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Fur Seal Investigations, 1996

by
E. H. Sinclair (editor)

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
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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 in the eastern Bering Sea and San Miguel Island located off the coast of California. The Pribilof Islands (St. Paul and St. George Islands) are home to approximately 800,000 northern fur seals - 90% of the world population.

Population parameters monitored in 1996 on the Pribilof Islands included direct counts of adult males (14,882 on St. Paul Island; 2,038 on St. George Island), and mark-recapture estimates of the number of pups born (170,125 on St. Paul; 27,385 on St. George). Counts of dead fur seals of all ages were incorporated into population estimates. The estimated number of pups born on St. Paul Island in 1996 was not significantly different from our 1990, 1992, or 1994 estimates. The 1996 estimate of pups born on St. George Island is significantly higher than 1992 (25,160) or 1994 (22,244) estimates. The 1996 estimate of number of pups born on St. George Island is the highest since 1985 when over 28,000 pups were born.

The patterns of fur seal entanglement in marine debris has been monitored annually on the Pribilofs. Similar to previous years, entangling debris in 1996 consisted primarily of pieces of trawl net, plastic packing bands, and loops of synthetic or natural twine. For the second year in a row, entanglement in packing bands was more prevalent on St. Paul Island (44.6%) than St. George Island (26.7%) for all age groups combined. No significant difference in overall entanglement was observed between the islands; however, juvenile male seals had a significantly higher rate of entanglement than adult male seals on both islands. The rate of entanglement for juvenile males was 0.23% on St. Paul Island and 0.21% on St. George Island relative to 0.14% and 0.06% for adult seals on St. Paul and St. George Islands, respectively. Female fur seals had

very low rates of entanglement relative to males. Female entanglement on St. Paul Island in 1996 (0.013%) was comparable to rates observed in 1992, 1993, and 1995.

Population monitoring studies of northern fur seals on San Miguel Island were based on direct counts of live and dead pups. A total of 2,009 pups were counted in Adams Cove in 1996, representing a 20.6% increase from 1995 counts. The number of territorial bulls increased from 104 in 1995 to 162 in 1996, indicating that new males continue to be recruited into the breeding population.

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INTRODUCTION

by

Elizabeth H. Sinclair

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 800,000 animals is the largest among U.S. rookeries (Figs. l-3) and comprises roughly 80% 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 level (OSP). 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 1996 was conducted under Marine Mammal Permit number 837.

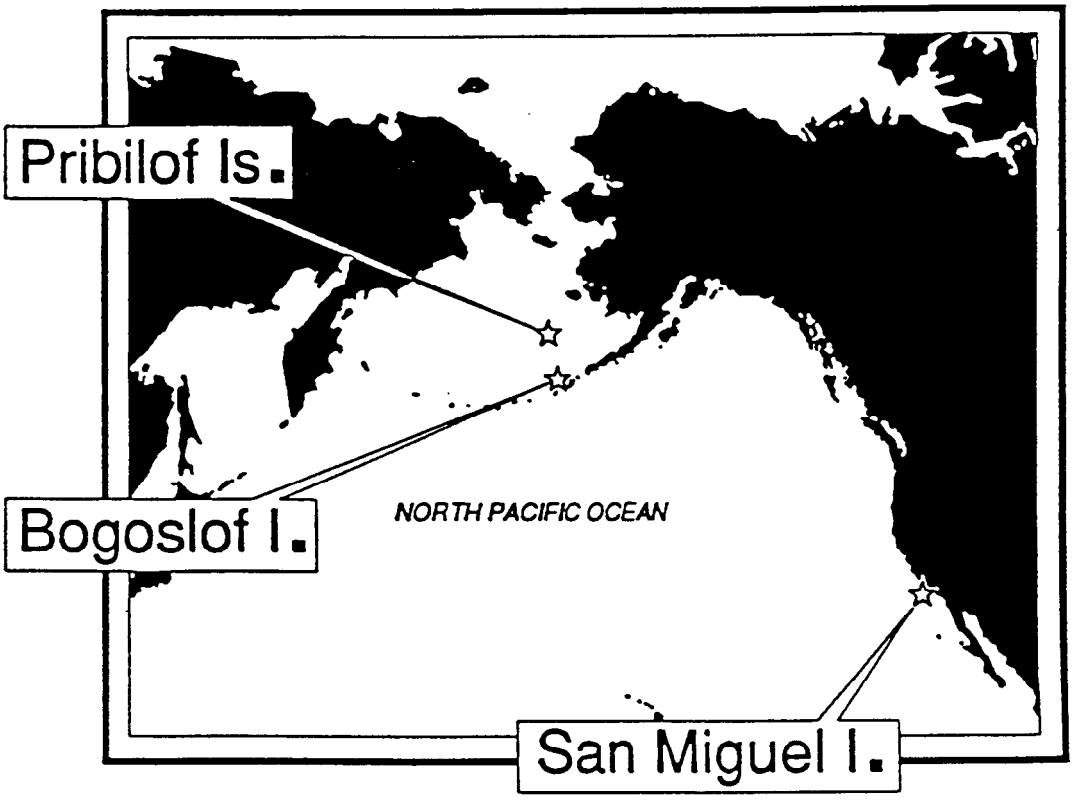

Figure l.--Location of the four northern fur seal breeding rookeries within U.S. waters.

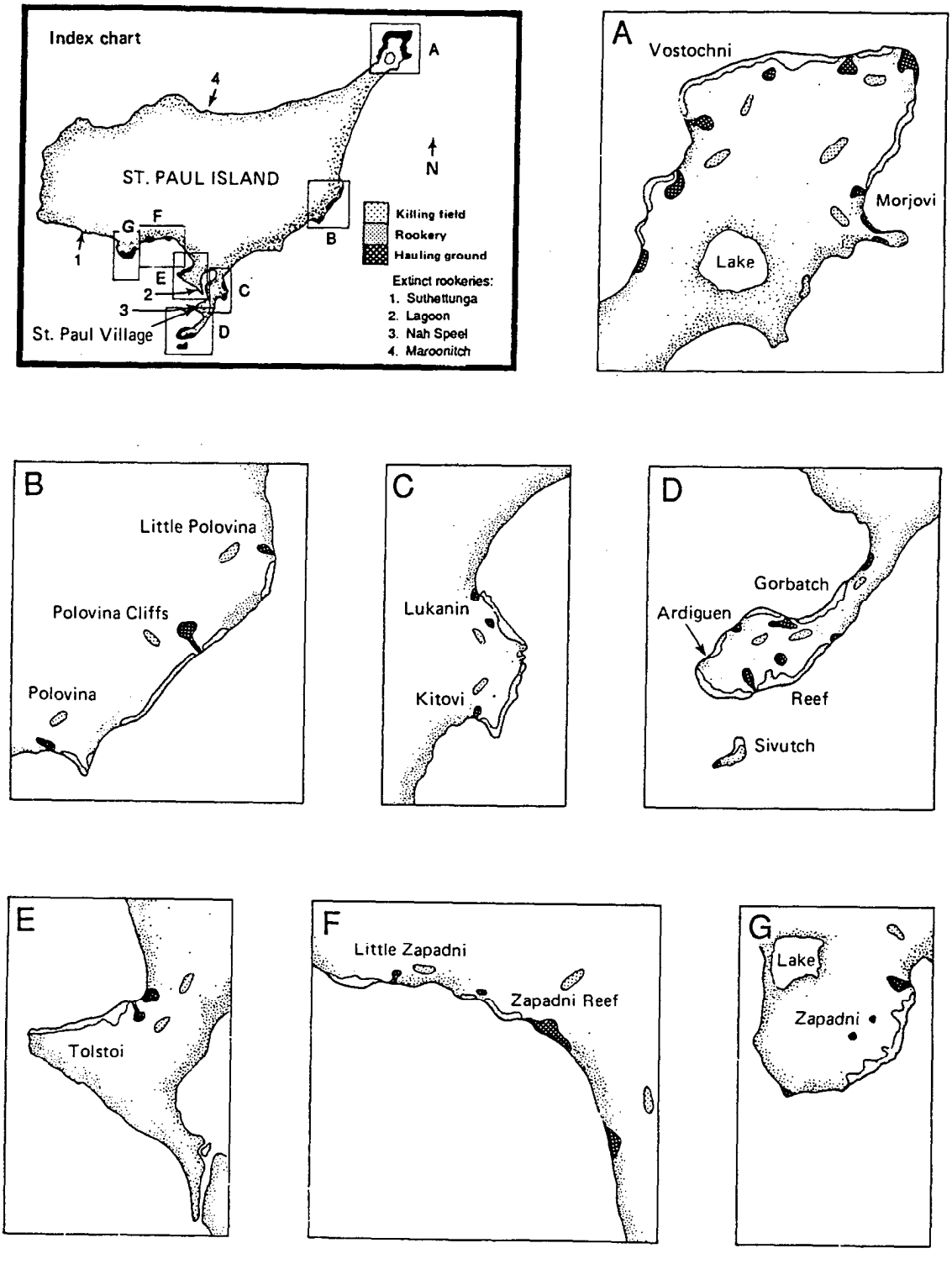

Figure 2.--Location of northern fur seal rookeries (present and extinct), hauling grounds, and harvesting areas, St. Paul Island, Alaska.

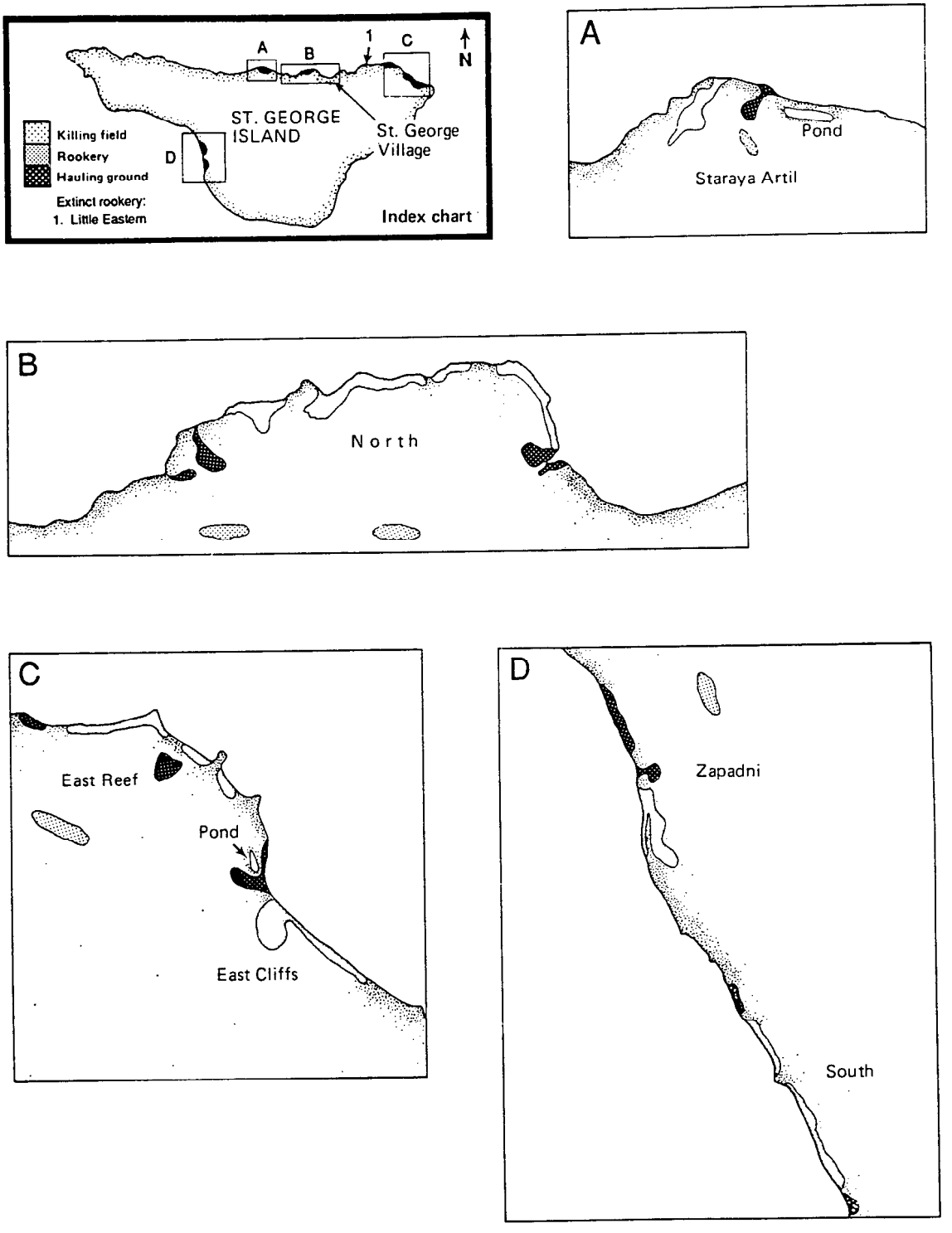

Figure 3.--Location of northern fur seal rookeries (present and extinct), hauling grounds, and harvesting areas, St. George Island, Alaska.

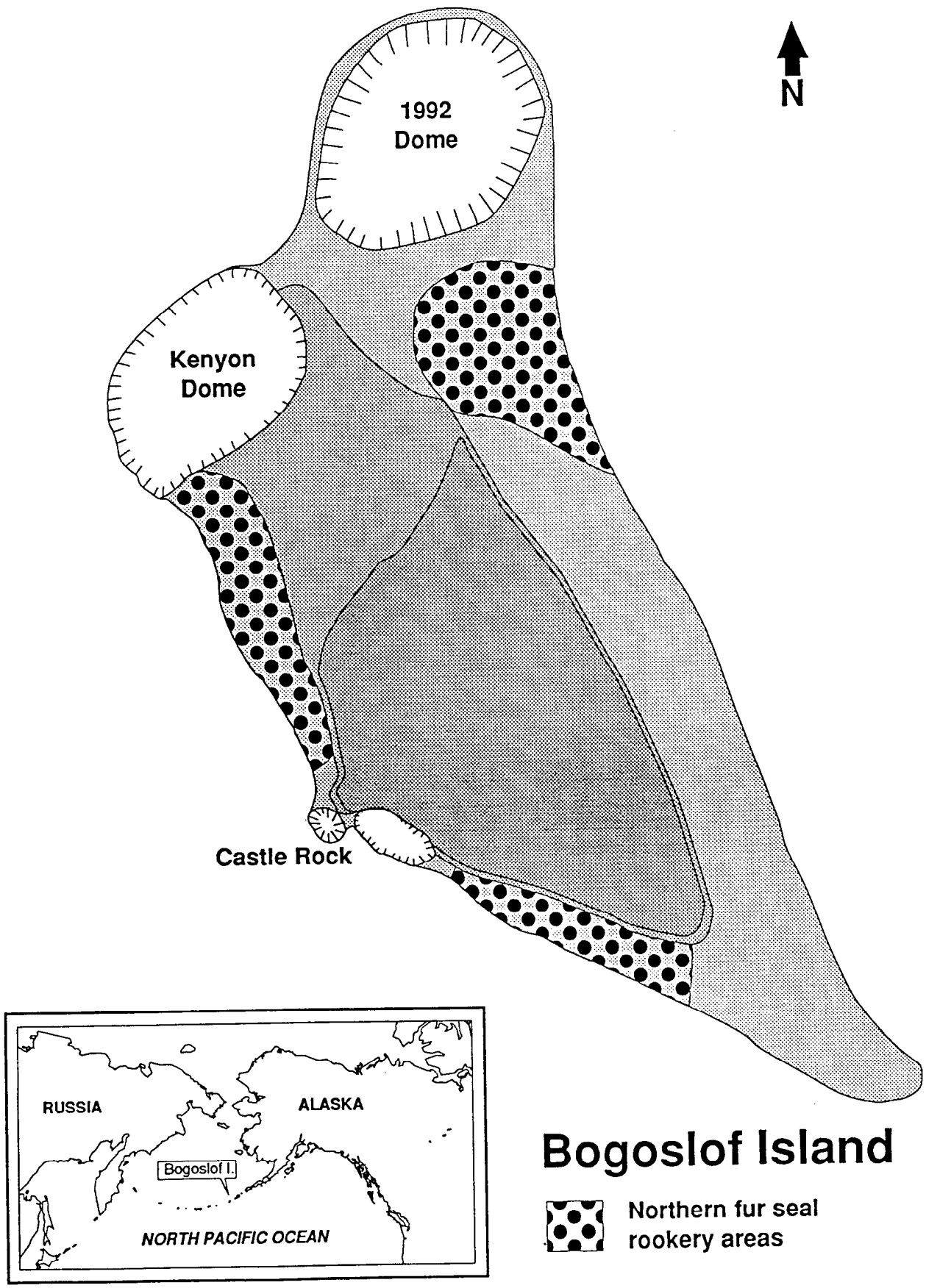

Figure 4.--Fur seal rookeries on Bogoslof Island, Alaska.

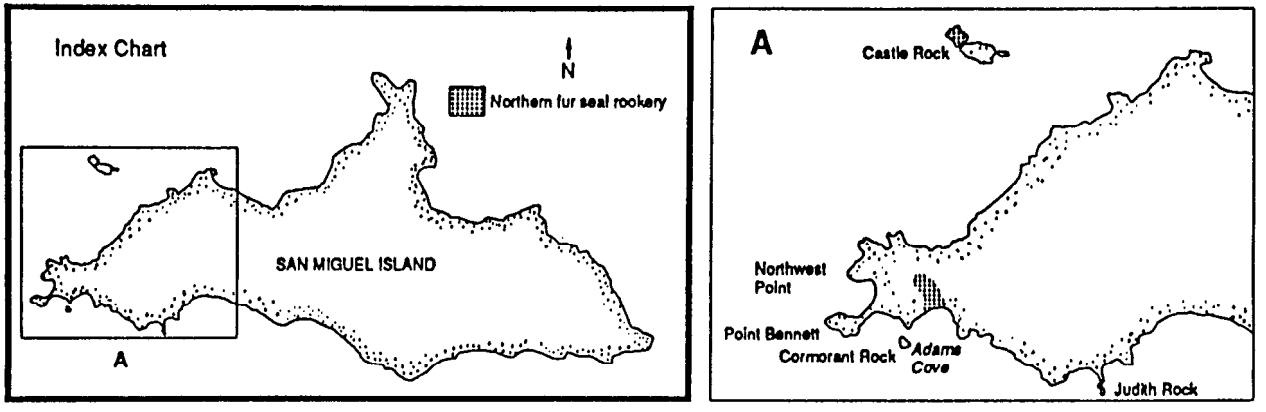

Figure 5.--Location of northern fur seal breeding colonies, San Miguel Island, California.

