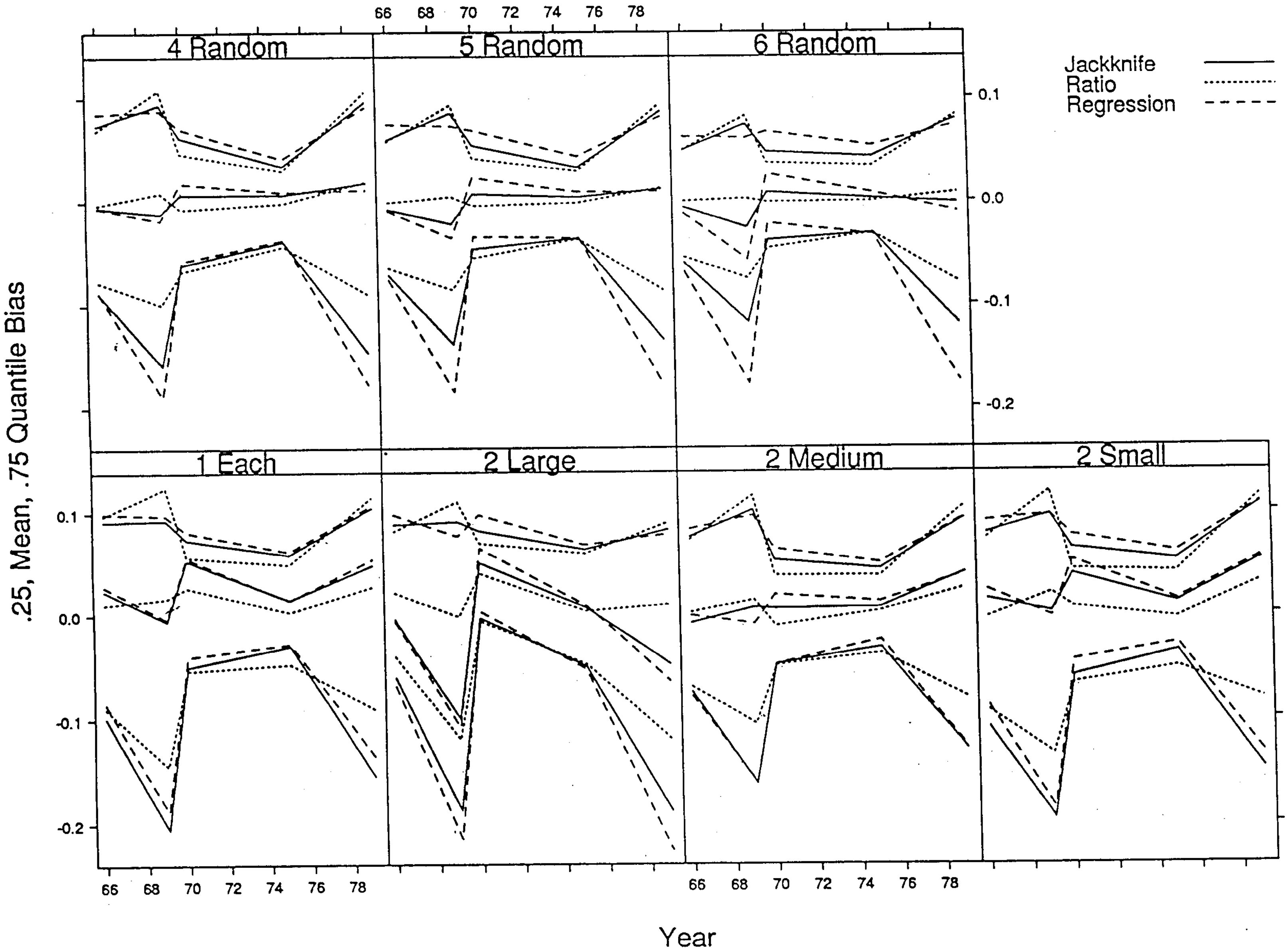

Figure 14.--The .25 quantile (lower), mean (middle), and .75 quantile (upper) of the percent bias of the estimate of pup production from June harem male counts by method. Each panel represents a different sampling scheme; 1 rookery from each strata, 2 large, 1 medium, and 1 small rookery, 1 large, 2 medium, and 1 small rookery, 1 large, 1 medium, and 2 small rookeries, 4 randomly sampled rookeries, 5 randomly sampled rookeries, and 6 randomly sampled rookeries.

bias was between -9.6% to 7.2% (Fig. 13) compared to -22.5% to 12.5% (Fig. 14) for the relative bias calculated from the estimates using June harem male counts.

The CVs of the bootstrap estimates measure the performance of the spread of the estimates of pup production relative to their size. A CV of 5% has been the standard in the pup production estimates when all rookeries of St. Paul Island were shear-sampled and can be considered an acceptable value for the pup estimate CV. Only the ratio estimates for all sampling schemes using June harem male counts and July harem male counts in 1979 produced CVs less than or equal to 5% for 87% or greater of their respective bootstraps. The July regression estimates produced CVs of 10% or less for over 94% of the bootstraps for all year and sampling scheme combinations except for the stratified sampling scheme of 2 large, 1 medium, and 1 small rookery in 1970 (which only produced CVs of 10% or less for 83% of the bootstraps). All other month and method combinations for all years and sampling schemes failed to consistently produce CVs of 10% or less. The sampling schemes that used more rookeries produced lower CVs. For example, smaller cv's resulted from using the 6 random rookeries sampling scheme than from using the 4 random rookeries sampling scheme. For the stratified sampling schemes, the 2 large, 1 medium, and 1 small rookeries scheme performed slightly better than the other stratified sampling schemes.