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

Anne E. York, Jason D. Baker, Rodney G. Towell, and Charles W. Fowler

In accordance with provisions originally established by the Interim Convention on Conservation of North Pacific Fur Seals, the National Marine Mammal Laboratory (NMML) of the Alaska Fisheries Science Center continues to monitor the status of fur seal populations on the Pribilof Islands. To meet this objective, data on population size, age and sex composition, and natural mortality are collected annually following the methods described by Antonelis (1992).

Population Parameters

Population characteristics monitored in 1996 include the size of the subsistence harvest, the number of adult males, estimates of numbers of pups born, and mortality rates of fur seals on St. Paul Island and St. George Island.

Sex Composition of Seals Harvested

A total of 1,588 sub-adult male seals were killed in the subsistence harvest by St. Paul Island residents in 1996 (Table 2). Three female fur seals were harvested accidentally on St. Paul Island. On St. George Island, 232 sub-adult male seals were taken in the subsistence harvest in 1996 (Table 3).

Living: Adult Male Seals Counted

Adult male seals were counted by section for each rookery (see Appendix A glossary for definitions of terms) on St. Paul Island from 11 to 17 July (Appendix Table B-l). A total of 5,643 harem (Class 3) and 9,239 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 1,248 harem (Class 3) and 790

Table 2. -- Date, location, and number of subadult male seals killed in subsistence harvest drives on St. Paul Island, Alaska, in 1996.

Date	Rookery	Number Killed
June 26	Reef	34
June 27	Polovina *	67
July 1	Zapadni **	22
July 9	Reef	80
July 10	Lukanin	69
July 16	Polovina	99
July 17	Lukanin	73
July 18	Zapadni	63
July 19	Reef	80
July 20	Kitovi	53
July 22	Polovina	67
July 23	Lukanin	64
July 24	Zapadni Reef *	51
July 25	Reef	99
July 26	Kitovi	27
July 27	Zapadni	18
July 29	Polovina	65
July 31	Reef	76
August 1	Zapadni Reef	44
August 2	Lukanin ***	56
August 3	Zapadni	51
August 5	Polovina	76
August 6	Lukanin	68
August 7	Zap Reef, L. Zap ***	88
August 8	Reef ***	101
TOTAL		1,591

* Includes 1 seal that died of heatstroke.
** Includes 10 seals that died of heatstroke.
*** Includes 1 female accidently struck and lost.

Table 3. -- Date, location, and number of subadult male seals killed in subsistence harvest drives on St. George Island, Alaska, in 1996.

Date	Rookery	Number Killed
July 2	North	13
July 7	Zapadni	18
July 9	North	10
July 14	Zapadni	14
July 16	North	20
July 20	Zapadni	10
July 23	North	11
July 27	Zapadni	13
July 30	North	9
August 4	Zapadni	60
August 6	North *	54
TOTAL		232

*Two animals not taken for food (1 died of heatstroke, 1 with infected chest tissue).

idle (Classes 2 and 5) adult male seals were counted from 10 to 16 July. The relative location of the different classes of adult males is illustrated for a typical fur seal rookery-hauling ground complex on the Pribilof Islands in Figure 6. Total numbers of harem and idle bulls counted since 1972 are given in Appendix Table B-2 and the classification and number of adult males counted by rookery for St. Paul and St. George Islands are presented in Table 4.

There was an increase in the count of territorial males with females (Class 3) on St. Paul Island between 1995 and 1996 (9.5%), and the count of these males on St. George Island was slightly higher in 1996 than in 1995 (0.5 % more). The total for these males for the Pribilof Islands was therefore greater by about 7.7% in 1996.

Number of Puns Born on St. Paul Island in 1996

The number of fur seal pups was estimated on six sample rookeries in August 1996 using the shearing-sampling method. Sample rookeries were chosen at random with the additional requirement that there be two large, two medium, and two small rookeries in the sample (following the protocol described in York and Towell, 1997). Counts of dead pups were made only on the same sample rookeries-- not on all rookeries as in previous years. The techniques and resampling design used to calculate the production estimate on the sample rookeries were as in 1994, using paired observers (York and Towel1 1996, York and Kozloff 1987, and Antonelis 1992). The total number of pups alive at the time of sampling was estimated by multiplying the total number of breeding males from all rookeries by a jackknife ratio of pups to breeding males on the six sample rookeries (York and Kozloff 1987, York and Towell, 1997). The total number of dead pups was estimated from the mortality rate on the sampled rookeries. The total number of pups born was estimated by summing the estimates of live and dead pups. Variances of numbers of pups and mortality rates were estimated following York and Kozloff (1987) and

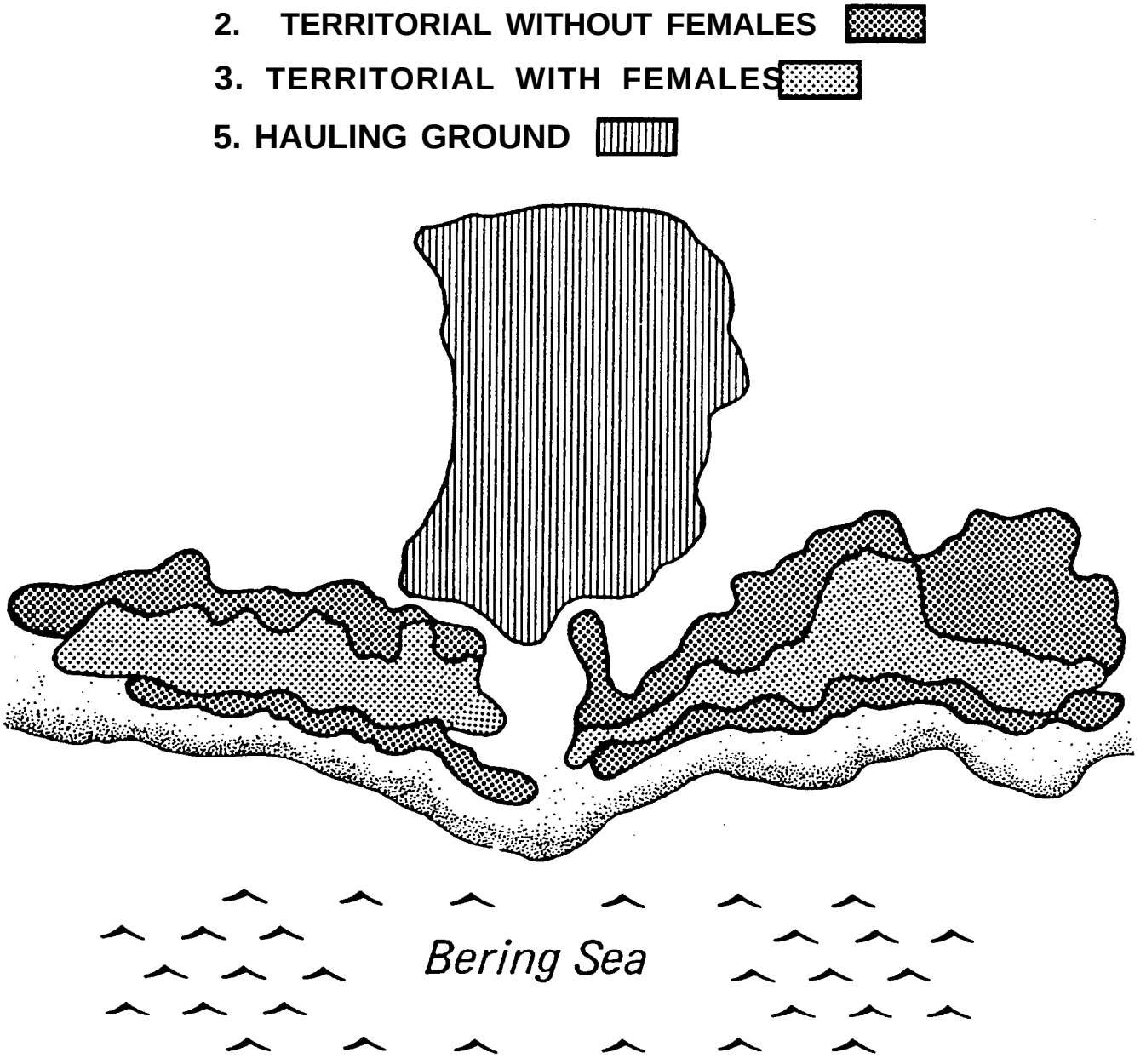

Figure 6.--The relative location of the different classes of adult males for a typical fur seal rookery.

Table 4.--Number of adult male northern fur seals counted, by rookery, Pribilof Islands, Alaska, July 1996.

Rookery	Date (July)	Class of Adult Male* 2	3	5	Total
St. Paul Island					
Lukanin	15	38	158	156	352
Kitovi	15	70	298	367	735
Reef	17	162	674	917	1,753
Gorbatch	11	120	446	874	1,440
Ardiguin	17	20	88	8	116
Morjovi	16	91	432	480	1,003
Vostochni	16	270	1092	1020	2,382
Little Polovina	13	10	9	399	418
Polovina	13	35	99	430	564
Polovina Cliffs	13	154	530	221	905
Tolstoi	12	216	624	894	1,734
Zapadni Reef	14	51	196	442	689
Little Zapadni	14	120	344	456	920
Zapadni	14	157	653	1061	1,871
Island Total		1,514	5,643	7,725	14,882
St. George Island					
South	15	100	248	45	393
North	12	164	442	68	674
East Reef	14	59	112	21	192
East Cliffs	16	60	267	55	382
Staraya Artil	10	47	54	60	161
Zapadni	11	57	125	54	236
Island Total		487	1,248	303	2,038

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

York and Towel1 (1997); in addition, bootstrap variances of the parameters based on 2,000 replicates were also obtained.

From 8 to 13 August, 10,715 pups were marked by shearing. The number of pups sheared on each rookery was a random number between 10% and 15% of the 1994 pup production estimate. The random numbers between 10% and 15% were chosen in such a way that all persons participating in the census were blind to the actual percentage of the pups marked; this was done to minimize the potential bias caused by observers knowing that the total number of marked animals was a fixed percentage of the previous production estimate. Shear marks were allocated proportionally on each rookery by section (Appendix Table B-3) according to the fraction of the rookery total for harem males counted in each section of the sampled rookery. The ratio of marked to unmarked pups was determined by at least three researchers (two of whom worked as a pair) on two occasions for each rookery from 14 to 22 August. Each researcher or pair of researchers obtained counts of marked and unmarked pups independently and in different areas to ensure that the entire rookery was well sampled. Each sampling day was considered an independent replicate from which the variance was computed for each rookery.

Dead pups were counted on all sampled rookeries from 18 to 22 August. The number of dead pups counted by section are given in Appendix Table B-4. A summary of the number of pups sheared, the estimated mean number of pups alive at the time of marking, and the standard error of the estimate for each sampled rookery is given in Table 5. The estimated number of pups born the standard error of the estimate, number of dead pups, number of harem bulls, and ratios of pups to adult males for each sampled rookery on St. Paul Island are summarized in Table 6. For each sampled rookery, the standard deviation of the pup estimate was computed from the standard error of the two estimates; in addition, we present bootstrapped estimates of the

Table 5.-- Total 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 (Mean) and standard error of the mean (SE), on sample rookeries of St. Paul Island, Alaska, 1996.

Rookery	Sheared	E1	E2	Mean	SE
Kitovi	678	5,946	6,281	6,114	167.5
Vostochni	2,918	25,292	26,922	26,107	815.0
Polovina Cliffs	1,859	14,785	15,965	15,375	590.0
Tolstoi	2,687	22,535	21,737	22,136	399.0
Zapadni Reef	791	6,385	6,260	6,323	62.5
Little Zapadni	1,782	14,617	15,274	14,946	328.5

Table 6.-- Number of pups alive at the time of marking, its standard deviation (SD), numbers of dead pups, total pups born, mortality rate, idle males, harem males, and ratio of pups alive at marking to harem males, on sample rookeries of St. Paul Island, Alaska, 1996.

Sample Rookery	Pups Alive at Marking	SD	Dead Pups*	Total Pups born	Mortality Rate (%)	Idle Bulls	Harem Bulls	Ratio Pups/Bulls
Kitovi	6,114	167.5	332	6,446	5.15	437	298	20.52
Vostochni	26,107	815.0	830	26,937	3.08	1,290	1,092	23.91
Polovina Cliffs	15,375	590.0	432	15,807	2.73	375	530	29.01
Tolstoi	22,136	399.0	1,136	23,272	4.88	1,110	624	35.47
Zapadni Reef	6,323	62.5	343	6,666	5.15	493	196	32.26
Little Zapadni	14,946	328.5	737	15,683	4.70	576	344	43.45
Sample Total	91,001	1,145.2	3,810	94,811	4.02	4,281	3,084	29.51

* Includes dead pups taken for necropsies; Polovina Cliffs (4) and Vostochni (56).

standard error of the estimate for each rookery based on 2,000 replicates of the estimation process.

The estimate for the total number of pups, alive on St. Paul Island at the time of marking was 163,288 . The empirical standard error was 20,390; the bootstrapped standard error was slightly smaller (17,175). The number of dead pups was estimated to be 6,837 (3,810 counted on sample rookeries and 3,027 estimated on the other rookeries; the estimated mortality rate for late August was 4.02% with a Standard Error (SE) of 0.05%. The total number of pups born on St. Paul Island was 170,125 (SE = 21,244); the standard error accounts for variance in the estimation of both live and dead pups (York and Towell, 1996). The approximate 95% confidence interval, computed by multiplying the standard deviation of the jackknife ratio of pups to breeding males (e.g., York and Kozloff 1987) by 2.447 (the 97.5 percentile of Student's t-distribution with 6 degrees of freedom (df)), was 170,125 ± (2.447 X 21,244) or 170,125 ± 51,984, or (118,141 - 222,109). The bootstrapped estimates the total number of pups born (170,252) is similar to the above, but the standard error (18,445), and 95% confidence interval (144,061- 213,280) based on 2,000 replications of the estimation process, are smaller than intervals produced above.

The above estimate does not include an estimate of pups on Sea Lion Rock. The last direct census of fur seals on Sea Lion Rock (1994) estimated 12,891 pups born (12,589 = live, 302 = dead). If we add this number to the St. Paul estimate calculated above, total pup production on St. Paul Island was 183,016; this value is comparable to years when Sea Lion Rock was censused.

The estimated number of pups born and their 95% confidence intervals for St. Paul Island, 1970-94, are shown in Figure 7. The total estimated number of pups born in 1996 was not significantly different (P = 0.05) from the 1990, 1992, and 1994 estimates, but the confidence

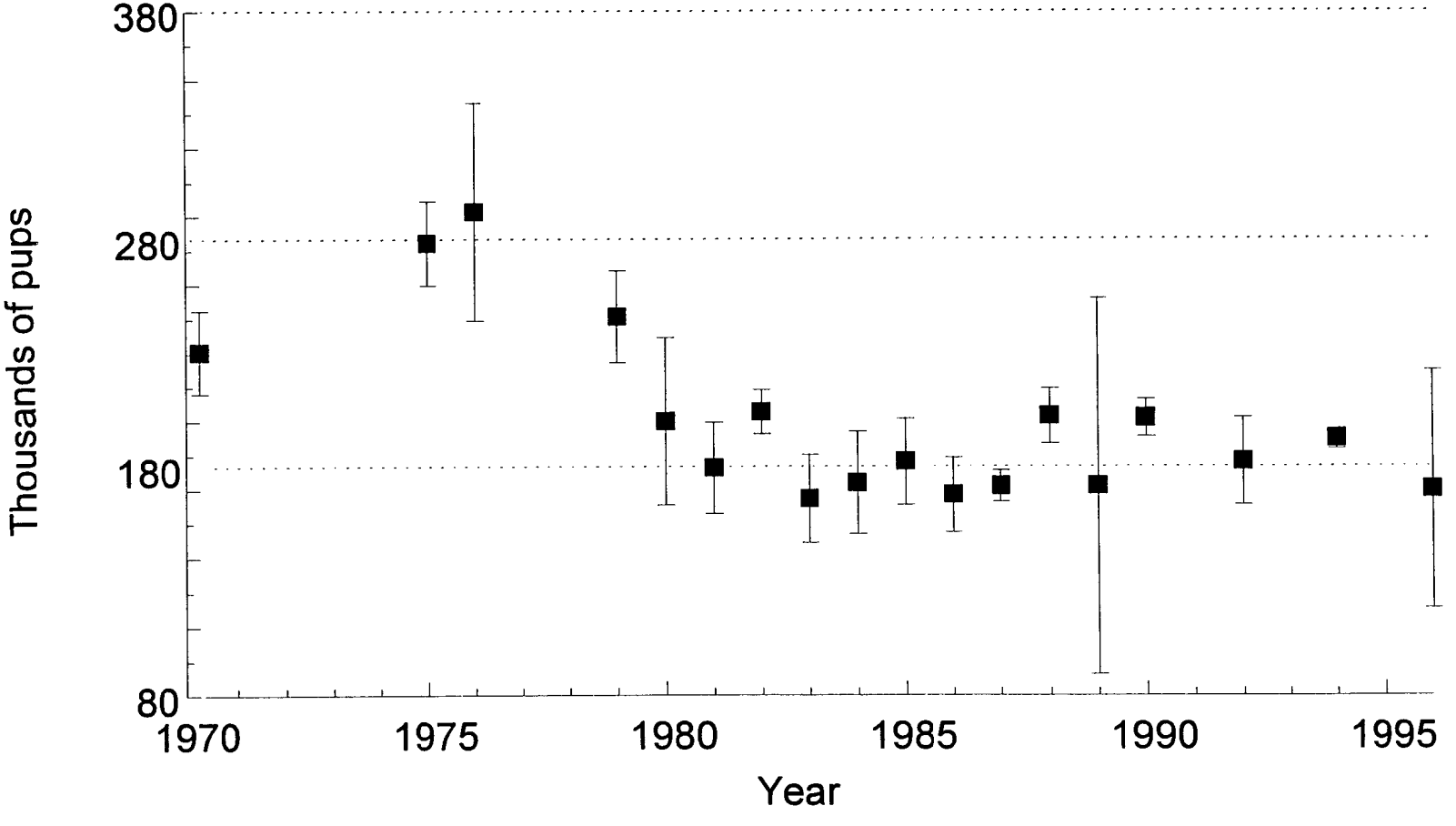

Figure 7.--Numbers of pups born, St. Paul Island, Alaska, 1970-96.

interval for the total estimate is quite wide. Appendix Table B-2 summarizes pup production and mortality excluding Sea Lion Rock since 1972.