We also looked at the calculated 95% confidence intervals for each year, method, scheme, and month of adult male counts to determine the percentage of confidence intervals that contain the "true" estimate. Using June harem male counts, the jackknife method had greater than 90% of the confidence intervals containing the "true" estimate for all years, schemes, and methods.

Using July adult male counts the ratio method provided the best coverage with over 90% inclusion of the "true" estimate for all years, methods, and sampling schemes.

CONCLUSIONS

Estimating the number of breeding males in July from the count of breeding males in June is not likely to produce a reliable estimate. The relationship between the June and July harem male counts is not stable enough to provide an accurate estimate of harem adult males in July. The larger CVs calculated may be acceptable but the large variance and lack of confidence interval coverage are enough to give an unreliable estimate.

The use of July harem male counts for estimating pup production results in a less biased estimate with a smaller CV than the use of June harem male counts. June harem male counts produced a larger variance which counteracted the bias in the estimate when confidence intervals were calculated. The estimates of pup production from July harem male counts produced estimates with approximately half the bias and half the variance (magnitude). Estimates calculated from June harem male counts that used the ratio method provided a smaller variance but was less likely than the estimates calculated from July harem male counts to contain the "true" pup production; that is, the estimated standard errors were likely underestimated. The estimates from July harem male counts using the regression method produced, on average, smaller variances but the ratio method with its larger variance was more likely to contain the "true" estimate in the confidence interval. Jackknife estimates using July harem male counts produced CVs of less than 12% for 75% of the estimates and the confidence intervals contained the "true" estimate over 85% of the time for all year and sampling scheme combinations. A total count of harem adult males is required for the methods described to calculate pup production for all rookeries. For those years that do not have estimates for pup production on all rookeries, using the methods described above with the July harem adult male counts are better predictors than the same methods using June harem adult male counts. It is possible to estimate pup production based on pup numbers on a subsample of rookeries and adult male counts in June, but that estimate will be highly variable and of dubious quality.

POPULATION MONITORING STUDIES OF NORTHERN FUR SEALS AT SAN MIGUEL ISLAND, CALIFORNIA

by

Robert L. DeLong and Sharon R. Melin

Population monitoring studies of the northern fur seal population at San Miguel Island, California (34°0l'N, 120° 26'W) have been conducted since the discovery of the colony in 1968. In general the population has grown steadily with one severe decline probably resulting from decreased natality and increased juvenile and adult mortality during the 1982-83 El Nino (DeLong and Antonelis 1991). Since 1984, the population has grown and, in 1991, fully recovered to pre-El Nino levels (Melin and DeLong 1994). The 1992-93 El Nino conditions resulted in reduced pup production in 1992 but the population recovered in 1993 and increased in 1994 (Melin et al. 1996). In 1997, El Nino conditions became apparent in the Southern California Bight during May when increases in sea level height were recorded at the San Diego Pier by NOAA.

This paper presents the results of the 1997 population monitoring studies at San Miguel Island. The studies continued to focus on estimates of pup production, mortality, and general health of pups and survival and reproductive status of tagged animals.

METHODS

Observations and Census of Adults

Observations of territorial northern fur seals at Adams Cove, San Miguel Island, were conducted every 1 to 3 days from 24 May through 25 July 1997. Observations were conducted using a 15-60x zoom scope and 10 x 50 binoculars from two blinds overlooking the Adams Cove rookery (approximately 20 m above and 40 to 300 m horizontal distance from the breeding animals).

Live Pup Census and Pup Mortality

Live pup counts were conducted on 30 July at Adams Cove and 28 July at Castle Rock. The live pup census was conducted by two observers using binoculars and counting groups of pups. The mean number of pups was calculated from the total counts of the two observers. The standard error about the mean was calculated using the sum of the variances from the two independent counts for each group of pups. To monitor the effects of the 1997 El Nino on the fur seal cohort, several more counts of live pups were conducted at Adams Cove in late September and October.

Fur seal pup mortality surveys were conducted one or more times each month from June through September in Adams Cove. Each dead pup was counted, removed from the territory, and then stacked away from the survey area to minimize the possibility of counting the same pup twice during the season. The total dead pup count is the sum of the dead pups counted and stacked by each observer. Observed pup mortality at Castle Rock was obtained from one survey at the time of the live pup count,

Pup Tagging and Growth

A total of 154 northern fur seal pups were tagged with pink plastic roto tags in Adams Cove on 29 September. Tags with the same number were placed on both foreflippers of each pup. Each pup was sexed, weighed and measured (length and girth), and released.

Resight Effort

Efforts to resight tagged juvenile and idle adult male northern fur seals at San Miguel Island were conducted every 1 to-3 days throughout the breeding season. Resight efforts for tagged females and territorial males were conducted on 30 July and 3 August. Tagged individuals were identified by reading tags on the foreflippers using binoculars or a zoom scope. The tag numbers, association, and reproductive status (with or without pup, territorial or non-territorial) were recorded.

Investigation of the Incidence of Hookworms

Samples of nine dead fur seal pups in July and eight dead pups in October were examined for evidence of hookworm infection. The gut from each dead pup was cut open and the mucosal lining was scraped. The gut contents and scrapings were fixed in 17% formalin for examination for hookworm eggs. During tagging operations on 29 September, fecal samples were taken with a plastic fecal loop from 33 live pups and fixed in formalin. The gut and fecal samples were examined by Dr. E. T. Lyons of the University of Kentucky for presence of hookworms and eggs.

In addition, a sample of hookworms from dead northern fur seal and California sea lion pups were collected and preserved in 100% ethanol to be used for DNA studies to determine if the hookworms in these two species of pinnipeds are the same species. These analyses are being conducted by Dr. Steven Nadler at the University of California, Davis, and results will be available by the end of 1998.

RESULTS

Observations and Census of Adults

Territorial northern fur seal males arrived before 24 May and the highest number of territorial males with females, 142, was recorded on 2 July. An additional 108 males held territories without females on the same date. The number of territorial males continues to increase (up 33.5% from 1996) and consequently, territories are extending westward beyond the border of Adams Cove into South Cove.

Live Pup Census and Pup Mortality

The mean count of live fur seal pups was 1,765 (SE = 1.20) at Adams Cove on 30 July and 940 (SE = 0.40) live pups at Castle Rock on 28 July. The total number of dead pups at the time of survey was 368 in Adams Cove and 5 1 on Castle Rock. The total observed production was 2,133 pups in Adams Cove and 991 pups on Castle Rock. Additional mortality of 488 pups occurred in Adams Cove tier the live pup survey resulting in a 40.1% observed mortality rate for the 1997 breeding season. This mortality rate was considerably higher than rates observed in recent years (Melin and DeLong 1997, Melin et al. 1996). Based upon several counts of live pups in Adams Cove conducted in late September and early October, it appeared there were fewer than 500 pups remaining alive on the island; thus, it is possible that pup mortality reached at least 75% by early October.

Pup Weights

Pups are weighed each year at the end of September when pups are about 4 months old. The mean weight of male (6.3 kg) fur seal pups in 1997 was significantly lower than the weight of males in 1996 (11.8 kg) (ANOVA; $P < 0.000$). The mean weight of female pups (5.9 kg) was significantly lighter than females in 1996 (10.6 kg) (ANOVA; $P < = 0.000$).

Resight Effort

Fifty-three (53) adult female and 60 male flipper-tagged individuals were identified throughout the season. The age groups of females ranged from 2 to 18 years (Table 26). Because of the difficulty sighting tagged, breeding animals, age-specific natality could not be estimated; however resighted females with pups ranged from 5 to 12 years of age. Tagged males ranged from 2 to 9 years of age and tagged territorial males were 7-9 years old.

Table 26.--Number of tagged northern fur seals sighted at Adams Cove, San Miguel Island, California, from May through August 1997.

	Females			Males		
Cohort	Number tagged	Number sighted	Percent sighted	Number tagged	Number sighted	Percent sighted
1979	52	1	1.9	157	---	---
1985	43	4	9.3	56	---	---
1986	51	2	3.9	48	---	---
1987	56	2	3.4	43	---	---
1988	192	9	4.7	195	2	1.0
1989	159	13	8.2	195	9	4.6
1990	85	5	5.9	114	7	6.1
1991	158	10	6.3	143	8	5.6
1992	163	2	1.2	136	3	2.2
1993	146	3	2.1	153	21	13.7
1994	144	2	1.4	156	9	5.8
1995	132	---	---	168	1	0.5

Incidence of Hookworms in pups

All dead fur seal pups examined in July had hookworm infections as evidenced by petichial hemorrages in the small intestines. However, fecal samples collected from 33 live fur seal pups on 29 September were all negative for hookworm eggs. Samples of small intestine and the ileo-cecal junction of the small and large intestine from eight dead northern fur seal pups collected between 1 and 9 October were also negative for hookworms.

DISCUSSION

The number of territorial bulls increased from 162 bulls in 1996 to 250 in 1997, indicating that new males continue to be recruited into the breeding population. The expansion of breeding territories into South Cove brings fur seals into direct competition with California sea lions for rookery space. South Cove is one of the preferred pupping and breeding sites for sea lions, so competition will likely lead to the exclusion of one of the two species from portions of this area if the fur seal population increases in future years.

The increase in pup production in Adams Cove indicates growth of the population. However, it was apparent by late July that pups were not growing and mortality was increasing. The emaciated state of most pups at the end of September suggests insufficient milk transfer from females to their pups. During the 1982-83 El Niño, it was hypothesized that changes in food availability associated with oceanographic changes due to the El Niño conditions along the California coast resulted in reduced milk production by female California sea lion and northern fur seal females at San Miguel Island (Costa et al. 1991, DeLong and Antonelis 199 1) which in turn resulted in higher pup mortality and lower weights of surviving pups at 3 months of age. In 1997, northern fur seal females did not appear emaciated themselves but may have had difficulty obtaining enough food energy to produce sufficient milk for their pups. The average weights of pups at about 3 months of age were within 1 kg of birth weights and were lighter than pups of similar age during the 1983 El Niño (DeLong and Antonelis 1991).

All dead pups examined during July had hookworm infections in the intestines. By 1 October the fecal and intestine samples were free of hookworm eggs and adults. We conclude that adult hookworms had completed their life cycle and all fur seal pups were free of hookworms by 1 October. This is consistent with what is known about hookworms in fur seals in the Pribilof Islands where adult hookworms are reported to live for 6 weeks in pups and thereafter not be present in the intestines of pups (Olsen and Lyons 1965). In contrast to this pattern in fur seals, hookworms were present in a high proportion (74%) of fecal samples from California sea lions collected on 25 September at San Miguel Island and were present in all five intestines sampled in October 1997. Thus, the hookworms and the infections appear to persist for longer periods of time in sea lions than in northern fur seals, suggesting that the hookworms in sea lions and fur seals may be different species.