The number of pups born and the number of harem bulls at different rookeries on St. Paul Island are significantly correlated (Fig. 8). When numbers of pups born are regressed on numbers of harem bulls, the value of R^2 for 1996 was 0.82. The intercept of the regression line of pups on breeding males is not significantly different from zero (P = 0.33) and was not included in the regression equation; the slope of the regression line is 27.83 (SE = 2.68), representing an estimate of the ratio of pups to breeding males.

Number of Puns Born on St. George Island in 1996

The number of pups born on St. George Island was estimated from a shearing-sampling study conducted on all rookeries. The most recent estimate of pup production prior to this study was obtained in 1994. From 9 to 12 August, a total of 3,094 pups were shear-marked on St. George Island; the total number sheared on each rookery was a random number between 10% and 15% of the total number estimated on the rookery in 1994, as on St. Paul Island. These marks were allocated proportionally within each rookery according to the fraction of harem bulls counted in 1996 (Appendix Table B-5). The ratio of marked to unmarked pups on each rookery was determined by two researchers on two occasions: once from 14 to 19 August and again from 20 to 22 August. A summary by rookery of the number of pups sheared, the estimated mean number of pups alive at the time of marking, and the standard error of the estimate is given in Table 7. Counts of dead pups were made from 19 to 22 August 1996. The ratio of marked to unmarked pups and the estimate of the number alive was calculated similarly to the method described for St. George Island for 1994. Since the rookeries on St. George Island are much smaller than on St. Paul Island, one person is capable of sampling the entire rookery. The

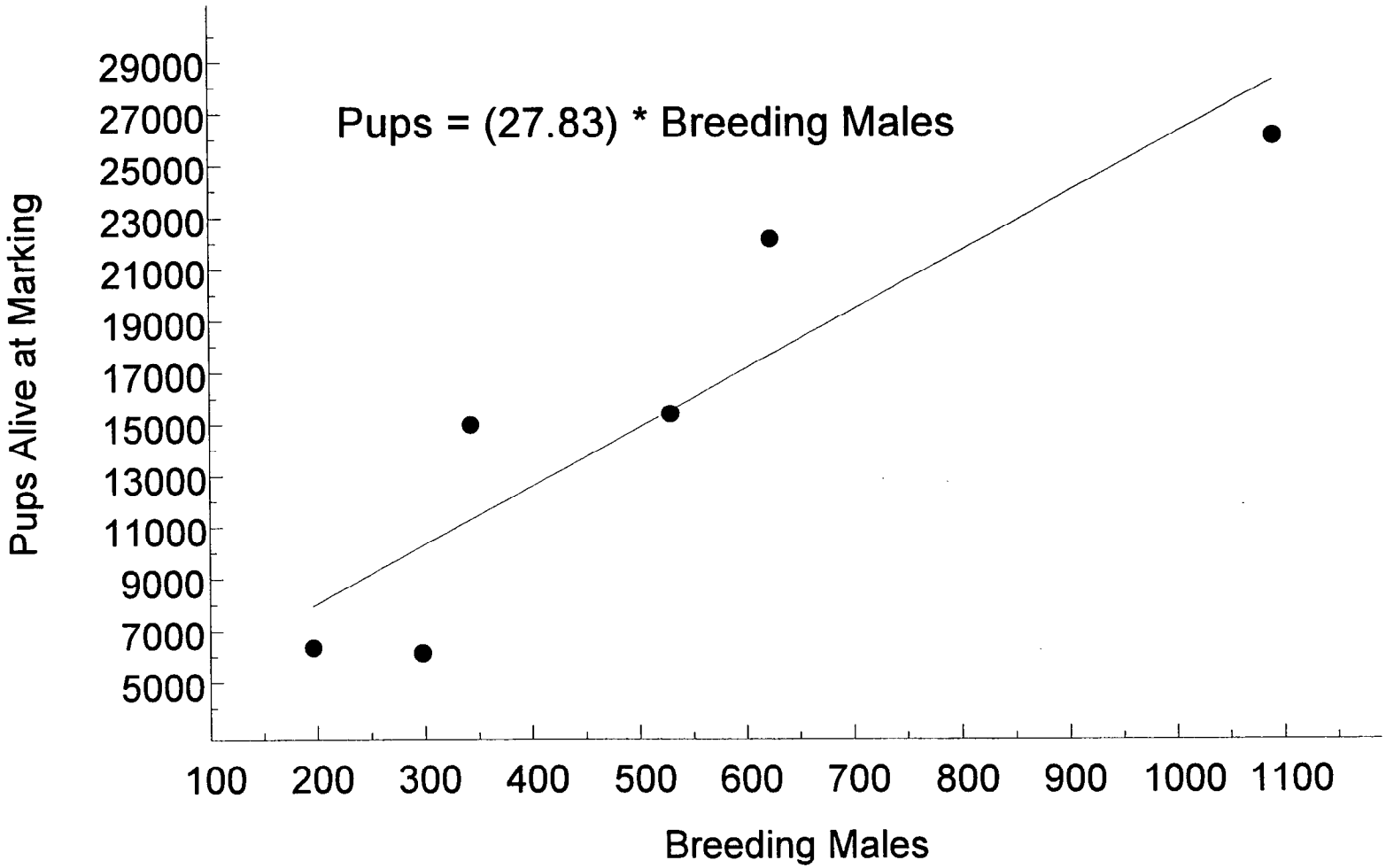

Figure 8.--Pups born versus number of breeding males on St. Paul Island, Alaska, 1996.

Table 7.-- Number of pups sheared, number of pups estimated to be alive at the time of marking (El and E2), and the mean number alive (Mean) and the standard error of the mean (SE), St. George Island, Alaska, 1996.

Rookery	Sheared*	E1	E2	Mean	SE
South	666	5,743	5,885	5,814	71.00
North	990	8,504	8,795	8,650	145.50
East Reef	173	1,278	1,607	1,443	164.50
East Cliffs	547	4,980	4,871	4,926	54.50
Staraya	244	1,920	2,161	2,041	120.50
Zapadni	459	3,666	3,918	3,792	126.00

* Sheared is defined as effective shear marks, total sheared minus dead with shear marks (Appendix Table B-6).

estimated total number of pups alive on St. George Island at the time of marking was 26,666 (SE = 294, Table 8). The total number of dead pups was 719 (Appendix Table B-6) and the estimated mortality rate was 2.63%. The total number of pups born on St. George Island and the approximate 95% confidence interval was 27,385 ± (2.447 X 294), or 27,385 ± 719, or 26,666 - 28,104. The bootstrapped median estimate was similar (27,511); the standard error (603) and confidence interval were somewhat larger (26,389 - 28,746).

The 1996 estimate of pups on St. George Island was significantly higher ($P<0.05$) than the 25,160 (SE = 707) and 22,244 (SE = 410) pups estimated in 1992 and 1994, respectively. This count was also significantly higher than the predicted number of pups born based on a regression fitted to the 1973-94 data, which had shown a 4.7% rate of decline with a predicted number of pups of 18,641 (SE = 1,076). Estimates and 95% confidence intervals of numbers of pups born on St. George Island for 1970-94 are shown in Figure 9. The 1996 estimate of pups born on St. George was the highest number since 1985, when over 28 000 pups were born.

The number of pups born and the number of breeding (harem) males on St. George Island rookeries were highly correlated (Fig. 10). When the number of pups born were regressed on the number of males, the value of R^2 was about 0.91. The intercept of the regression line was not significantly different from zero ($P = 0.35$) and was not included in the regression equation; the slope of the regression line was 20.39 (SE = 1.51).

Counts of Dead Fur Seals Older Than Pups and Collection of Teeth

Tooth samples (usually canines) were collected from all dead fur seals other than pups whenever possible. The sample rookeries and adjacent beaches of St. Paul Island and all rookeries of St. George Island were surveyed for dead fur seals older than pups during August 1996 (Table 9). In 1996, tooth samples were collected from a total of 112 fur seals (20 males and

Table 8.-- Number of pups alive at the time of marking, its standard deviation (SD), numbers of dead pups, total pups born, mortality rate, idle males, harem males, and ratio of pups alive at marking to harem males, St. George Island, Alaska, 1996.

Rookery	Pups Alive at Marking	SD	Dead Pups	Total Pups born	Mortality Rate (%)	Idle Bulls	Harem Bulls	Ratio Pups/Bulls
South	5,814	71.0	99	5,913	1.67	145	248	23.44
North	8,650	145.5	282	8,932	3.16	232	442	19.57
East Reef	1,443	164.5	11	1,454	0.76	80	112	12.88
East Cliffs	4,926	54.5	116	5,042	2.30	115	267	18.45
Staraya	2,041	120.5	71	2,112	3.36	107	54	37.80
Zapadni	3,792	126.0	140	3,932	3.56	111	125	30.34
Island Total	26,666	294.3	719	27,385	2.63	790	1,248	21.37

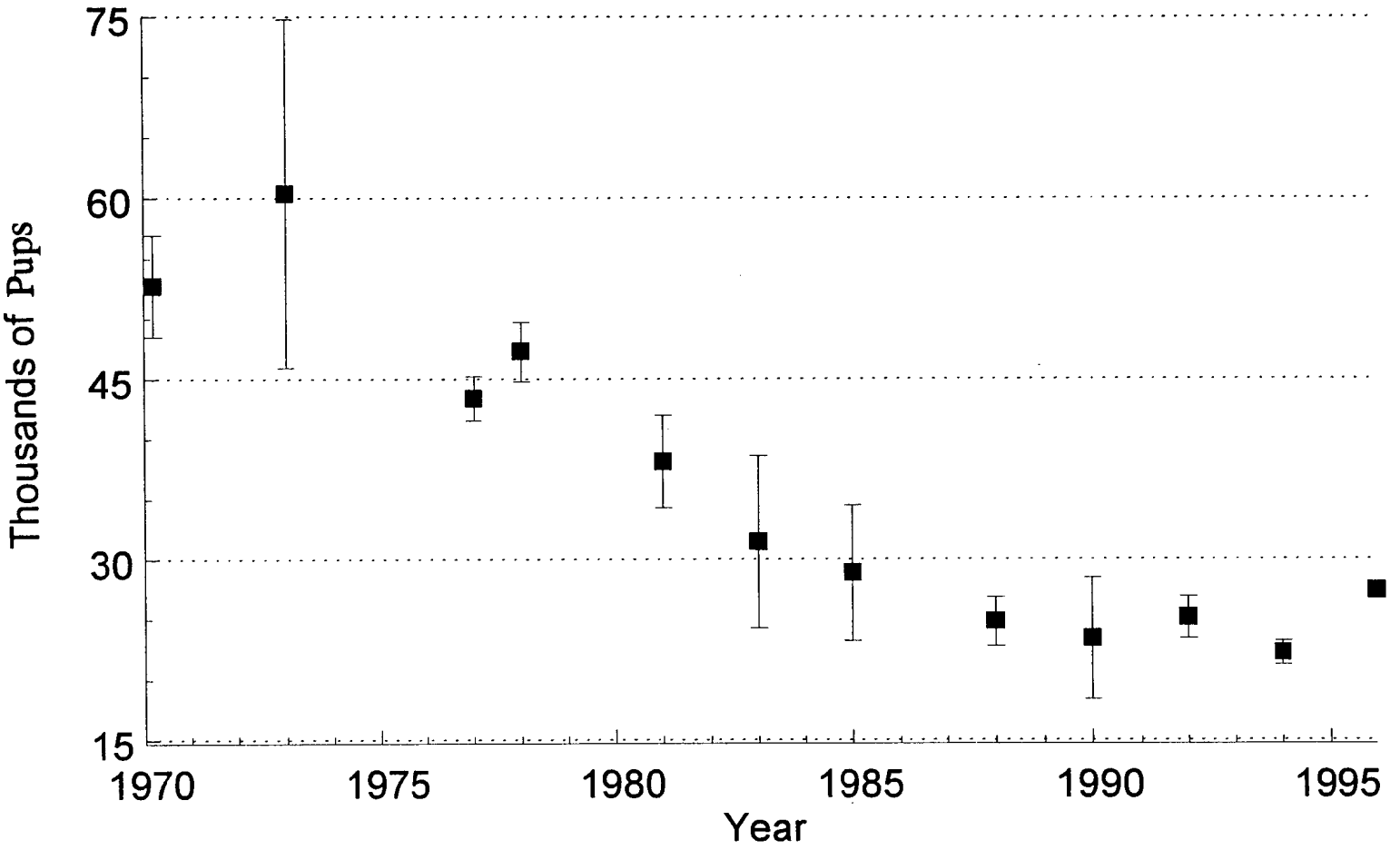

Figure 9.--Numbers of pups born, St. George Island, Alaska, 1970-96.

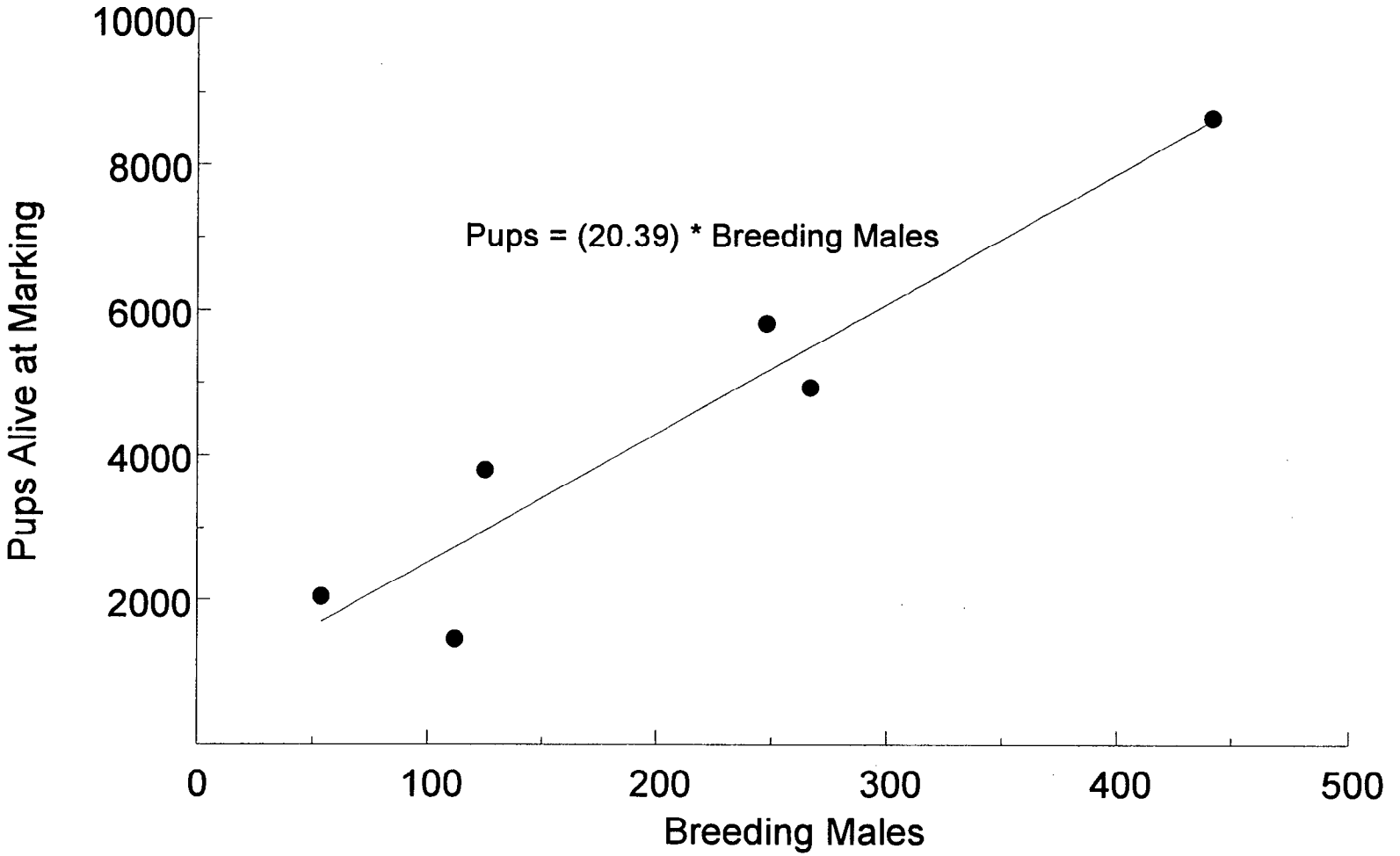

Figure 10.--Pups born versus number of breeding males on St. George Island, Alaska, 1996.

Table 9.--Number of animals older than pups found dead on the Pribilof Islands from which teeth were collected during August 1996. Numbers in () are animals with no teeth where sex was identified.

Rookery	Males	Females	No Teeth Sex Unidentified	Total
St. Paul				
Kitovi	1	5	0	6
Vostochni	2	18	0	20
Polovina Cliffs	1	14	0	15
Tolstoi	5	33	0	38
Zapadni Reef	7	7	0	14
Little Zapadni	4	15	0	19
Total St. Paul	20	92	0	112
St. George*				
South	-	-	-	-
North	(2)	(3)	6	11
East Reef	-	-	2	2
East Cliffs	-	-	3	3
Staraya Artil	(1)	-	2	3
Zapadni	-	-	4	4
Total St. George	3	3	17	23
Total both Islands	23	95	17	135

* All teeth for adult fur seals from St. George were accidentally destroyed.

92 females) on St. Paul Island. A total of 23 tooth samples (3 males, 3 females, and 17 unidentified) were collected on St. George Island, respectively; those samples were accidentally destroyed. Appendix Table B-7 summarizes the total number of dead male and female fur seals from which teeth were collected from 1965 to 1996.

NORTHERN FUR SEAL ENTANGLEMENT STUDIES: ST. PAUL AND ST. GEORGE ISLANDS, 1996

by

Bruce W. Robson, Michael T. Williams, Masa Kiyota, Gary E. Merculief and Candace M. Stepetin

Entanglement of northern fur *seals (Callorhinus ursinus) in* marine debris has been studied since the early 1980s by the National Marine Fisheries Service (NMFS) in cooperation with the National Research Institute of Far Seas Fisheries (NRIFSF) and the Aleut community of St. Paul Island. 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).

Incidence of entanglement in juvenile males increased from the mid-1960s to the mid-1970s reaching a peak in 1976 at 0.71% among subadult males (Fowler 1987, Fowler et al. 1992, 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). Studies from 1988 to 1992 indicate a decline in the rate of entanglement among both subadult males (Fowler and Ragen 1990, Fowler et al. 1992) and females (Kiyota and Fowler 1994) on St. Paul Island.

In 1996, in cooperation with the St. Paul and St. George Islands Tribal Councils and the Pribilof Islands Stewardship Program, the NMFS continued a study on juvenile and adult male fur seal entanglement using a combination of research roundups and surveys during the subsistence harvest initiated in 1995. Surveys conducted in conjunction with the subsistence harvests are designed to reduce the number of times seals are disturbed by not conducting subsistence harvests and entanglement roundups on the same haulouts during July and early August.