El Niño conditions and disease appear to be important factors influencing the growth of the San Miguel Island fur seal population. Although the number of pups born reached a historical high in 1997, the observed high pup mortality indicates the 1997 El Niño will cause almost total mortality of the 1997 cohort. The high pup mortality also suggests that northern fur seal females were nutritionally stressed during the breeding season. If females remain nutritionally stressed after the breeding season, they may experience high mortality or decreased pup production in 1998. Thus, it is probable that the 1997 El Niño impacts will be multi-year in nature. Total mortality of the 1997 cohort will result in slowed recruitment in the future and if substantial adult female mortality occurs, a pattern of slow recovery of the population, similar to that observed after the 1983 El Niño, will likely occur (DeLong and Antonelis 1991).

BOGOSLOF ISLAND STUDIES, 1997

by

Rolf R. Ream, Jason D. Baker, and Rodney G. Towell

Northern fur seal studies were conducted on Bogoslof Island, Alaska, from 4 to 23 September 1997 to assess the rapid growth of the population. Pup production estimates and a census of non-pup northern fur seals were obtained. Female foraging was investigated through the use of satellite telemetry, time-depth recorders, and enema and scat collections. Preliminary information on female foraging trips during September 1997 are presented. Additionally, information on northern fur seal entanglement in marine debris, observations of other species, and a brief summary of tufted puffin *(Fratercula cirrhata)* food habits data collected for the U.S. Fish and Wildlife Service (USFWS) is discussed.

Population Assessment

Number of Northern Fur Seal Puns Born on Bogoslof Island, 1997

In the past, pup production on Bogoslof Island has been assessed by walking through or next to the rookeries and counting the number of pups directly. As the numbers of pups born has increased, direct counts have become more difficult, and methods of estimation are necessary. The number of pups born on Bogoslof Island in 1997 was assessed by adding the number of dead pups counted to the number of live pups estimated using the "shearing-sampling" (mark/recapture) method (Chapman and Johnson 1968, York and Kozloff 1987, York and Towel1 1996) currently used in pup production estimates on the Pribilof Islands, Alaska.

A total of 291 pups were shear-marked from 4 to 5 September, representing greater than

20% of the number of pups counted in 1995 (Towel1 and Strick, 1997). Shear marks were distributed in three rookery areas defined as East, Northwest, and Southwest, based on the relative abundance of pups in each area. The shear-marks were distributed throughout the rookeries such that each pup had about the same chance of being marked. The percentage of pups shear-marked differed from the approximately 10% typically used on the Pribilof Islands because the Bogoslof Island population appeared to have changed dramatically in number since the 1995 census. Shear-mark allocation also differed from the methods used on the Pribilof Islands because of an absence of harem male counts. Counts of dead pups were obtained during pup shearing.

After a few days to allow mixing, the ratio of marked to unmarked pups was determined by two researchers. Each researcher sampled the entire island on two occasions: from 7 to 9 September and from 12 to 13 September. The estimate of the number of pups alive at the time of marking and the standard error was calculated for each rookery area. The proportion of marked to unmarked pups observed by each researcher was averaged and then multiplied by the number of pups sheared to calculate an estimate of the number of live pups for each sampling occasion. The mean of the estimates from each sampling occasion determined the final live-pup estimate for each rookery area.

Pup production is the most reliable indicator of population trends because, at any moment, a portion of the adults and juveniles are at sea. Pup counts on Bogoslof Island have been made on an opportunistic basis since 1980, when evidence of pups on the island was first recorded (Lloyd et al. 1981). The rate of growth of the pup population (including immigration) from 1980 to 1997, and from 1988 to 1997, was determined by compiling previous pup estimates for Bogoslof Island, and regressing the natural logarithm of pup number on year.

A summary by rookery of the numbers of pups sheared, the estimates of pups alive at the time of marking from two sampling occasions, the estimated mean number of pups alive at the time of marking, the standard error of the estimate, number of dead pups counted, and the total number of pups born on Bogoslof Island is given in Table 27. The estimate for the total number of pups alive at the time of marking was 5,055 (SE = 32.6). The total number of dead pups was 41 and the mortality rate for the island was 0.8%. The total number of pups born on Bogoslof Island in 1997 and the approximate 95% confidence interval was 5,096 + (3.182 x 32.6), or 5,096 + 104. The last count of northern fur seal pups on Bogoslof Island was in 1995, and yielded 1,272 pups. The 1997 estimate represents a 300.6% increase in the number of pups over the 1995 count.

Since the first evidence of pup production on Bogoslof Island in 1980, the pup population has grown at a rate of 59% per year (R^2 = 0.98l), including immigration (Fig. 15). At the 95% confidence interval, the population has grown at a rate between 53% to 66% per year. Loughlin and Miller (1989) reported a similar rate of pup growth of 57% per year from 1980 to 1988. They stated that it was unlikely that pup production would continue at such a high rate without a continued high level of immigration. Since that time, from 1988 to 1997, the number of pups on Bogoslof Island has grown at a rate of 58% per year (R^2 = 0.975), and must be greatly influenced by immigration.

Table 27.--Number of northern fur seal pups sheared, number of pups estimated to be alive at the time of marking (El and E2), mean number alive, standard error of the mean (SE), number of dead pups, and total number of pups born, Bogoslof Island, Alaska, 1997.