The objective of this study is to determine current trends in the rate of entanglement of northern fur seals in marine debris on St. Paul and St. George Islands. This information is being collected in order to provide: 1) a continuing index of entanglement rates, 2) a comparison of entanglement rates on St. Paul Island (stable population) and St. George Island (decreasing population), 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 proportion of debris types associated with different fisheries that may be impacting fur seals.

In addition to the continuation of juvenile male entanglement studies, NRIFSF researchers continued to collect information on seasonal and annual (1991-95) rates of entanglement among adult female fur seals. As in previous years, researchers continued to capture and remove 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 1996. Surveys were conducted in conjunction with the Aleut subsistence harvest and using non-harvest roundups following the methods

described in Bengtson et al. (1988), Fowler and Ragen (1990), and Fowler et al. (1992). The harvest sampling protocol was adjusted to fit the logistical requirements of conducting the surveys during the subsistence harvest. Under each sampling regime, seals were prevented from escaping to the water and herded into groups by harvest or roundup crews. Seals were then released to sea in small groups or in a single file line allowing observers to count and examine seals for entangling debris or scars indicating previous entanglement. Separate counts were made by different observers of the total number of male seals (all age groups) and the number of juvenile male seals of the size and age (2-4 years old) historically taken in the commercial harvest (Bengtson et al. 1988, Fowler et al. 1992). The count of adult seals was derived by subtracting the number of juveniles from the total count of all seals for a survey. 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, following the initial roundup, small groups of seals (consisting primarily of older males) were separated from the main group. Most seals were released to the water and only smaller groups consisting primarily of juvenile seals were retained for the duration of the harvest. Seals released during the drive were counted and examined for entanglement upon release. Seals in the group retained for the subsistence harvest (but not killed) were also counted and examined for entanglement upon release. Harvested seals were examined for evidence of entanglement and added to the final count.

When an entangled seal was sighted during release, 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 diameter of the entangling loop for other materials such as packing bands or ropes) and saved for future analysis. Entangled seals judged to be of harvestable size were marked by lightly shearing marks into the pelage on the shoulders indicating the island of capture and type of survey. 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. Because some seals on haulouts are observed more than once (Fowler and Ragen 1990, Baker et al. 1995), roundups (after 1985) sampled seals with replacement. Samples taken during the commercial harvest (prior to 1985) in which both entangled and nonentangled seals were killed were obtained without replacement.

The overall 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).

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 1996, island-wide surveys of entangled adult female fur seals by NRIFSF scientists 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-three subsistence harvest surveys and 30 roundups were conducted on St. Paul Island (53 total) and 26 roundups and 9 harvest surveys (35 total) were conducted on St. George Island during July and early August of 1996 (Table 10). Observers sampled 38,311 and 10,763 seals of all age groups combined on St. Paul and St. George Islands, respectively. Samples included 24,701 juveniles (2-4 years old) on St. Paul Island and 6,057 juveniles on St. George island. Seventy-one entangled juvenile and adult male seals were captured, examined, and the debris was removed during harvest surveys and roundups (56 on St. Paul Island and 15 on St. George Island).

Forty-three seals with scars indicating evidence of previous entanglement were also observed during surveys (Table 10). Twenty-one of these seals were adult males, some of which had fresh, open wounds indicating their debris was removed or lost during 1996. Due to the difficulty involved with handling adult male fur seals, they were not marked for resighting and observations of scarred adult seals were not used in calculations of the incidence of entanglement described below.

Table 10.--Summary of harvest surveys and roundups ofjuvenile and adult northern fur seal males conducted on St. Paul and St. George Islands during July and August, 1996 including the number of seals entangled, resighted, and observed with scars.

Date	Survey Type	Location	Total Count	Juvenile Count	Juveniles Entangled	Juveniles Resighted	Juveniles Scarred	Adults Entangled	Adults Scarred
09-Jul-96	H	Reef	476	255	1	1	0	0	0
09-Jul-96	R	Zolotoi Sands	2,265	1,018	1	0	1	3	1
10-Jul-96	H	Lukanin	380	228	1	0	0	0	0
11-Jul-96	R	Vostochni Sec. 14	283	105	0	0	0	0	0
11-Jul-96	R	Vostochni Sands	206	81	0	0	0	0	1
11-Jul-96	R	Vostochni Sec. 13	400	212	1	0	0	0	0
11-Jul-96	R	Vostochni Sec. 11	886	501	0	0	1	1	0
11-Jul-96	R	Vostochni Sec. 1	343	146	0	0	0	0	0
11-Jul-96	R	Northeast Point	446	210	0	0	1	0	0
12-Jul-96	R	Tolstoi Sands & Hill	1,315	382	1	0	0	0	1
12-Jul-96	R	Zapadni Reef Sands	1,817	1,086	1	0	0	0	1
13-Jul-96	R	Little Polovina	654	129	0	0	0	0	2
14-Jul-96	R	Zapadni	1,950	1,057	0	1	0	2	0
14-Jul-96	R	Little Zapadni	383	154	0	1	1	0	0
16-Jul-96	H	Polovina	0	666	0	0	1	0	0
17-Jul-96	H	Lukanin	537	393	1	0	1	0	0
17-Jul-96	R	Zolotoi Sands	1,686	855	0	0	1	3	0
18-Jul-96	H	Zapadni	948	630	1	0	0	1	0
19-Jul-96	H	Reef	852	689	0	1	0	0	0
20-Jul-96	H	Kitovi	253	168	0	1	0	0	0
21-Jul-96	R	Little Zapadni	608	250	0	0	0	0	0

Table 10.--continued.

Date	Survey Type	Location	Total Count	Juvenile Count	Juveniles Entangled	Juveniles Resighted	Juveniles Scarred	Adults Entangled	Adults Scarred
21-Jul-96	R	Tolstoi Sands	721	228	0	0	0	1	0
22-Jul-96	H	Polovina	946	759	0	0	0	0	0
22-Jul-96	R	Zapadni Reef Sands	1,034	674	0	0	1	0	0
23-Jul-96	H	Lukanin	889	747	2	0	0	1	0
23-Jul-96	R	Vostochni Sec. 14	264	122	1	0	0	2	0
23-Jul-96	R	Vostochni Sec. 12	988	657	3	1	0	1	0
24-Jul-96	H	Zapadni Reef Sands	356	254	0	0	0	0	0
24-Jul-96	R	Vostochni Sec. 1	404	308	0	1	0	0	1
24-Jul-96	R	Northeast Pt.	859	702	3	0	0	0	2
24-Jul-96	R	Morjovi Sec. 1	856	694	2	0	0	0	0
25-Jul-96	H	Reef	1,037	736	1	0	0	0	0
26-Jul-96	H	Kitovi	435	210	0	1	0	0	0
27-Jul-96	H	Zapadni	801	597	0	0	0	1	0
29-Jul-96	H	Polovina	0	771	2	0	3	0	0
29-Jul-96	R	Zolotoi	759	259	0	0	0	0	0
31-Jul-96	H	Reef	874	745	0	1	0	0	2
31-Jul-96	R	Tolstoi Sands	676	188	1	0	1	0	1
31-Jul-96	R	Tolstoi Hill	768	218	1	1	1	0	2
01-Aug-96	H	Zapadni Reef Sands	314	201	1	0	0	0	0
02-Aug-96	H	Lukanin	712	625	2	1	0	0	0
03-Aug-96	H	Zapadni	377	275	0	1	0	0	0
05-Aug-96	H	Polovina	955	844	0	2	0	0	1
05-Aug-96	R	Vostochni Sec. 4	368	145	0	1	0	0	0

Table 10.--continued.

Date	Survey Type	Location	Total Count	Juvenile Count	Juveniles Entangled	Juveniles Resighted	Juveniles Scarred	Adults Entangled	Adults Scarred
05-Aug-96	R	Northeast Point	1,541	946	0	2	0	0	0
05-Aug-96	R	Morjovi Sec. 1	1,073	804	3	0	0	2	0
06-Aug-96	H	Lukanin	468	346	1	1	0	0	0
06-Aug-96	R	Vostochni Sec. 14	310	191	1	0	0	0	0
06-Aug-96	R	Vostochni Sec. 11	701	651	1	0	0	0	1
06-Aug-96	R	Vostochni Sec. 11	655	492	4	1	0	1	0
07-Aug-96	H	Zapadni Reef Sands	225	155	0	0	0	0	0
07-Aug-96	H	Little Zapadni	203	133	0	0	0	0	0
08-Aug-96	H	Reef	1,054	809	0	0	0	0	0
St. Paul Totals			38,311	24,701	37	19	13	19	16
		St. George Island							
02-Jul-96	H	Northeast	664	275	0	0	0	0	0
02-Jul-96	R	Staraya Artil	443	115	0	0	0	0	1
02-Jul-96	R	Northwest	85	34	0	0	0	0	0
02-Jul-96	R	Northcentral	192	47	0	0	0	0	0
03-Jul-96	R	East Reef	549	188	1	0	0	1	0
03-Jul-96	R	East Cliffs	1,106	491	0	0	0	0	0
07-Jul-96	H	Zapadni East	328	165	0	0	1	0	0
07-Jul-96	R	Zapadni West	236	81	0	0	0	0	0

Table 10.--continued.

Date	Survey Type	Location	Total Count	Juvenile Count	Juveniles Entangled	Juveniles Resighted	Juveniles Scarred	Adults Entangled	Adults Scarred
09-Jul-96	R	North Central	223	34	0	0	0	0	0
09-Jul-96	R	North West	258	84	0	0	0	2	0
11-Jul-96	R	Staraya Artil	282	117	0	0	1	0	0
14-Jul-96	H	Zapadni	292	192	0	0	0	0	0
14-Jul-96	R	East Reef	226	138	0	0	0	0	0
14-Jul-96	R	East Cliffs 1	645	474	0	0	0	0	0
16-Jul-96	H	Northeast	313	171	0	0	0	0	1
18-Jul-96	R	Northcentral	134	26	0	0	0	0	1
18-Jul-96	R	Northwest	168	117	1	0	0	0	1
18-Jul-96	R	Staraya Artil	117	50	1	0	0	0	1
19-Jul-96	R	East Cliffs 1	272	242	0	0	1	0	0
19-Jul-96	R	East Reef	96	65	1	0	0	0	0
19-Jul-96	R	East Cliffs 2	259	221	0	0	1	0	0
20-Jul-96	H	Zapadni	105	76	0	1	0	0	0
23-Jul-96	H	Northeast	186	160	0	0	1	0	0
25-Jul-96	R	East Reef	189	115	1	0	0	0	0
25-Jul-96	R	East Cliffs 1	219	141	0	0	1	0	0
25-Jul-96	R	East Cliffs 2	377	306	2	0	1	0	0
30-Jul-96	H	Northeast	416	193	0	0	0	0	0
30-Jul-96	R	Northcentral	127	12	0	0	1	0	0
30-Jul-96	R	Northwest	41	9	0	0	0	0	0
31-Jul-96	R	Zapadni	588	476	2	0	1	0	0
31-Jul-96	R	Staraya Artil	176	90	1	0	0	0	0

Table 10.--continued.

Date	Survey Type	Location	Total Count	Juvenile Count	Juveniles Entangled	Juveniles Resighted	Juveniles Scarred	Adults Entangled	Adults Scarred
01-Aug-96	R	East Cliffs 1	166	114	0	0	0	0	0
01-Aug-96	R	East Cliffs 2	404	377	0	0	0	0	0
04-Aug-96	H	Zapadni	301	190	1	0	0	0	0
06-Aug-96	H	Northeast	580	471	1	0	0	0	0
St. George Totals			10,763	6,057	12	1	9	3	5

Resights of Previously Entangled Seals

Shear marks on the shoulders proved to be easily visible during roundups and other activities. Nineteen juvenile males on St. Paul Island and 1 on St. George Island were observed with shear marks indicating prior removal of entangling debris during 1996 (Table 10).

In previous studies of entanglement, samples of entangled and control animals were tagged to assess the survival and subsequent resighting of entangled seals within seasons and between years. This information was incorporated into the calculation of the rate of entanglement assuming a 50% survival rate of entangled seals (had debris been left on) between years (Fowler and Baba 1991). In the current study, no tags were applied. 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 and may be better understood as an index of the minimum rate of entanglement among juvenile male fur seals.

In entanglement studies conducted from 1985 to 1992, the within-year resight rate of both control and entangled seals was about 25% (Fowler et al. 1993). During 1996, this rate for entangled juvenile seals on both islands combined was 29.0%, implying similar resighting rates between study methods.

Incidence of Entanglement.

During subsistence harvest surveys and roundups on St. Paul Island, 37 juvenile and 19 adult entangled fur seals were observed and the type of debris was determined. Twelve juvenile and 3 adult male entangled seals were observed on St. George Island. Data on all observations of entangled seals used to calculate the rate of entanglement are presented in

Table 11. In situations where it was not possible to capture an entangled seal, age and debris information was recorded. An additional 47 male seals, 14 female seals, 25 seals of unknown sex, and approximately 7 pups were captured and disentangled during other research activities from late June through November (Table 12).

As in previous years, entangling debris consisted primarily of pieces of trawl net, plastic packing bands, and loops of synthetic or natural twine (Table 13). No seals entangled in monofilament gillnet were observed during male entanglement surveys in 1996. Differences in the relative percentage of entangling debris were observed between age groups of seals (Fig. 11). On St. Paul Island, the greatest proportion (68.4%) of entangled adult males had packing bands around their necks. On St. George Island, only 3 adult males were observed entangled, one in each of the three major debris types. Trawl net comprised the largest proportion of entangling debris among juveniles on both islands (43.2% and 50.0% on St. Paul and St. George Islands, respectively), followed by packing bands (32.4 % on St. Paul Island and 25.0% on St. George Island). The observed incidence of entanglement in loops of twine on St. George Island decreased from 29.4% in 1995 to 15.8% in 1996. As in 1995, more entanglement in packing bands was observed on St. Paul Island (44.6%) relative to St. George Island (26.7%) for all age groups combined.

The rate of entanglement for juvenile males was 0.23% (56/24,701) on St. Paul Island and 0.21% (13/6,057) on St. George Island. Among adult males, the rate of entanglement was 0.14% (19/13,610) on St. Paul Island and 0.06% (3/4,706) on St. George Island. The overall rate of entanglement for males was 0.19% (73/38,311) and 0.15% (16/10,763) for St. Paul and St. George Islands, respectively.

Table 11 .-- Adult and juvenile male northern fur seals observed entangled during harvest surveys and roundups on St. Paul and St. George Islands during July and August of 1996 including a description of the debris and the wound on each seal.

Date	Location	Est. Age	Survey Type	Debris Removed[1]	Debris Type	Debris Wt.	Mesh Size	Twine Size	Wound (deg.)	Tightness[2]
St. Paul Island										
07/09/96	Reef	2	HV	Y	Trawl Net	368	20.0	0.4	0	T
07/09/96	Zolotoi	7	RU	Y	Packing Band	13.5	26.5	1.3	360	VT
07/09/96	Zolotoi	5	RU	Y	Packing Band	6.0	24.5	1.2	360	VT
07/09/96	Zolotoi	8	RU	N	Packing band				360	VT
07/09/96	Zolotoi	3	RU	Y	Trawl net	240.0	22.5	0.6	0	T
07/10/96	Lukanin	3	HV	Y	Nylon belt	23.0	22.0	5.0	0	T
07/11/96	Vostochni Sec. 11	8	RU	Y	Packing band				180	VT
07/11/96	Vostochni Sec. 13	4	RU	Y	Trawl net	110.0	26.0	2.2	0	T
07/12/96	Zapadni Reef Sands	4	RU	Y	Packing band	2.5	24.2	1.5	0	L
07/12/96	Tolstoi	3	RU	Y	Trawl net	300.0	22.0	2.4	0	T
07/14/96	Zapadni Sands	6	RU	Y	Packing band				360	VT
07/14/96	Zapadni Sands	5	RU	Y	Trawl net	55.0	22.5	3.2	0	T
07/17/96	Lukanin	3	HV	Y	Twine	1.8	24.5	3.0	360	VT
07/17/96	Zolotoi	8	RU	N	Packing band				360	VT
07/17/96	Zolotoi	7	RU	Y	Packing band				360	VT
07/17/96	Zolotoi	6	RU	Y	Packing band				360	VT
07/18/96	Zapadni	3	HV	Y	Packing band	1.7	21.7	1.1	0	T
07/18/96	Zapadni	5	HV	Y	Trawl net	18.3	21.7	1.4	360	VT
07/21/96	Tolstoi	7	RU	N	Twine				360	VT
07/23/96	Lukanin	4	HV	Y	Packing band	2.7	21.5	1.1	180	VT
07/23/96	Lukanin	7	HV	Y	Packing band				0	L

Table 11 .--continued.

Date	Location	Est. Age	Survey Type	Debris Removed[1]	Debris Type	Debris Wt.	Mesh Size	Twine Size	Wound (deg.)	Tightness[2]
07/23/96	Lukanin	4	HV	Y	Trawl net	45.0	23.0	3.6	360	VT
07/23/96	Vostochni Sec. 14	4	RU	Y	Packing band	5.2	36.5	1.4	0	T
07/23/96	Vostochni Sec. 14	7	RU	Y	Packing band				0	L
07/23/96	Vostochni Sec. 14	7	RU	Y	Packing band	2.3	26.5	1.1	0	T
07/23/96	Vostochni Sec. 12	8	RU	Y	Packing band				340	VT
07/23/96	Vostochni Sec. 12	3	RU	Y	Packing band	1.7	20.7	1.1	360	VT
07/23/96	Vostochni Sec. 12	3	RU	Y	Twine	4.5	24.0	2.7	360	VT
07/23/96	Vostochni Sec. 12	3	RU	Y	Trawl net	8.3	NA	2.3	360	VT
07/24/96	Northeast Pt.	3	RU	Y	Trawl net	4.9	NA	3.1	180	VT
07/24/96	Northeast Pt	3	RU	Y	Trawl net	236.0	NA	1.7	360	VT
07/24/96	Northeast Pt	3	RU	Y	Trawl net	235	23.0	3.6	0	T
07/24/96	Morjovi Sec. 1	3	RU	Y	Trawl net	120	15.5	3.0	0	L
07/24/96	Morjovi Sec. 1	3	RU	Y	Trawl net				0	T
07/25/96	Reef	4	HV	Y	Packing band	2.2	27.2	1.2	0	T
07/27/96	Zapadni	5	HV	Y	Trawl net	80.0	NA	3.2	360	VT
07/29/96	Polovina	2	HV	Y	Rubber gasket	5.2	17.5	3.9	0	T
07/29/96	Polovina	3	HV	Y	Packing band	4.6	19.8	1.2	360	VT
07/31/96	Tolstoi	3	RU	Y	Packing band	1.6	22.5	1.1	0	L
07/31/96	Tolstoi	2	RU	Y	Packing band	3.1	22.3	1.1	0	T
08/01/96	Zapadni Reef	4	H	Y	Twine	3.1	23.5	2.5	360	VT
08/02/96	Lukanin	2	HV	Y	Twine				360	VT
08/02/96	Lukanin	2	HV	Y	Trawl net	450.0	18.5	0.5	0	T
08/05/96	Morjovi Sec. 1	3	RU	Y	Rubber gasket	7.9	17.25	1.7	360	VT
08/05/96	Morjovi Sec. 1	5	RU	Y	Twine	1.6	17.6	2.0	360	VT

Table 11 .--continued.

Date	Location	Est. Age	Survey Type	Debris Removed[1]	Debris Type	Debris Wt.	Mesh Size	Twine Size	Wound (deg.)	Tightness[2]
08/05/96	Morjovi Sec. 1	7	RU	Y	Twine	6.3	44.7	2.0	360	VT
08/05/96	Morjovi Sec. 1	4	RU	Y	Trawl net	660.0	17.5	2.8	360	VT
08/05/96	Morjovi Sec. 1	3	RU	Y	Trawl net	190.0	20.0	1.7	360	VT
08/06/96	Lukanin	2	HV	Y	Packing band				0	T
08/06/96	Vostochni Sec. 10	3	RU	Y	Gasket	8.8	20.5	5.0	360	VT
08/06/96	Vostochni Sec. 10-11	5	RU	Y	Packing band				360	VT
08/06/96	Vostochni Sec. 10-11	3	RU	Y	Packing band	0.7	23.4	0.6	0	T
08/06/96	Vostochni Sec. 10-11	3	RU	Y	Packing band				0	T
08/06/96	Vostochni Sec. 10-11	2	RU	Y	Twine	1.5	22.1	2.5	360	VT
08/06/96	Vostochni Sec. 14	2	RU	Y	Trawl net	130.0	20.5	1.0	0	T
08/06/96	Vostochni Sec. 10-11	3	RU	Y	Trawl net	95.0	22.5	2.3	360	VT
St. George Island										
07/03/96	East Reef	2	RU	Y	Trawl net	38.7	23.5	2.5	180	T
07/03/96	East Reef	6	RU	Y	Packing band	3.0	29.0	1.1	360	VT
07/09/96	Northwest	5	RU	Y	Twine	50.6	30.2	4.0	180	VT
07/09/96	Northwest	7	RU	Y	Trawl net				360	VT
07/18/96	Staraya	2	RU	Y	Rubber band	10.4	25.2	4.0	0	T
07/18/96	Northwest	3	RU	Y	Packing band	1.4	24.4	0.7	0	L
07/19/96	East Reef	3	RU	Y	Twine	10.6	25.2	4.0	360	VT
07/25/96	East Cliffs	2	RU	Y	Packing band	1.7	20.7	1.2	90	L
07/25/96	East Cliffs	2	RU	Y	Twine	2.1	25.0	2.0	270	VT
07/25/96	East Reef	2	RU	Y	Trawl net	32.2	22.0	1.2	180	VT
07/31/96	Zapadni	2	RU	Y	Trawl net	240.0	24.0	3.1	0	L

Table 11 .--continued.

Date	Location	Est. Age	Survey Type	Debris Removed[1]	Debris Type	Debris Wt.	Mesh Size	Twine Size	Wound (deg.)	Tightness[2]
07/31/96	Zapadni	2	RU	Y	Trawl net	90.0	20.5	2.2	270	VT
07/31/96	Staraya	3	RU	Y	Trawl net	460.0	22.5	3.0	0	T
08/04/96	Zapadni	2	HV	Y	Trawl net	10.4	21.5	2.1	360	VT
08/06/96	Northeast	2	HV	Y	Packing band				0	L

[1]Debris removed (yes or no).

[2] L = loose, T = tight, VT = very tight.

Table 12.--Entangled seals observed during entanglement surveys and other research activities from which debris was removed during the field season 1996.

Date	Location	Sex	Age Group[1]	Activity[2]	Description of Debris						
					Disentangled Y/N[3]	Debris Type	Weight	Mesh Size	Twine Size	Tightness[4]	Wound (deg.)
St. Paul Island											
12-Jul	Zapadni	M	Juvenile	Bull counts	Y	Trawl net	20	23.0	3.0	-	0
12-Jul	Zapadni	M	Juvenile	Bull counts	Y	Packing band	-	-	-	VT	360
15-Jul	Vostochni	U	Unknown	Bull counts	Y	Trawl net	296.0	21.0	5.0	-	-
15-Jul	Tolstoi	M	Juvenile	Foraging studies	Y	Packing band	-	-	-	VT	360
17-Jul	Polovina	F	Unknown	Harvest survey	Y	Trawl net	63.5	UNK	7.0	T	0
30-Aug	Reef	F	Unknown	Pup Mortality	Y	Trawl net	51.3	25.0	2.0	-	-
2-Sep	Zapadni	M	Juvenile	Scat collection	Y	Packing band	1.1	23.0	6.0	VT	360
3-Sep	Reef	U	Pup	Misc.	Y	Hemp twine	6.9	25.2	6.0	T	0
3-Sep	Reef	M	Juvenile	Misc.	Y	Trawl net	118.0	22.0	6.0	L	0
3-Sep	Reef	F	Unknown	Misc.	Y	Trawl net	98.3	19.0	3.0	T	90
Fall	Tolstoi	M	Juvenile	Foraging studies	Y	Plastic laundry box	52.3	12.5	-	T	0
Fall	Unknown	U	Pup	Pup activity	Y	Rubber band	4.4	21.0	1.4	-	-
Fall	Unknown	U	Pup	Pup activity	Y	Rubber band	7.3	18.5	1.5	-	-
Fall	Unknown	U	Pup	Pup activity	Y	Rubber band	12.3	21.0	2.0	-	-
Fall	Unknown	U	Pup	Pup activity	Y	Raingear material	7.1	19.5	3.8	-	-
Fall	Reef	M	Juvenile	Pup activity	Y	Packing band	-	-	-	-	-
Fall	Reef	M	Juvenile	Pup activity	Y	Packing band	-	-	-	-	-
Fall	Reef	M	Juvenile	Pup activity	Y	Unidentified	-	-	-	-	-
Fall	Reef	F	Unknown	Pup activity	Y	Unidentified	-	-	-	-	-

Table 12.--continued.

Date	Location	Sex	Age Group[1]	Activity[2]	Description of Debris: Disentangled Y/N[3]	Debris Type	Weight	Mesh Size	Twine Size	Tightness[4]	Wound (deg.)
St. George Island											
2-Jul	Northwest	M	Juvenile	Roundups	Y	Trawl net	6.6	22.0	1.2	VT	360
14-Jul	East Cliffs[2]	M	Adult	Roundups	Y	Synthetic twine	43.6	29.5	9	VT	360
28-Jul	Northeast	M	Juvenile	Roundups	Y	Trawl net	8.2	-	3.0	T	360
28-Jul	East Reef	M	Juvenile	Roundups	Y	Trawl net	2.5	18	1.8	VT	90
1-Aug	Northeast	M	Juvenile	Roundups	Y	Trawl net	40.4	12	2.2	VT	300
6-Aug	North	U	Juvenile	Misc.	Y	Packing band	1.6	21.5	9	-	0
7-Aug	Zapadni	U	Juvenile	Misc.	Y	Cotton twine	7.2	22.5	4.2	VT	90
10-Aug	Zapadni	M	Juvenile	Misc.	Y	Packing band	1.4	22	6	VT	360
11-Aug	East Reef	M	Adult	Misc.	Y	Trawl net	250	21.5	2.4	VT	360
14-Aug	South	F	Unknown	Shearing samp.	Y	Trawl net	322	24	2.7	-	0
14-Aug	South	F	Unknown	Shearing samp.	Y	Packing band	-	-	-	VT	360
6-Sep	East Reef	M	Juvenile	Foraging studies	Y	Trawl net	109.5	21.5	3.5	T	0
6-Oct	East Cliffs	M	Juvenile	Foraging studies	Y	Trawl net	38.0	22	4.2	VT	180
16-Oct	East Cliffs	M	Juvenile	Foraging studies	Y	Bait bag	22.1	24	2.9	VT	360
Fall	East Cliffs	U	Unknown	Foraging studies	Y	Trawl net	215.0	22.5	4.0	-	-
Fall	East Cliffs	U	Unknown	Foraging studies	Y	Trawl net	166.0	23.0	3.0	-	-

[1]Only pups for which debris was saved are included. Total numbers of pups disentangled were estimated by researchers conducting pup activity

[2]Seals disentangled incidental to, but which were not in roundups or harvest samples were not included in entanglement calculations.
[3]Whether debris was removed (yes or no).
[4]L=loose, T=tight, VT=very tight

Table 13 .-- Number of adult and juvenile male nor-them fur seals observed in frequently occurring types of debris and percent entangled by island and age group.

Island/Age	Type of Debris								
	Trawl Net		Packing Band		Twine		Misc.		
	No.	%	No.	%	No.	%	No.	%	Total
St. Paul Juvenile	16	43.2	12	32.4	5	13.5	4	10.8	37
St. George Juvenile	6	50.0	3	25.0	2	16.7	1	8.3	12
St. Paul Adult	3	15.8	13	68.4	3	15.8	--	--	19
St. George Adult	1	33.3	1	33.3	1	33.3	--	--	3
St. Paul Overall	19	33.9	25	44.6	8	14.3	4	7.1	56
St. George Overall	7	46.7	4	26.7	3	20.0	1	6.7	15

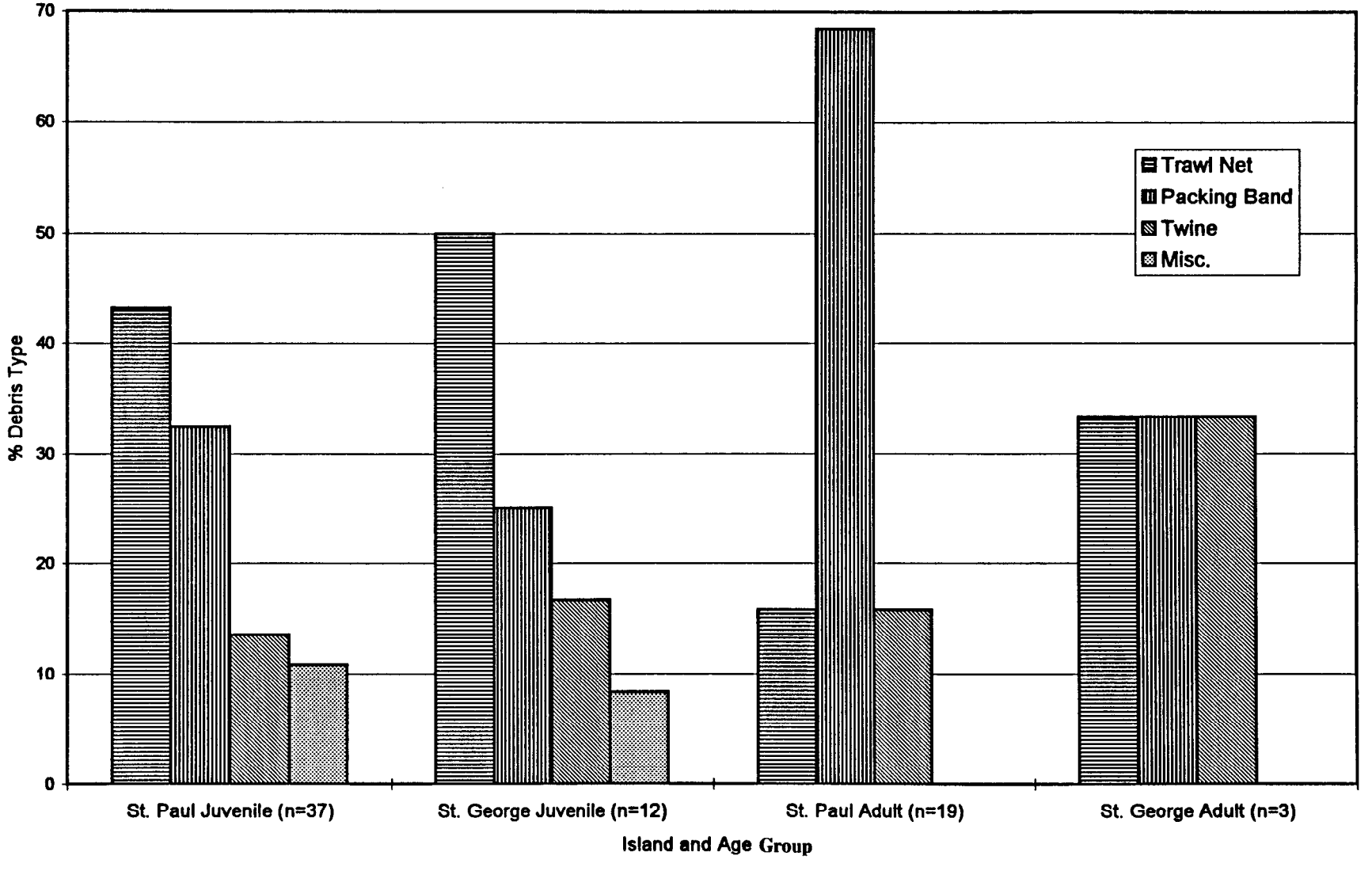

Figure 11 .--Composition of entangling debris observed on northern fur seals during 1996 entanglement surveys.

Under the full linear model only the age of a seal (juvenile vs. adult) had a significant effect on the rate of entanglement (P=0,003) (Table 14). No significant difference in the entanglement rate was observed between islands (P=0.45) or sample type (P=0.41) for either juvenile or adult male fur seals. In contrast, results from 1995 surveys showed a significantly higher rate of juvenile male entanglement on St. George Island.

The incidence of entanglement among juvenile males on St. Paul Island is within the range of entanglement rates observed from 1988 to 1992 (Table 15; Fig. 12) and in 1995 (Robson et al. 1997). Fowler et al. (1993) attributed decline in the rate of entanglement on St. Paul Island from a mean rate of 0.4% between 1976 and 1985 to current levels to a reduction in the fraction of seals entangled in trawl net fragments (Table 16). The percent composition of debris types among juvenile male fur seals in 1996 (Fig. 11) was consistent with previous years on St. Paul Island. A decrease in the number of seals observed entangled in trawl net and in twine, rope, or string on St. George Island from 1995 to 1996 resulted in a similar proportion of debris in each category on both islands in 1996 (Table 16).

Adult Female Entanglement

Four entangled and 7 scarred (evidence of previous entanglement) adult female fur seals were observed during female entanglement surveys on St. Paul Island (Table 17). The rate of entanglement among females was calculated at 0.013 % for entangled females, 0.02 % for scarred females and 0.036% for the two categories combined. Information on the type of entangling debris is given in Table 18. The 1996 data are comparable to the observed rate of entangled and entangled and scarred females combined in 1995, and to that observed in 1992 and 1993 (Table 19) (Kiyota and Fowler 1992, Kiyota unpublished data). Information on the type of entangling debris is given in Table 18.

Table 14.--Results of statistical analysis of adult and juvenile male northern fur seal entanglement rates on St. Paul and St. George Islands, 1996.

Factor	Df	Deviance	Residual Df	Residual Deviance	Pr(Chi)
Null			173	162.59	
Age	1	9.11	172	153.47	0.00
Island	1	0.55	171	152.91	0.45
Sample type	1	0.66	170	152.24	0.41
Age x Island	1	0.80	169	151.44	0.36
Age x Sample type	1	0.44	168	150.99	0.50
Island x Sample type	1	0.71	167	150.28	0.39
Age x Island x Sample type	1	0.89	166	149.38	0.34

Table 15 .--The percentage of juvenile 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 1996.

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

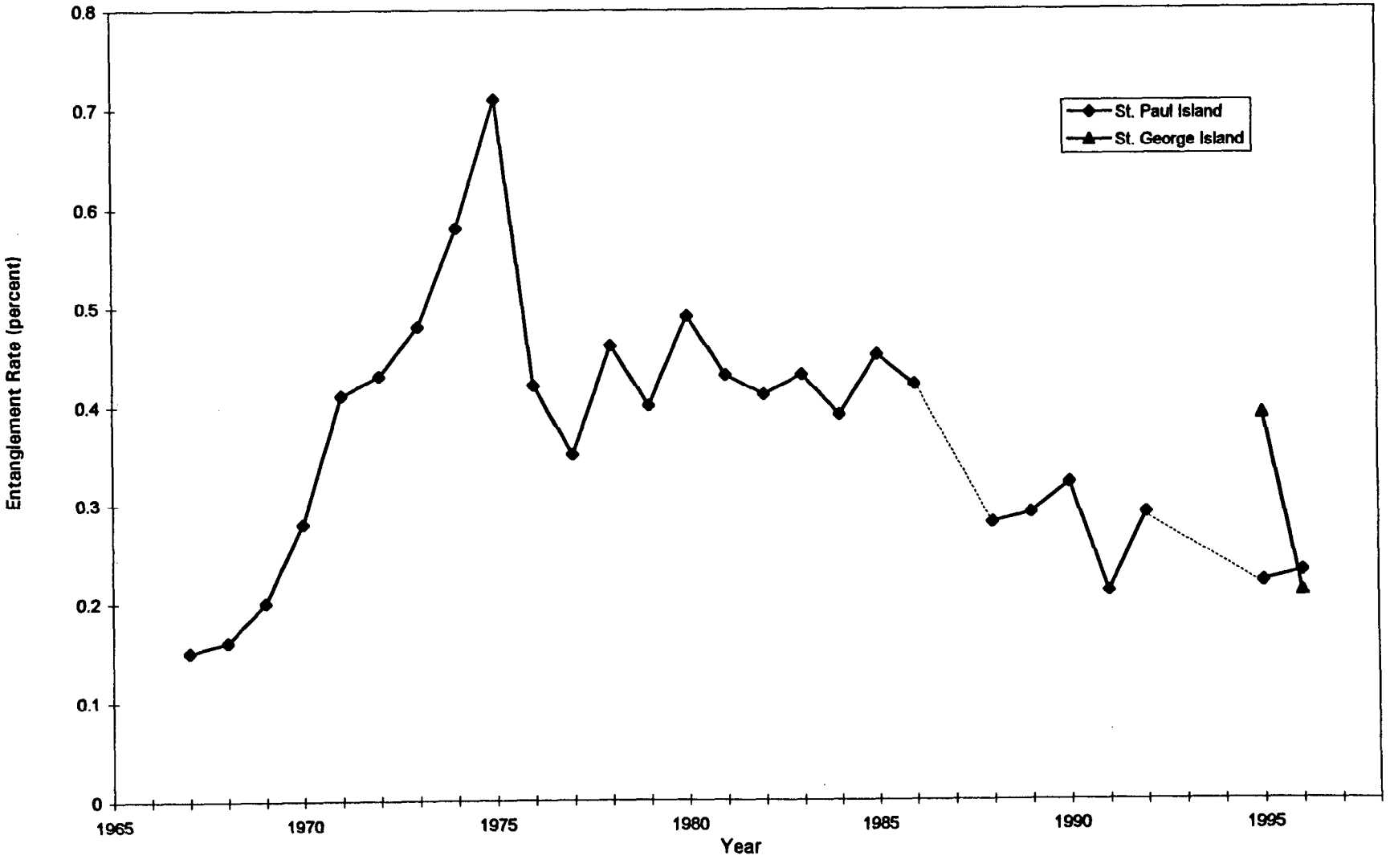

Figure 12.--The percentage of juvenile male northern fur seals from St. Paul and St. George Islands, Alaska, entangled in marine debris recorded during the commercial harvest (1967-84) and entanglement surveys (1985-96).