Rookery	Sheared pups	E1	E2	Pups alive at marking	SE	Dead pups	Total pups born
East	60	926	947	937	10.5	4	941
Northwest	173	3439	3493	3466	27.0	28	3494
Southwest	58	667	637	652	15.0	9	661
Island Total	291	5032	5077	5055	32.6	41	5096

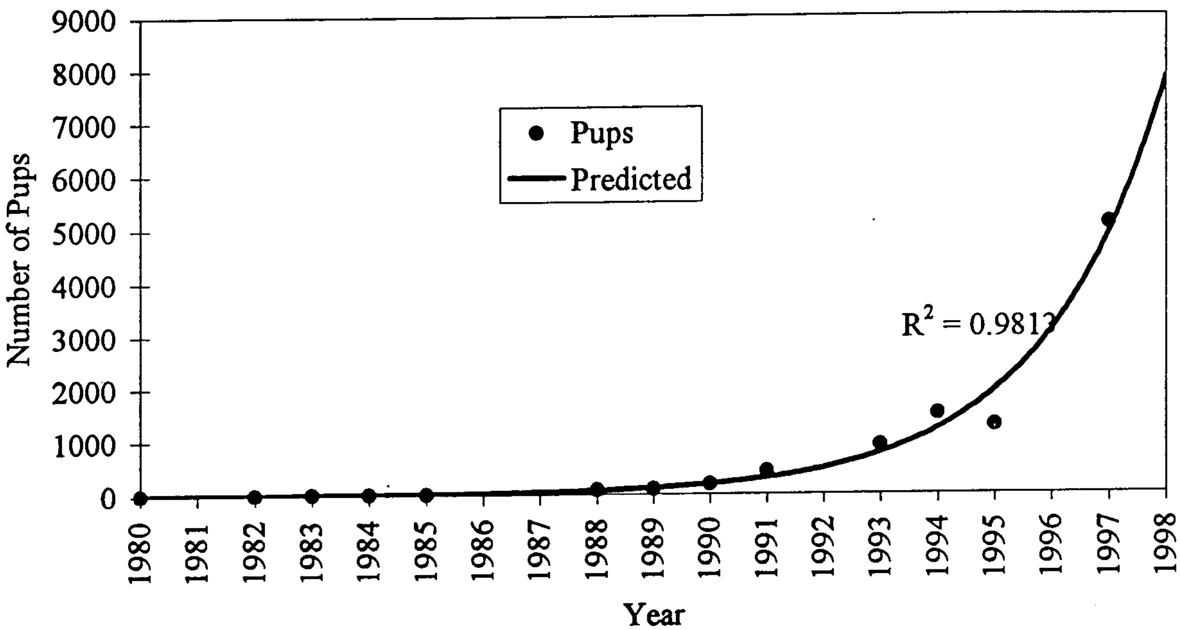

Figure 15 .--The number of pups observed on Bogoslof Island 1980- 1987.

Number of Non-Pup and Total Number of Northern Fur Seals on Bogoslof Island in 1997

An island-wide census of non-pup (1 year of age or older) northern fur seals was conducted on 20 September. Counts were made while walking on the periphery of rookeries and haulouts, and from strategic vantage points on the hillside above the animals. Counts were made by two researchers and averaged. Two estimates of the total Bogoslof Island northern fur seal population were made. The first was simply the sum of the pup production estimate and the non-pup census, and therefore did not account for adults and juveniles at sea. The second estimate used the life table reported by Lander (198 1) adjusted to remove harvest mortality of males (Laughlin et al. 1994).

The number of non-pup northern fur seals counted on Bogoslof Island in 1997 was 13,751 (SE = 541.5). This count represents a 272.6% increase over the last count of 3,691 in 1994. Adding the non-pup count to the estimate of pup production yielded a total Bogoslof Island population size of 18,847 (SE = 542.5). Use of the life table increased the total population estimate to 22,803 northern fur seals. The number of pups, number of non-pups, and two estimates of total population on Bogoslof Island are plotted from 1980 to 1997 in Figure 16.

Female Northern Fur Seal Foraging Studies

Northern fur seal foraging studies were conducted from 8 to 23 September. Female fur seals were captured in nets and placed on a restraint board where they were weighed, measured, fitted with radio transmitters and time-depth recorders (TDR Mk7, Wildlife Computers, Redmond, WA 98052), and released. The first six females captured also were fitted with satellite transmitters. Females were recaptured when radio telemetry presence/absence data indicated the animal had either 1) returned from a multiple-day foraging trip or 2) made multiple

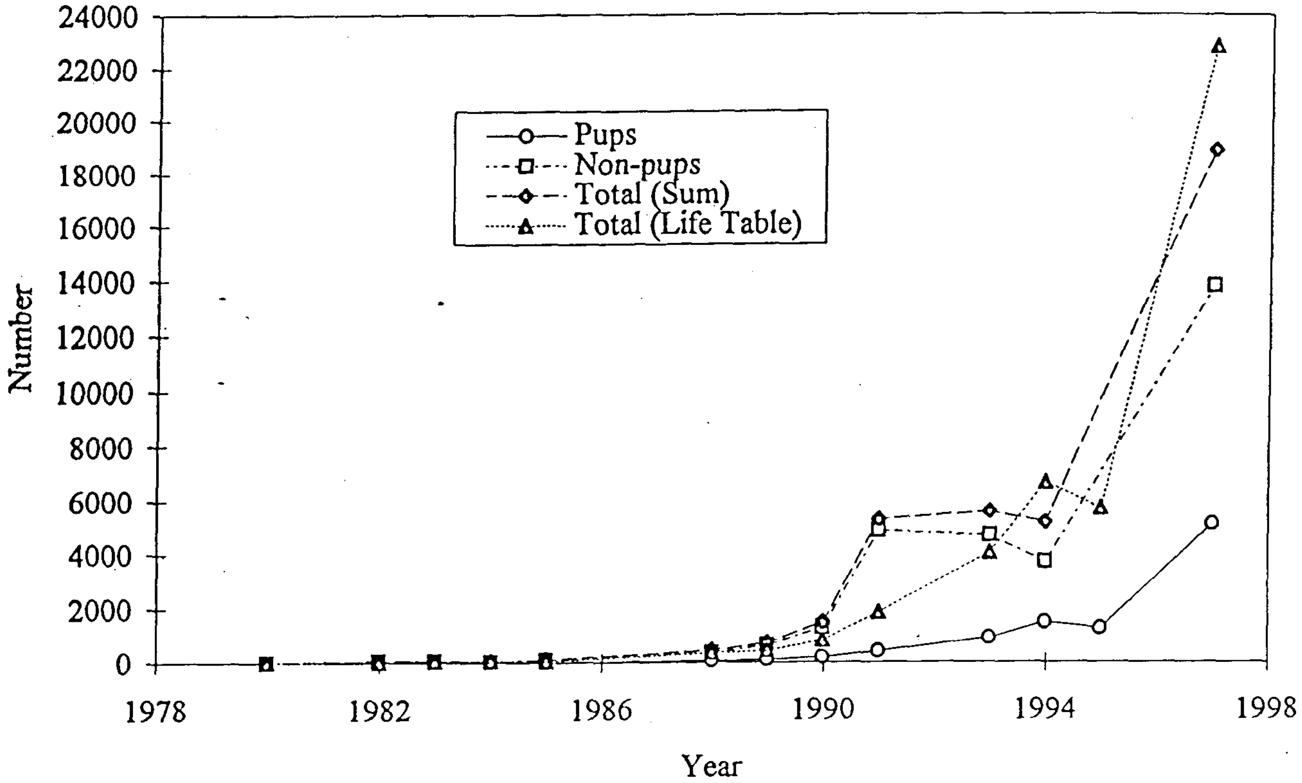

Figure I6.-Number of pups, number of non-pups, total population size (sum), and total population size using life table of Lander (1981), adjusted for lack of harvest mortality, for Bogoslof Island.

foraging trips. The female northern fur seals were weighed and measured again, the instruments were removed, and an enema was given if the female had not defecated during holding.

Preliminary information indicated that female northern fir seals with pups on Bogoslof Island tended to feed close to the island (Fig. 17). Only one female traveled more than 75 km from the island, based on positions recorded using satellite transmitters (cycling at 4 hours on, 4 hours off) on six female fur seals. Positions recorded for three of the six females did not exceed a distance of 22 km from the island. The average of the maximum distance traveled by the females was 51.2 km. Based on radio telemetry data, foraging trips were of relatively short duration. Three of the 10 females with radio transmitters were never absent for more than 24 hours, 8 females appeared to have made overnight foraging trips, and the maximum duration that a female northern fur seal was absent from Bogoslof Island was 4 days.

Foraging trips of female fur seals on Bogoslof Island were shorter in distance and duration than foraging trips of females on the Pribilof Islands. Data received from 6 females, fitted with instruments on St. Paul Island during August 1998, indicated that all foraging trips lasted more than 5 days. Foraging trip distances exceeded 190 km from the island for all of these females. The preliminary results of female foraging studies at Bogoslof Island are consistent with predictions based on the physical and biological environment surrounding the island (Antonelis et al. 1997); Bogoslof Island has a compressed neritic zone and probably little separation between frontal systems.