Table 16.-- Debris found on juvenile male northern fur seals from St. Paul and St. George Islands, Alaska, 1981-95, expressed as the incidence of entanglement (observed percent) among juvenile males entangled by debris catagory (data for 1981-91 from Fowler and Ragen 1990, Fowler and Baba 1991, and Fowler et al. 1992).

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	0.00	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	0.00	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	0.00	0.01	0.22	22
1996	0.10	0.07	0.03	0.00	0.02	0.23	37
St.George Island							
1995	0.18	0.05	0.11	0.00	0.05	0.39	17
1996	0.11	0.05	0.04	0.00	0.02	0.21	12

Table 17.--Surveys of female entanglement conducted during July 1996

Date	Rookery	No. Counted	Females Entangled	Females Scarred	Females Entangled and Scarred
7/14/96	Zapadni	3,424	0	1	1
7/14/96	Little Zapadni	2,442	0	0	0
7/14/96	Zapadni Reef	949	0	0	0
7/12/96	Tolstoi	4,164	1	2	3
7/17/96	Gorbatch	2,571	0	0	0
7/17/96	Ardiguen	521	0	0	0
7/17/96	Reef	4,437	1	2	3
7/15/96	Kitovi	1,084	0	0	0
7/15/96	Lukanin	887	0	0	0
7/13/96	Polovina	484	0	0	0
7/13/96	Polovina Cliffs	3,596	0	0	0
7/13/96	Little Polovina	50	0	0	0
7/16/96	Morjovi	1,680	2	0	2
7/16/96	4137	4,137	0	2	2
Total		30,426	4	7	11
Rate (%)			0.0131	0.0230	0.0362

Table 18.--Information on entangled females observed during surveys of female entanglement during 1996.

Date	Rookery	Entangling Debris	Color	Position	Vibrissae Color
7/12/96	Tolstoi	not visible	--	neck	white
7/16/96	Morjovi	trawl net	white	neck	white
7/16/96	Morjovi	trawl net	grey-green	neck	white
7/17/96	Reef	monofilament net	transparent	neck	black

Table 19.-- 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	Ent+Scar
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

MASS, LENGTH AND SEX RATIOS OF NORTHERN FUR SEAL PUPS ON ST. PAUL AND ST. GEORGE ISLANDS, 1996

by

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and Bruce W. Robson

Trends in the mass and length of fur seal pups serve as indicators of population health between years and locations. Here we report average mass, lengths, and sex ratios from male and female pups from Tolstoi, Vostochni, Polovina, and Reef rookeries on St. Paul Island and all rookeries on St. George Island in 1996. We also report on comparisons of mass, length, and sex ratios between islands and years in which the sampling was done on about the same dates. Mass and length data are included in the figures for 1992 and 1993, St. George Island, for comparison but are not in the analyses due to differences in timing of collection.

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 analysis of variance on sex and rookery. We limited our statistical comparisons to information collected on similar dates (24 to 29 August) during the breeding season; between islands in 1994, 1995, and 1996, between 1992, 1994, 1995, and 1996 on St. Paul Island, and between 1994, 1995, and 1996 on St. George Island. Sex ratio comparisons were made among rookeries, islands, and years for all years of data.

The proportions of pups sampled on each rookery were not the same for all years. Therefore, the mean mass for all pups on St. Paul Island was calculated for males and females for 1992 and 1994 using a weighted sum of the rookery means; weights were chosen to be proportional to the fraction of total pup production for the island by that rookery. For each sampled rookery in 1995, the means were weighted by the proportion of the total harem (territorial) bulls contributed by that rookery since pup production numbers were not available. In 1996, the means for each rookery on St. George Island were weighted by pup production numbers and St. Paul Island means were weighted by harem bull counts. These fractions are considered representative of the size of the pup population, or harem bull population, on each rookery and are independent of the mass data. The variance of the weighted mean is estimated as the sum of the product of the squared weight with the variances of the mean mass from each rookery.

The calculations were determined in the following manner: Let B_1, B_2, . . . B_4 be the 1996 harem bull counts on the four St. Paul rookeries where studies were conducted during 1996). Let W_{ij} be the corresponding mean mass of pups on rookery I, I = 1, 4 for sex j (j = 1 for females, 2 for males) from Appendix Table C-l. Let V_{ij} be the variance for W_{ij}; V_{ij} is calculated as the square of the standard deviation (Appendix Table C-l) divided by the sample size (Appendix Table C-l). For example, for females on Reef rookery in 1996 the calculation was $V(1,l) = (1.36)^2/128$. For each rookery, I, the fraction of pups or harem bulls (f_i, Appendix Table C-2) contributed by that rookery is computed as:

$$f_i = B_i \; / \; \sum_{i=1}^{4} B_i .$$

Then the weighted mean (M) for sex j is

$$M_j = \sum_{i=1}^{4} f_i \, W_{i,j} \; ,$$

with variance:

$$S^2{}_j = \sum_{i=1}^{4} f_i \, V_{i,j} .$$

Similar calculations were made for lengths of pups on St. Paul Island (Appendix Table C-3) and for mass and length of pups on St. George (Appendix Tables C-4 and C-5) Island. B_i is replaced by P_i = number of pups (on a given rookery I) for 1992 and 1994 on both islands and 1996 on St. George Island. Pair-wise significant differences among the means were assessed using Tukey's Honest Significant Difference Test (Neter et al. 1990), q(7,df,.95). The first parameter, 7, represents the number of comparisons made within sex by year and island. Degrees of freedom (df) were determined to be the total number of sample points (pups) in all years minus the number of parameters estimated minus l(df = 3,806 females, df = 4,481 males, the test statistic is equal to 4 significant digits, 4.1696, for all categories).

An analysis of the sex ratios by rookery and year was conducted using a general linear model (McCullagh and Nelder 1983) assuming that the fraction of females in each rookery was a binomial random variable. The logit of the fraction of females [log(p/(l-p)] was modeled as a linear function of rookery and year of sample. The analysis is similar to an ordinary analysis of

variance, except that the significance of a factor is judged by comparing the total sum of squares explained by that factor with a chi-square random variable with degrees of freedom equal to the degrees of freedom of that factor.

RESULTS AND DISCUSSION

Pup Mass and Length

Pup mass (Pig. 13) varied significantly ($P < 0.001$, Table 20a) by sex and rookery for St. Paul Island. Male and female pups were analyzed separately since the variance for males was greater than females and again the difference between rookeries was significant ($P < 0.001$, Table 20b). Similarly, pup lengths (Pig. 14) were significantly different ($P < 0.001$, Table 21a) by sex and rookery on St. Paul Island in 1996. Male and female pups were again analyzed separately and there was a significant difference between rookeries for each ($P < 0.001$ females, $P < 0.001$ males Table 2lb). Pup mass was less on Tolstoi than on the other three sample rookeries ($P < 0.05$) in 1996, and pups from Tolstoi and Vostochni rookeries were shorter than pups from Polovina Cliffs and Reef rookeries ($P < 0.05$).

On St. George Island, pup mass (Fig. 15) was also significantly different ($P < 0.001$, Table 22) by sex and rookery. The analysis of variance for lengths (Fig. 16), for all sample years also indicated significant differences by sex ($P < 0.001$, Table 23) and by rookery ($P < 0.001$, Table 23). Pups on South rookery were shorter than all other rookeries on St. George Island ($P < 0.05$). The mass of pups on Zapadni rookery was less than all other rookeries on St. George Island ($P < 0.05$).

A separate analysis was conducted to compare the pup mass (Table 24) and length (Table 25) for pups that were measured on similar dates (within 3 to 5 days). Pup mass in 1996 was not

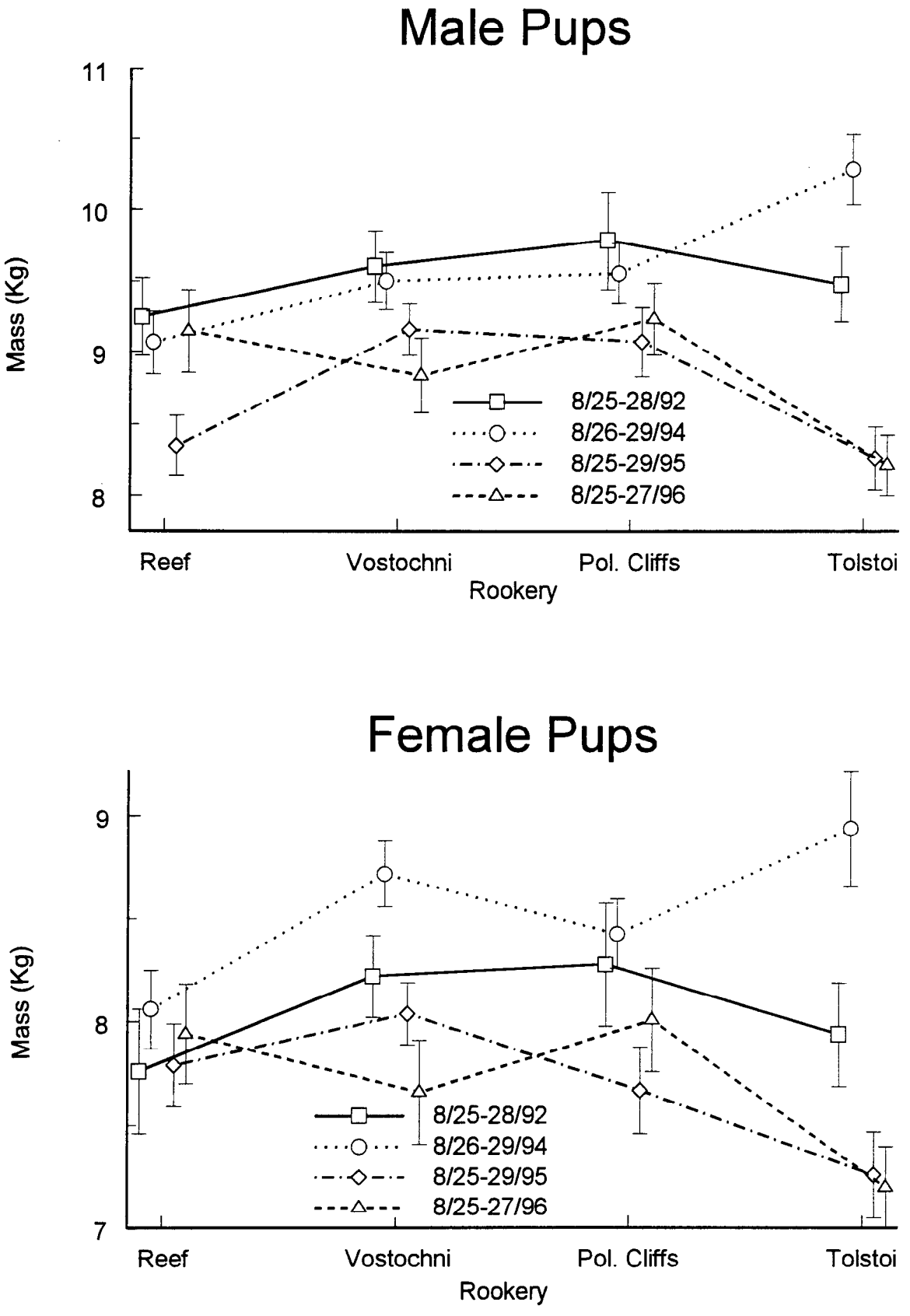


Figure 13.--Mean mass with 95% confidence intervals of northern fur seal pups weighed during August 1992, 1994, 1995, and 1996, St. Paul Island, Alaska.

Table 20a.--Analysis of variance of mass of northern fur seal pups on St. Paul Island, Alaska, August 1996, by sex (Sx) and rookery (R).

Factor	df	SS Due to Factor	MSS*	Residual	df	F	p
Sex	1	451.6	451.6	2653	1147	207.6	1.000
Rookeries	3	168.8	56.3	2484	1144	25.9	1.000
Sx x R	3	2.4	0.8	2482	1141	0.6	0.223

Table 20b.--Analysis of variance of mass of northern fur seal pups on St. Paul Island, Alaska, August 1996, by sex on rookery.

Factor	df	SS Due to Factor	MSS*	Residual	df	F	p
Females							
Rookeries	3	56.8	18.9	930.1	516	10.5	1.000
Males							
Rookeries	3	114.4	38.1	1551.4	625	15.4	1.000

*MSS = SS divided by df

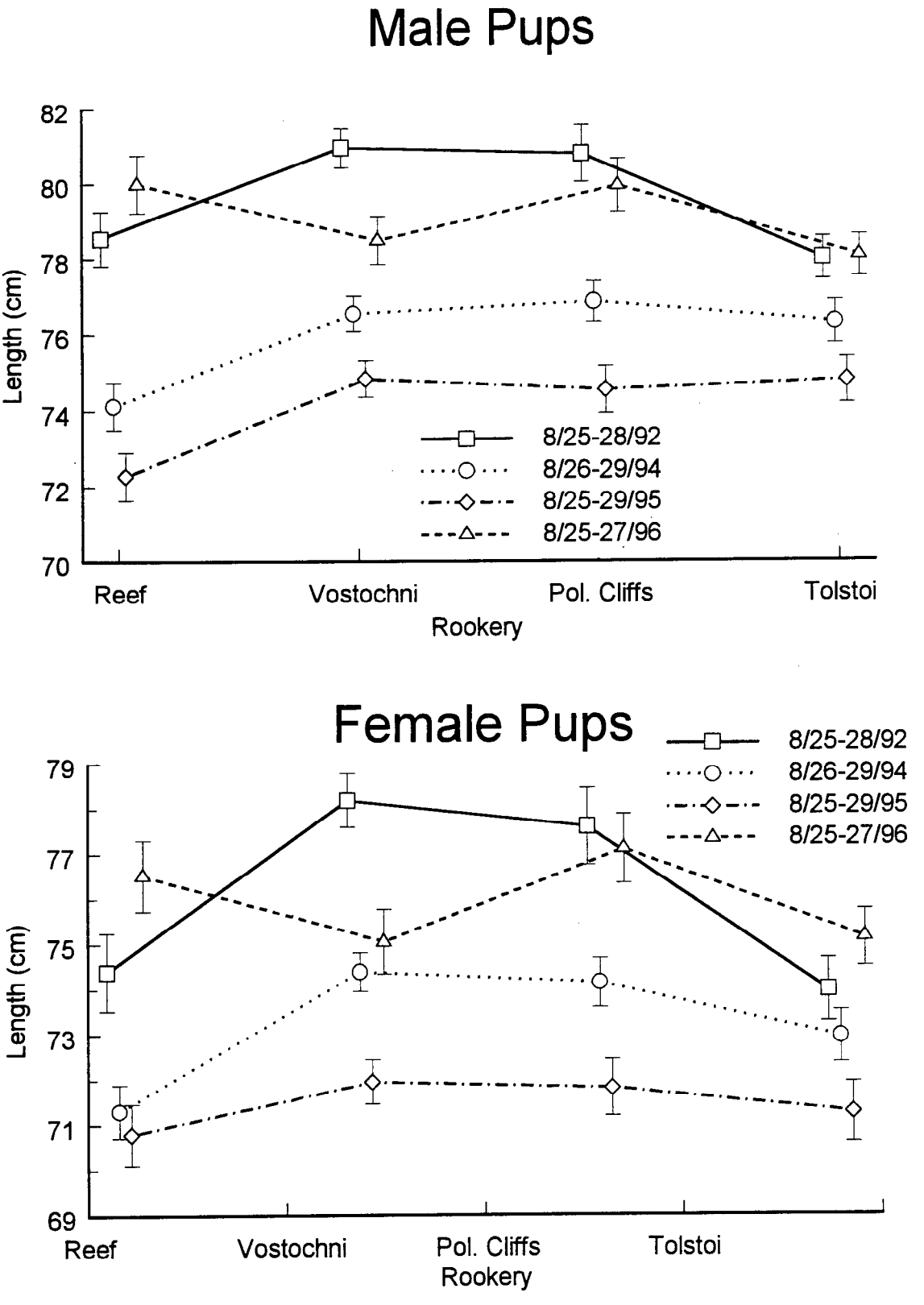


Figure 14.--Mean length with 95% confidence intervals of northern fur seal pups weighed during August 1992, 1994, 1995, and 1996, St. Paul Island, Alaska.