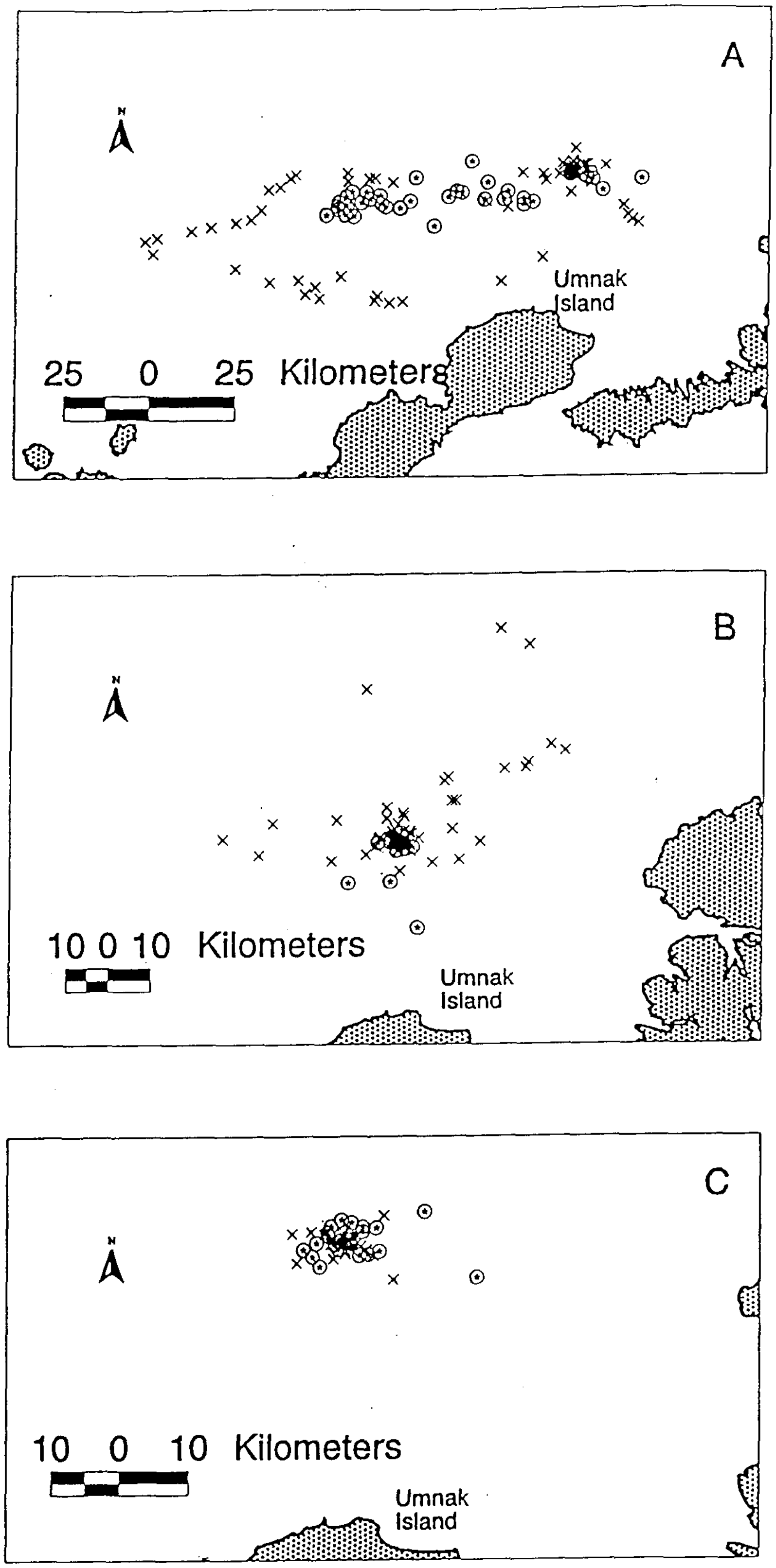

Figure 17.-At-sea locations of female fur seals instrumented on Bogoslof Island, 1997. Each plot (A, B, and C) represents locations of two females (x and ⊛)

Other Research and Observations

Northern Fur Seal Entanglement in Marine Debris

Northern fur seals observed entangled in marine debris were captured and the debris removed during research activities conducted on Bogoslof Island in 1997. The number, sex, and approximate age of seals disentangled, and the type of debris, were recorded.

From 4 to 21 September, 17 fur seals were captured and disentangled: 15 were males and 2 were young females. Trawl net, found on 64.7% (n = 11) of the captured seals was the most common type of debris removed from the seals. Packing bands (n = 2), plastic rings (n = 2), and rope/twine were the other types of debris removed from fur seals on Bogoslof Island.

Tufted Puffin Food Habits

Because of the success of the northern fur seal population on Bogoslof Island in recent years, and our lack of understanding of the ecology in the marine environment surrounding the island, it is important to document information that may provide insight into future northern fur seal research on Bogoslof Island. During September 1997, a high frequency of puffins returning to the island appeared to have prey. Additionally, puffins were observed diving just outside the kelp bed offshore. Tufted puffin food habits data were collected on 11, 18, and 20 September. Screens were placed in the mouths of burrows and left for 3-6 hours. Burrows were then checked, any prey items deposited were typed, counted, and measured and the screens were removed. Prey was identified as either sablefish *(Anoplopoma fimbria)* or rock greenling *(Hexugrammos lagocephalus).*[1]

Observations of Other Species

A single sea otter *(Enhydra lutris)* was observed on multiple occasions and locations just offshore of Bogoslof Island. Five harbor seals *(Phoca vitulina)* hauled-out on the east side of the island near the sand spit on *20* September. Killer whales *(0rcinus orca)* were observed cruising the shoreline on 8 September (n = 3), and 17 September (n = 4). Three large cetaceans, believed to be fin whales *(Balaenoptera physalus)*, were observed on 2 September, and 5 + 2 unidentified large cetaceans were observed on 13 September. Two peregrine falcons were seen throughout the month, sometimes chasing other birds; one falcon was observed successfully predating on a kittiwake chick. Other less commonly sighted birds on Bogoslof Island were ravens and a bald eagle.

‘More detailed information regarding methods and data should be requested through G.V. Byrd, USFWS, Homer, Alaska.

ACKNOWLEDGMENTS

The fur seal research team extends its special thanks to the communities of St. George Island and St. Paul Island who so continuously support our research efforts. We are especially appreciative of the participation of youth from the stewardship programs which have become increasingly integral to our field work. The bulk of our work would not be possible without the assistance of the numerous volunteers and contract employees from affiliated universities and institutions (see Appendix C), or without financial support from Marine Mammal Protection Act funds. The quality of this published version of our work was greatly improved by Gary Duker and James Lee, technical editors at the Alaska Fisheries Science Center (AFSC). The frontispiece is the eighth in a series illustrated by AFSC graphic artist Katherine Zecca for the annual *Fur Seal Investigations* reports.

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APPENDIX A

Glossary

The following terms used in fur seal research and management on the Pribilof Islands, Bogoslof Island, San Miguel Island, and Castle Rock have special meanings or are not readily found in standard dictionaries.

Bachelor	Young male seals of age 2-5 years.

Classifications of adult male fur seals

Class 1 (shoreline)	Full-grown males apparently attached to "territories" spaced along the water's edge at intervals of l0-15 m. Most of these animals are wet or partly wet, and some acquire harems of one to four females between 10 and 20 July. They would then be called harem males (Class 3). Class 1 males should not be confused with Class 2 animals, which have definite territories, whereas the shoreline males appear to be attached to such sites but may not be in all cases.
Class 2 (territorial without females)	Full-grown males that have no females, but are actively defending territories. Most of these animals are located on the inland fringe of a rookery: some are between Class 1 (shoreline) and Class 3 (territorial with females) males, and a few are completely surrounded by Class 3 males and their harems.
Class 3 (territorial with females)	Full-grown males actively defending territories and females. Most Class 3 males and their harems combine to form a compact mass of animals. Isolated individuals, usually with small harems, may be observed at each end of a rookery, on sandy beaches, and in corridors leading to inland hauling grounds. Some territorial males have as few as one or two females. Should these females be absent during the counts, their pups are used as a basis for putting the adult male into Class 3 rather than Class 2.

Class 4 (back fringe)	Full- and partly grown males on the inland fringe of a rookery. A few animals too young and too small to include in the count may be found here. Though some Class 4 males may appear to be holding territories, most will flee when approached or when prodded with a pole.
Class 5 (hauling ground)	The hauling grounds contain males from May to late July and a mixture of males and females from then on. The counts include males that obviously are adults and all others that have a mane and the body conformation of an adult. Males included in this count are approximately 7 years of age and older. Prior to 1966, Class 3 males were called harem bulls, and Classes 1,2,4, and 5 were collectively called idle bulls. From 1966 through 1974, the adult male seals were classified into five groups (Classes 1, 2, 3, 4, and 5). Beginning in 1975, Classes 1 and 2 were combined and designated as Class 2, Class 3 remained the same, and Classes 4 and 5 were combined and designated as Class 5.
Drive	The act of surrounding and moving groups of seals from one location to another.
Hauling ground	An area, usually near a rookery, on which nonbreeding seals congregate. See Rookery.
Haul out	The act of seals moving from the sea onto shore at either a rookery or hauling ground.
Kleptogyny	The act of an adult male seal (primarily Classes 1, 2, or 3) seizing an adult female from another male's territory.
Known-age	Refers to a seal whose age is known because the animal bears an inscribed tag or other type of mark.

Marked	Describes a seal that has been marked by attaching an inscribed metal *or* plastic tag to one or more of its flippers, by hair clipping, or by bleaching.
Mark recoveries	Recovery (sighting) of a seal that has been marked by one of several methods. See marked.
Rookery	An area on which breeding seals congregate. See Hauling ground.
Roundup	Biologists surround and herd juvenile male fur seals close to the location they haul out.
Vibrissae (facial whiskers)	To determine the relative age structure of females in a population, the color of their whiskers are used. Facial vibrissae are black at birth and remain black through age 3 years; become mixed (black and white) at ages 4 and 5 years; and by age 7 years, the vibrissae usually are entirely white.

APPENDIX B

Scientific staff engaged in northern fur seal
field research in 1997

National Marine Mammal Laboratory
Howard W. Braham, Director
Thomas R. Loughlin, Leader, Alaska Ecosystem Program
Jason D. Baker, Northern Fur Seal Program

Name	Affiliation
Employees	NMML
Jason Baker	NMML
Robert Caruso	NMML
Robert Delong	NMML
Charles Fowler	NMML
Sharon Melin	NMML
Rolf Ream	NMML
Bruce Robson	NMML
Elizabeth Sinclair	NMML
Rod Towell	NMML
Anne York	NMML
Research Associates and Cooperators	
Aquilina Lestenkof Bourdukofsky	PISP
Benny	PISP
David Cormany	NMFSJ
Eric Galaktionoff	PISP
Chris Gburski	IND
Henry Hanson	TGSP

Appendix B .-- continued.

Name	Affiliation
John Hapoff	PISP
Karen Holzer	PISP
Steve Insley	SI
Gilbert Kashavarof	TGSG
Masashi Kiyota	NRIFSF
Joseph Kozloff	PISP
Carolyn Kurle	IND
Shawn Lekanof	CSG
Dimitri Lestenkof	CSG
Eugene Lyons	UK
Maxim Malavansky	CSG
Victor Malavansky	CSG
Mariamna Melovidov	NMFS
Robert Melovidov	TGSP
Grace Merculief	CSG
Marissa Merculief	PISP
Stacy Merculief	PISP
Isiah Shabolin	CSG
Denise Spraker	WPI
Terry Spraker	WPI
Nicolai Deon Zacharof	TGSP

Appendix B.-- continued

Affiliation Code

CSG - City of St. George, St. George Island, Alaska
CSP - City of St. Paul, St. Paul Island, Alaska
IND - Independent
NMFS - NMFS
NMFSJ - National Marine Fisheries Service Regional Office, Juneau, Alaska
NRIFSF - National Research Institute of Far Seas Fisheries, Shimizu, Japan
PISP - Pribilof Island Stewardship Program
SI - Smithsonian Institution, Washington, D.C.
TGSG - Tribal Government of St. George, St. George Island, Alaska
TGSP - Tribal Government of St. Paul, St. Paul Island, Alaska
UK - University of Kentucky
USFWS - U.S. Fish and Wildlife Service
WPI - Wildlife Pathology International

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