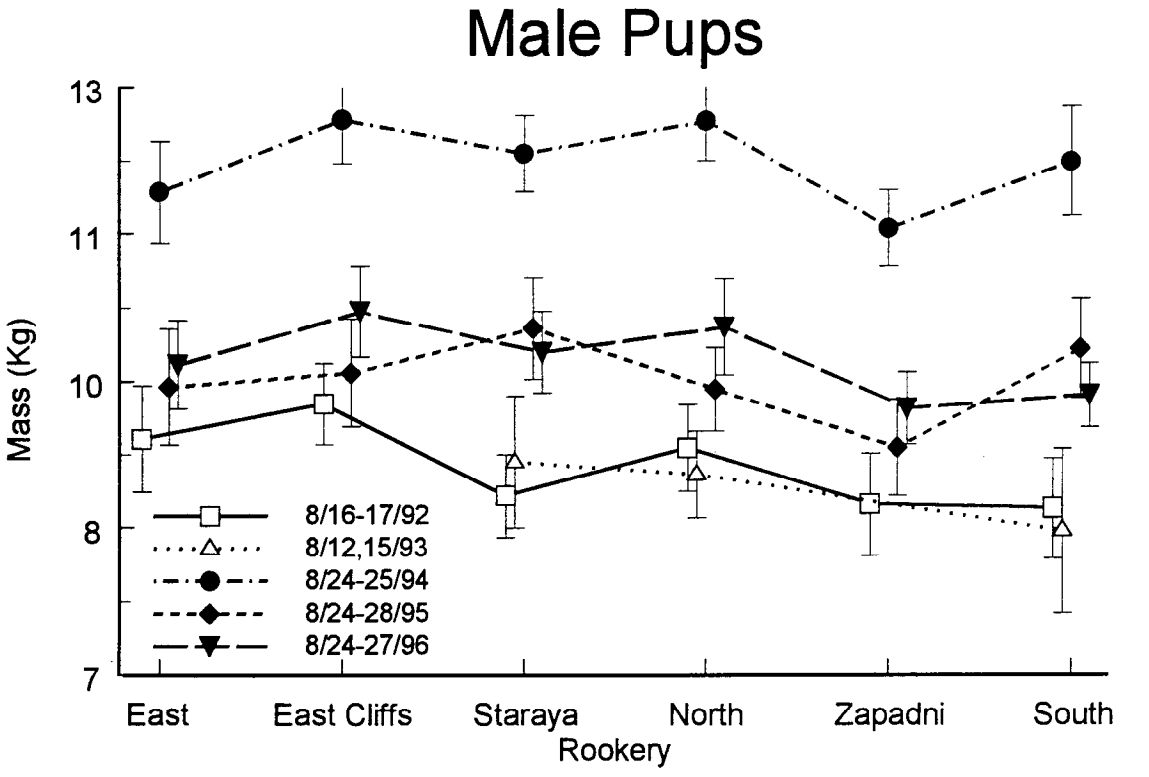
Table 2la.--Analysis of variance of length of northern fur seal pups on St. Paul Island, Alaska, August 1996, by sex (Sx) and rookery (R).

Factor	df	SS Due to Factor	MSS*	Residual	df	F	p
Sex	1	2766.7	2766.7	20940	1147	157.3	1.000
Rookeries	3	849.8	283.3	20090	1144	16.1	1.000
Sx x R	3	23.5	7.8	20066	1141	0.4	0.280

Table 2lb.--Analysis of variance of length of northern fir seal pups on St. Paul Island, Alaska, August 1996, by sex on rookery.

Factor	df	SS Due to Factor	MSS*	Residual	df	F	p
Females							
Rookeries	3	389.9	129.9	8885	516	7.5	1.000
Males							
Rookeries	3	483.4	161.1	11182	625	9.0	1.000

*MSS = SS divided by df



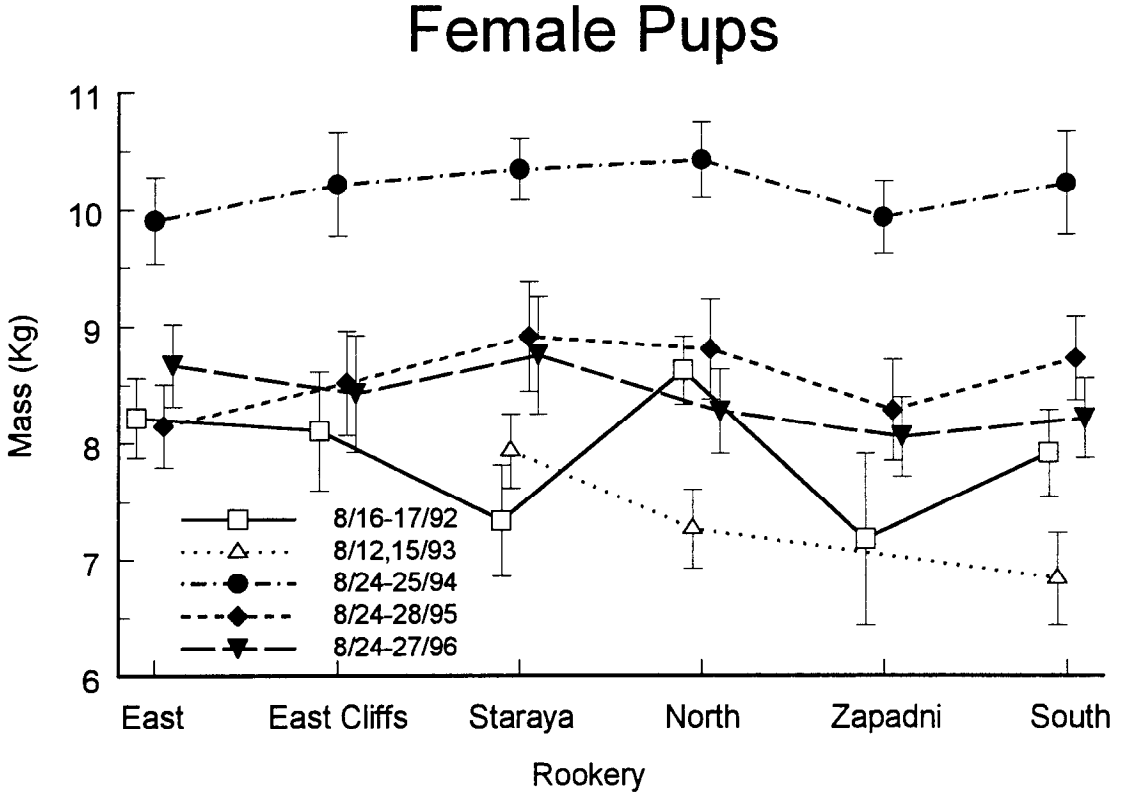


Figure 15.--Mean mass with 95 % confidence intervals of northern fur seal pups measured during August 1992-96, St. George Island, Alaska.

Table 22.--Analysis ofvariance of the effects of sex and rookery on the mass of northen fur seal pupsweighed on St. George Island, Alaska, 24-27 August 1996.

Factor	df	SS Due to Factor	MSS*	Residual	df	F	p
Sex	1	423.3	423.3	1696.9	747	191.4	1.000
Rookeries	5	50.3	10.1	1646.7	742	4.5	1.000
Sx x R	5	16.6	3.3	1630.1	737	1.5	0.812

Table 23.--Analysis of variance of the effects of sex and rookery on the length of northern fur seal pups weighed on St. George Island, Alaska, 24-27 August 1996.

Factor	df	SS Due to Factor	MSS*	Residual	df	F	p
Sex	1	2678.6	2678.6	12502.6	747	171.8	1.000
Rookeries	5	990.0	198.0	11512.6	742	12.7	1.000
Sx x R	5	23.6	4.7	11489.1	737	0.3	0.884

*MSS = SS divided by df

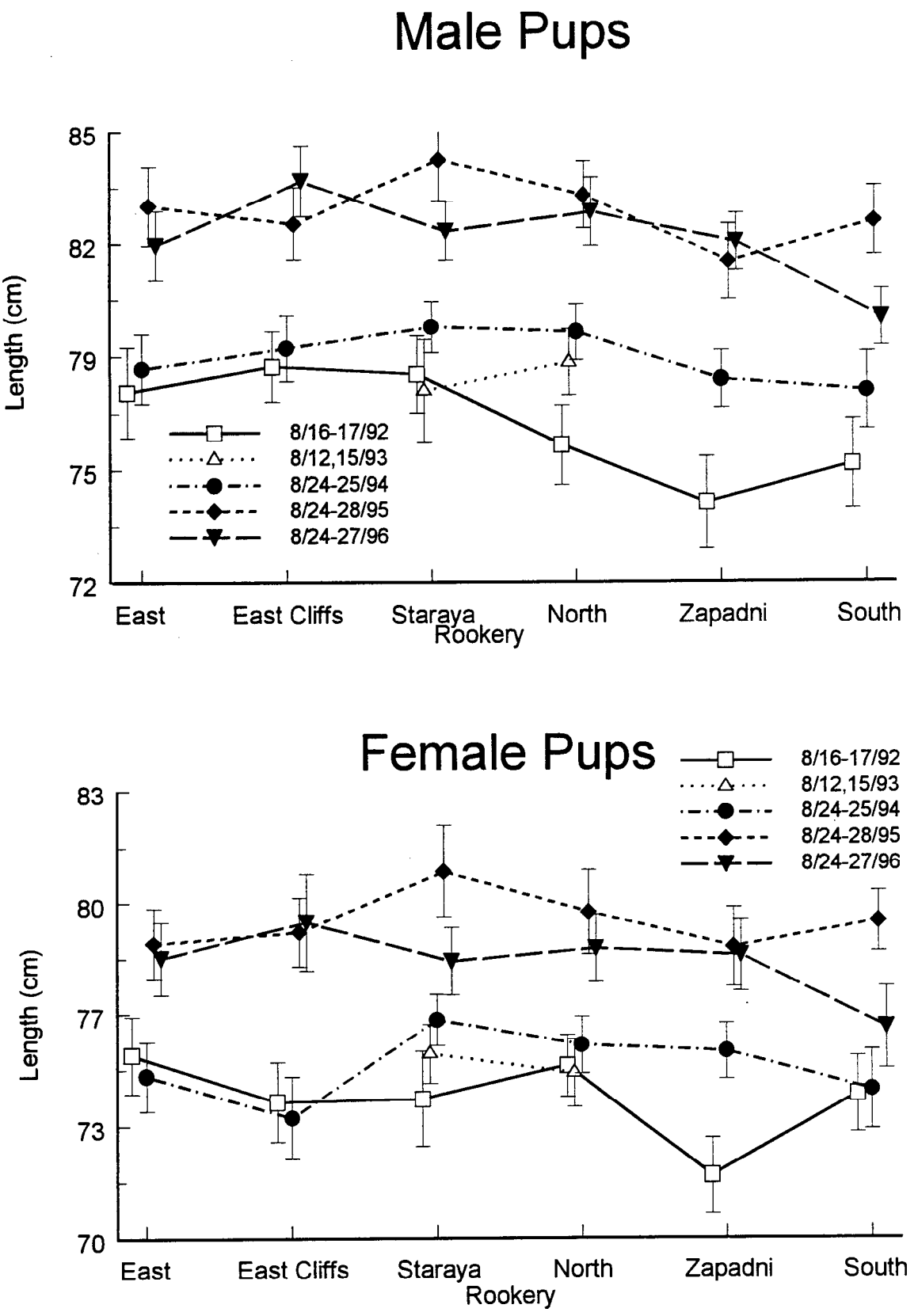


Figure 16.--Mean length with 95 % confidence intervals of northern fur seal pups measured during August 1992-96, St. Paul Island, Alaska.

Table 24.--Estimated mean mass (kg) with its standard error for northern fix seal female and male pups, St. Paul Island, Alaska, 1992-96 and St. George Island, Alaska, 24-29 August 1994-96.

	St. Paul				St. George		
	1992	1994	1995	1996	1994	1995	1996
Females	8.90	8.38	8.06	8.02	10.25	8.64	8.33
SE	0.065	0.054	0.049	0.064	0.084	0.101	0.088
Males	9.97	10.07	9.20	9.30	11.91	9.75	9.99
SE	0.070	0.057	0.054	0.068	0.095	0.105	0.093

Table 25.--Estimated mean length (cm) with its standard error for northern fur seal female and male pups, St. Paul Island, Alaska, 1992-96 and St. George Island, Alaska, 24-29 August 1994-96.

	St. Paul				St. George		
	1992	1994	1995	1996	1994	1995	1996
Females	76.11	73.21	71.50	75.80	75.00	79.21	78.00
SE	0.185	0.138	0.155	0.191	0.225	0.275	0.258
Males	79.59	75.95	74.11	79.00	78.60	82.65	81.94
SE	0.158	0.141	0.147	0.177	0.208	0.243	0.217

significantly different (P> 0.05, Appendix Table C-6) from 1995, within island and within sex. Male pups on St. George Island were heavier than male pups on St. Paul Island in 1996 (P < 0.05). Significant differences in pup length between islands and years were parallel between males and females (Appendix Table C-7). The length of pups in 1996 on St. George Island was not significantly different than in 1995 (P> 0.05, Appendix Table C-7). Pups on St. Paul Island were significantly longer (P< 0.05, Appendix Table C-7) in 1996 than in 1995.

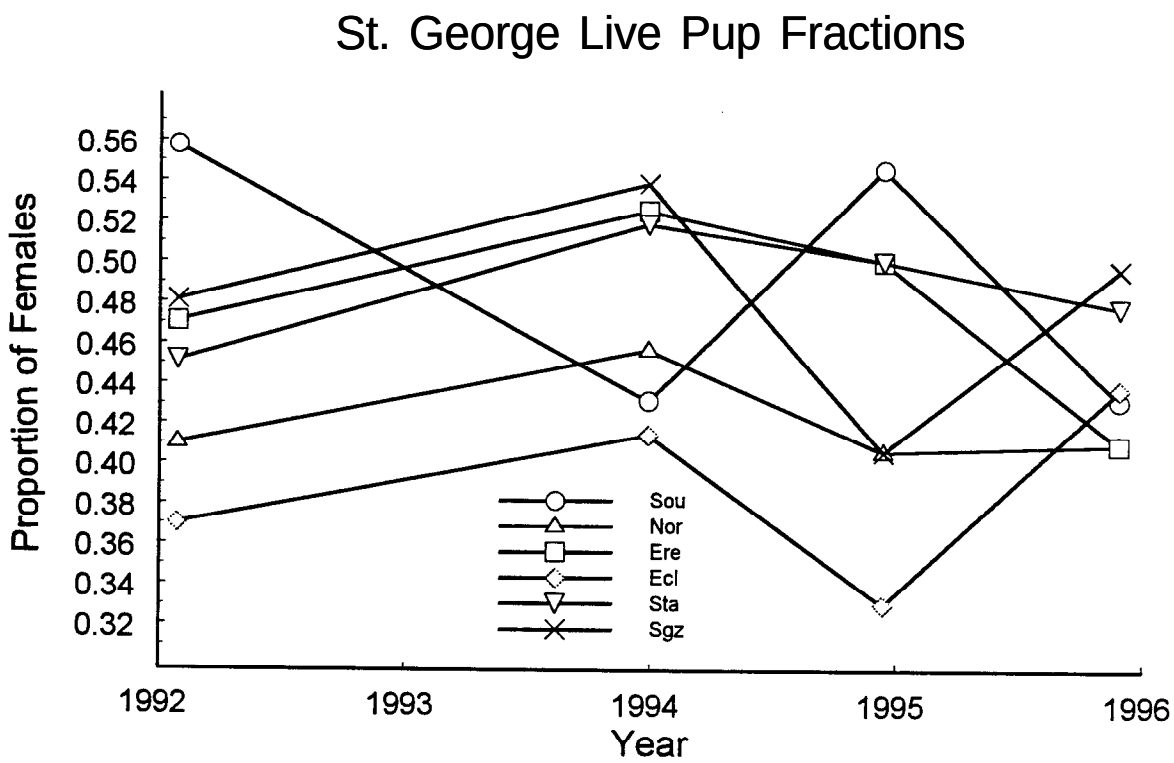
Sex Ratios

An analysis of variance of the proportion of female to male pups born (Table 26; Fig. 17) by rookery was conducted assuming that the fraction of females in each rookery was a binomial random variable. In 1996, there was no significant difference (P = 0.44) in the proportion of females to males by rookery. Furthermore, there was no difference between islands for 1996 (P = 0.65). The fraction of females (44.8%) was significantly less than 50% (P < 0.001).

A significant year-rookery interaction (P = 0.058, Table 27) was found when all sex ratio data (Table 28) were combined in a general linear model (GLM). We used a tree-based model to determine year-rookery groups such that within groups the sex ratios were similar and dissimilar sex ratios between groups. We then fit a GLM based on these groups. This procedure produced a GLM with deviance 46.08 (df = 37) which was not significantly different (P = 0.145) from the full interaction model. Both models confirmed the following three groups: 1) the proportion, 39.5%, for North and East Cliffs in all years; 2) the proportion, 48.4%, for all rookeries in 1994, as well as South and Staraya Artil in all years; 3) 45.3% for all rookeries on St. Paul Island and Zapadni and East Reef on St. George Island, in all years except 1994. All of the above groups were significantly different from each other (P = 0.025). The fraction of females was less than 50% for the groups listed in 1 and 3 above.

Table 26.--Numbers of female northern fur seal pups, total number of pups, and fraction (that were female) of northern fur seal pups sampled during pup weighing on St. Paul Island, Alaska, August 1996. The fraction of females was significantly less than 50% (p =.95) for bold items.

	1996		
Rookery	Females	Total	Fraction
Reef	128	251	0.510
Vostochni	122	269	0.454
Pol. Cliffs	**110**	**269**	**0.409**
Tolstoi	**160**	**360**	**0.444**
Total	**520**	**1,149**	**0.453**
East Reef	**63**	**154**	**0.409**
East Cliffs	52	119	0.437
Staraya Artil	51	107	0.477
North	**45**	**110**	**0.409**
Zapadni	64	129	0.496
South	56	130	0.431
Total	**331**	**749**	**0.442**



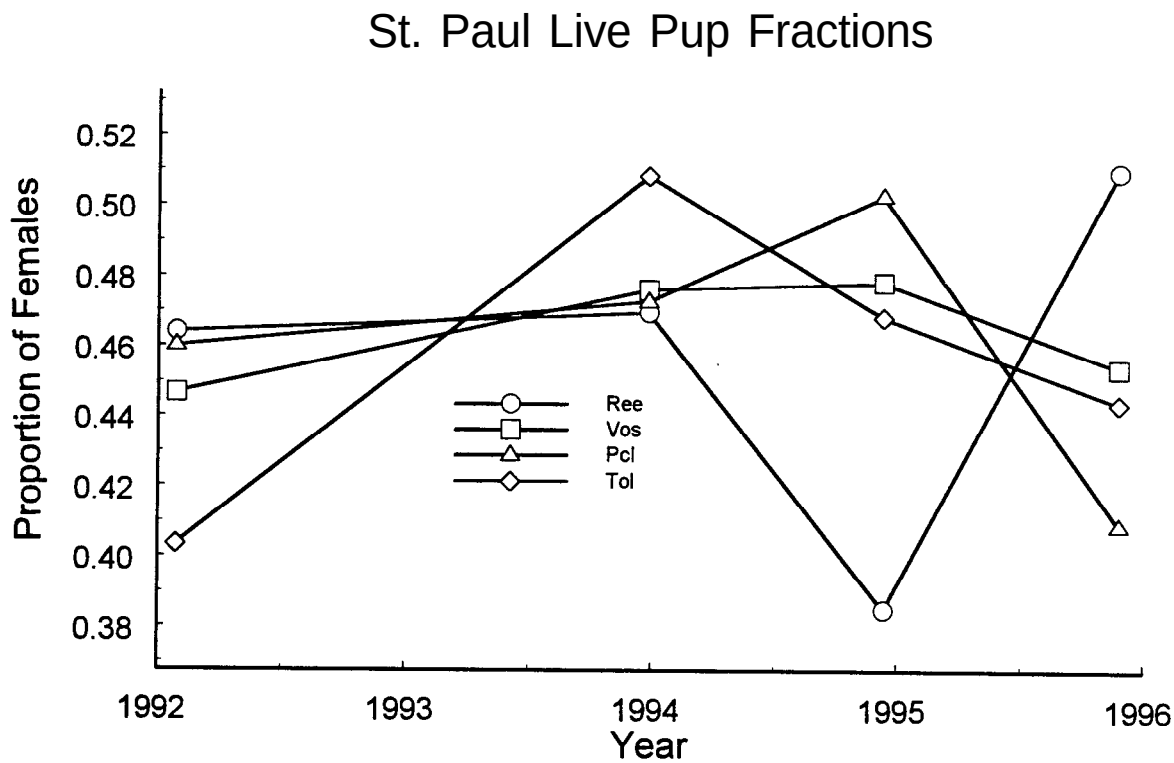


Figure 17.--Fraction of live female pups on the Pribilof Islands, Alaska, 1992, 1994, 1995, and 1996.

Table 27.--Analysis of deviance for dependence of sex-ratio on rookery and year sampled of northern fur seal pups on the Pribilof Islands, Alaska, 1992-96. Fraction of females modelled as a general linear model with binomial errors and logit link functions. The "reduction in deviance" is the amount the residuals are reduced when the given factor is entered into the model in order of significance; the deviance is the weighted residual sum of squares for the model.

Factor	df	Deviance	df	Deviance Reduction	P
Grand Mean	39	65.985			
Year	30	47.078	9	18.907	0.026
Rookery	27	39.433	3	7.645	0.054
Rky * Year	0	0.000	27	39.433	0.058

Table 28.--Numbers of female pups, total number of pups, and fraction (that are female) of live northern fir seals pups captured during weighing operations on St. Paul Island and separate samples on St. George Island, Alaska, for the years 1992-96.

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

SUMMARY

Consistent with earlier evaluations of pup mass data (York and Antonelis 1990, York and Towell 1993, Antonelis et. al. 1994, and Towell et. al. 1997) the strongest pattern was that the size of pups varied by sex: males outweighed females and male pups are longer than female pups. Some inter-annual and inter-island differences are also apparent. On St. Paul Island the mass of male pups in 1996 was significantly less than in 1992 and 1994 but not different from 1995. The length of male and female pups was significantly less on St. Paul Island in 1996 than on St. George Island in 1995 and 1996. There is no significant difference in the mass of females between islands in 1996 ($P > 0.05$) but the St. George Island males are heavier than the St. Paul Island males ($P < 0.05$). Pups were significantly longer ($P < 0.05$) on St. George Island than on St. Paul Island in 1996. The proportion of females was significantly less ($P < 0.01$) than 50%,(45% on St. Paul Island and 44% on St. George Island) for both islands in 1996.

These differences in mass, length, and sex ratio may reflect variability in the environmental influences on the condition of pups and their mothers. Undetected biases in sampling techniques may also be responsible of the differences detected in this study.

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

by

Sharon R. Melin and Robert L. DeLong

The northern fur seal population at San Miguel Island, California (34° 01'N, 120° 26'W), was discovered in 1968. The population was discovered when very small and has provided an opportunity to study the dynamics of a growing population.

In general the population has grown steadily with one severe decline probably resulting from high adult mortality during the 1982-83 El Niño (DeLong and Antonelis 1991). Since 1984, the population has grown and, in 1991, fully recovered to pre-El Niño levels (Melin and DeLong 1994). The 1992-93 El Niño conditions resulted in reduced pup production in 1992 but the population recovered in 1993 and increased in 1994 (Melin et al. 1996).

This paper presents the results of the 1996 population monitoring studies at San Miguel Island with 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

Counts of territorial male northern fur seals (Classes 2 and 3) at Adams Cove, San Miguel Island, were conducted every 1 to 3 days from 3 June through 24 July 1996. 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, but were not conducted at Castle Rock due to unfavorable weather conditions. Pups censuses were 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.

Two fur seal pup mortality surveys, one each in June and July were conducted in Adams Cove. In June, pups were not collected from within the breeding groups because of the potential for disturbance to newborn pups and pregnant females. During the July survey, pups were collected from the entire fur seal rookery. Each dead pup was also counted, removed 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 by each observer.

Pup Tagging and Growth

A total of 300 northern fur seal pups were tagged with pink plastic roto tags in Adams Cove on 1 October. 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 2, 3 and 30 July. 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.

Instrumentation of Adult Females

On 2 and 3 July, three northern fur seal females with pups were instrumented with 0.25 watt satellite-linked depth recorders (SLTDRs) in order to study dive patterns. The instruments were recovered from 20-24 July. Two instruments functioned throughout the deployment and one instrument failed shortly after deployment. The data from the SLTDRs have not yet been analyzed.

Investigation of the Incidence of Hookworms

In July 1996, dead northern fur seal pups were examined for the presence of hookworms. Dead pups were collected and the small and large intestines removed. The intestines were then rinsed into sieves and the hookworms were collected from the sieves, placed in containers, and stored in 50 to 100% ethanol. The hookworms for each pup were counted and sexed to determine incidence of hookworms in dead fur seal pups (see Lyons et al., In press for detailed methods).

RESULTS

Observation and Census of Adults

Territorial northern fur seal males arrived before 3 June and the maximum number of territorial males with females, 162, occurred on 6 July. An additional 43 males held territories without females on the same date. The 1996 total represents a 33% increase in the number of territorial males from the 154 recorded in 1995 (Melin and DeLong, 1997).

Pup Census

The mean count of live fur seal pups was 1,808 (S.E.=0.28) pups at Adams Cove on 30 July. A total of 201 dead pups were counted. The total observed production was 2,009 pups, a 20.6% increase from the Adams Cove production in 1995 (Melin and DeLong, 1997). The observed mortality rate was 10%, considerably higher than the 5.3% in 1995 (Melin and DeLong, 1997).

Pup Growth

The mean weights of male (11.8 kg) fur seal pups were similar to the weights of male pups in 1995 (11.9 kg) (ANOVA, $p=0.601$) (Table 29). However, the mean length (78.2 cm) and girth (52.6 cm) of male pups in 1996 were less than male pups in 1995 (lengths ANOVA $p<0.00l$; girths ANOVA $p<0.001$).

The mean weight of female pups (10.6 kg) was similar to females in 1995 (10.8 kg) (ANOVA, $p=0.220$) (Table 29). The mean length of females in 1996 (75.0 cm) was greater than females in 1995 (ANOVA $p=0.005$) but the average girth (50.8 cm) was less than females in 1995 (ANOVA, $p<0.001$).

Resight Effort

Forty-five adult female and 77 male tagged individuals were identified throughout the season. The age groups of females ranged from 3 to 15 years (Table 30). Eleven females sighted with pups ranged from 5 to 15 years old.

Age groups of the 77 males identified ranged from 3 to 11 years (Table 30). Only one 9-year-old male was territorial with females. Two territorial males without females were 7 and 8 years old.

Table 29.--Length, girth, and weight of northern fur seal pups at approximately 3 months of age at Adams Cove, San Miguel Island, in 1995 and 1996. P-value is derived from a one-way analysis of variance by years.

Sex	Parameter	n	Mean	S.E.	P-value
Females	Length (cm)				
	1995	132	73.2	0.33	< .001
	1996	47	75.0	0.54	
	Girth (cm)				
	1995	132	56.3	0.34	< .001
	1996	47	50.8	0.49	
	Weight (kg)				
	1995	132	10.8	0.15	<.001
	1996	147	10.6	0.13	
Males	Length (cm)				
	1995	168	79.5	0.36	<.001
	1996	98	78.2	0.50	
	Girth (cm)				
	1995	168	57.9	0.34	<.001
	1996	55	52.6	0.46	
	Weight (kg)				
	1995	168	11.9	0.15	0.601
	1996	153	11.8	0.14	

Table 30.--Number of tagged northern fur seals sighted at Adams Cove, San Miguel Island, California, from May through August, 1996.

	Females				Males			
Cohort	n	Number Sighted	Percent of Cohort Sighted	Number with Pups	n	Number Sighted	Percent of Cohort Sighted	Number of Territorial Males
1981	102	2	2.0	1	104	--	----	-
1984	51	1	2.9	-	48	--	----	-
1985	43	4	9.3	-	56	--	----	-
1986	51	1	2.0	1	48	--	----	-
1987	56	3	5.4	1	43	1	2.3	1
1988	192	5	2.6	2	195	6	3.1	1
1989	159	7	4.4	2	195	18	9.2	1
1990	85	8	9.4	2	114	13	11.4	-
1991	159	10	6.3	2	142	11	7.7	-
1992	163	--	---	-	136	8	5.9	-
1993	185	4	2.2	-	189	20	10.6	-
Total		42		18		128		10

Incidence of Hookworms in Pups

The hookworms occurring in northern fur seal pups were identified as ***Urcinaria*** spp. and occurred in 24 pups collected from Adams Cove (Lyons et al., In press). The single pup collected from West Cove was not infected. The total number of worms in an individual pup ranged from 5 to 1,775 with a mean of 643.

DISCUSSION

The indices of population growth traditionally monitored at San Miguel Island, territorial male and pup counts, have provided good indicators of the population trends over the past 28 years. The number of territorial males increased from 104 in 1995 to 162 in 1996, indicating that new males continue to be recruited into the breeding population.

The increase in pup production in Adams Cove also indicates growth of the population. The increased mortality rate may have resulted from extensive flooding of the rookery in July that washed pups out to sea and disrupted breeding territories such that pups may have been separated from their mothers and perished. The 100% infection rate of hookworms for pups in Adams Cove suggests that hookworm infections may have further contributed to the increased pup mortality in Adams Cove.

Pup masses indicate that the condition of pups remained stable in 1996. The mean length and girth of males indicates smaller male pups in 1996 than in 1995 and female pups were longer but thinner in 1996. However, the length and girth of pups are more variable than the weight and are less precise indices of pup condition. Thus, the weight index is a better measure of year-to-year variation in pup condition.

The small sample size of known age individuals at San Miguel Island currently precludes estimation of survival and age of first reproduction. After a year of slowed growth in 1995, the

results of the 1996 monitoring studies indicate that the northern fix seal population at San Miguel Island is once again increasing. Population monitoring studies in the next few years will determine if the increase is a temporary fluctuation or a long-term trend.

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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, 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

Tabulations of adult male northern fur seals counted by rookery, size class, and rookery section.

Appendix Table B-1. --Number of adult male northern fur seals counted, by class[a] and rookery section, St. Paul Island, Alaska, 12-17 July 1996. 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	17	21	-	-	-	-	-	-	-	-	-	-	-	-	38
3	83	75	-	-	-	-	-	-	-	-	-	-	-	-	158
5	135	21	-	-	-	-	-	-	-	-	-	-	-	-	156
Kitovi[b]															
2	12(4)	6	13	28	7	-	-	-	-	-	-	-	-	-	70
3	45(24)	14	57	70	88	-	-	-	-	-	-	-	-	-	298
5	18(87)	6	34	16	206	-	-	-	-	-	-	-	-	-	367
Reef															
2	18	14	24	16	2	17	7	29	14	18	3	-	-	-	162
3	54	71	145	53	14	110	19	107	52	41	8	-	-	-	674
5	17	50	95	75	258	16	51	135	17	48	155	-	-	-	917
Gorbatch															
2	35	19	22	3	17	24	-	-	-	-	-	-	-	-	120
3	127	70	83	5	76	85	-	-	-	-	-	-	-	-	446
5	547	34	60	198	16	19	-	-	-	-	-	-	-	-	874
Ardiguen															
2	20	-	-	-	-	-	-	-	-	-	-	-	-	-	20
3	88	-	-	-	-	-	-	-	-	-	-	-	-	-	88
5	8	-	-	-	-	-	-	-	-	-	-	-	-	-	8
Moriovi[c]															
2	14(4)	14	12	13	19	15	-	-	-	-	-	-	-	-	91
3	51(41)	55	82	40	105	58	-	-	-	-	-	-	-	-	432
5	237(14)	18	47	34	28	102	-	-	-	-	-	-	-	-	480
Vostochni															
2	15	7	12	10	14	43	21	10	24	8	22	19	41	24	270
3	64	34	69	55	54	135	68	84	42	48	54	75	213	97	1092
5	45	59	31	83	96	80	33	28	68	8	3	155	204	127	1020
Little Polovina															
2	10	-	-	-	-	-	-	-	-	-	-	-	-	-	10
3	9	-	-	-	-	-	-	-	-	-	-	-	-	-	9
5	399	-	-	-	-	-	-	-	-	-	-	-	-	-	399
Polovina															
2	21	14	-	-	-	-	-	-	-	-	-	-	-	-	35
3	63	36	-	-	-	-	-	-	-	-	-	-	-	-	99
5	364	66	-	-	-	-	-	-	-	-	-	-	-	-	430
Polovina Cliffs															
2	18	22	9	32	28	27	18	-	-	-	-	-	-	-	154
3	63	37	44	72	141	62	111	-	-	-	-	-	-	-	530
5	76	26	13	15	18	27	46	-	-	-	-	-	-	-	221
Tolstoi															
2	27	12	21	16	37	36	37	30	-	-	-	-	-	-	216
3	58	44	60	90	104	106	96	66	-	-	-	-	-	-	624
5	0	5	17	18	30	42	43	739	-	-	-	-	-	-	894
Zapadni Reef															
2	39	12	-	-	-	-	-	-	-	-	-	-	-	-	51
3	148	48	-	-	-	-	-	-	-	-	-	-	-	-	196
5	201	241	-	-	-	-	-	-	-	-	-	-	-	-	442
Little Zapadni															
2	8	13	31	25	20	23	-	-	-	-	-	-	-	-	120
3	11	66	87	62	50	68	-	-	-	-	-	-	-	-	344
5	37	26	37	50	59	247	-	-	-	-	-	-	-	-	456
Zapadni[d]															
2	14	23	18	22	31	20	23	6	-	-	-	-	-	-	157
3	63	65	114	91	98	112	85	25	-	-	-	-	-	-	653
5	119	30	43	67	111	65	66	560	-	-	-	-	-	-	1061

[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.

Appendix Table B-2.--Number of harem and idle males, pups born, number of rookeries sampled, standard deviation (SD) of the number of pups born, and the number of dead pups on the Pribilof Islands, Alaska, 1975-1994. A dash indicates no data.

	St. Paul						St. George					
Year	Harem Bulls	Idle Bulls	Pups Born	N Rookeries Sampled	SD	Dead Pups	Harem Bulls	Idle Bulls	Pups Born	N Rookeries Sampled	SD	Dead Pups
1972	3,738	2,384	--	--	--	22,649	1,153	328	--	--	--	2,484
1973	4,906	2,550	--	--	--	9,908	875	375	60,385	6	--	2,661
1974	4,563	1,782	--	--	--	--	822	481	--	--	--	1,353
1975	5,018	3,535	278,261	14	8,620	20,625	877	1,427	--	--	--	3,289
1976	5,324	4,041	291,000	2	11,108	23,676	1,093	996	--	--	--	2,289
1977	6,457	3,845	--	--	--	14,083	1,610	899	43,407	6	748	1,208
1978	6,496	3,908	--	--	--	8,073	1,590	1,220	47,248	6	1,009	2,518
1979	6,242	4,457	245,932	14	9,464	6,444	1,716	1,942	--	--	--	2,191
1980	5,490	4,248	203,825	4	11,672	7,859	1,563	1,795	--	--	--	2,385
1981	5,120	4,003	179,444	4	5,876	6,798	1,472	1,646	38,152	6	1,581	2,025
1982	5,767	4,009	203,581	4	3,482	7,301	1,410	1,319	--	--	--	1,600
1983	4,827	4,242	165,941	4	6,034	5,997	--	--	31,440	6	2,930	903
1984	4,803	3,977	173,274	5	8,117	6,115	1,473	1,452	--	--	--	--
1985	4,372	3,363	182,258	7	7,997	5,266	1,268	1,601	28,869	6	2,297	806
1986	4,603	1,865	167,656	4	5,086	7,771	1,394	1,342	--	--	--	--
1987	3,636	1,892	171,610	13	3,218	7,757	1,303	1,283	--	--	--	--
1988	3,585	3,201	202,229	4	3,751	7,272	1,259	1,258	24,820	6	827	1,212
1989	4,297	6,400	171,534	4	25,867	9,096	1,241	1,163	--	--	--	--
1990	4,430	7,629	201,305	13	3,724	9,128	909	1,666	23,397	6	2,054	928
1991	4,729	9,453	--	--	--	--	736	1,271	--	--	--	--
1992	5,460	10,940	182,437	13	8,918	8,525	1,029	1,834	25,160	6	707	806
1993	6,405	9,301	--	--	--	--	1,123	1,422	--	--	--	--
1994	5,715	10,014	192,104	13	2,029	8,180	1,179	1,481	22,244	6	410	788
1995	5,154	8,459	--	--	--	--	1,242	1,054	--	--	--	--
1996	5,643	9,239	170,125	6	21,244	6,837*	1,248	790	27,385	6	294	719

* Dead pups for the entire island is estimated from the mortality rate on sampled rookeries.

Appendix Table B-3.--Number of northern fur seal pups sheared on each sampled rookery of St. Paul Island, Alaska, 1996.*

Rookery	Section														Total
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	
Kitovi	153	31	128	158	208										678
Vostochni	169	107	183	147	143	352	183	224	112	131	148	205	558	256	2,918
Polovina Cliffs	203	121	142	274	475	254	390								1,859
Tolstoi	243	193	256	377	443	454	425	296							2,687
Zapadni Reef	590	201													791
Little Zapadni	60	350	451	323	254	344									1,782
Total															10,715

'The total pups to be sheared is 10% times the total number of pups born in the previous pup estimate. The total number is allocated by section based on number of harem bulls in that section.

Appendix Table B-4.--Number of dead northern fur seal pups counted by section on the sampled rookeries of St. Paul Island, Alaska, 1996.

Rookery	Date	Section															Total
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	necropsies	
Kitovi*	8/19	55	6	99	111	61											332
Vostochni**	8/18	44	10	31	42	32	142	61	53	30	15	22	44	177	71	56	830
Polovina Cliffs	8/22	32	27	38	130	52	41	112									432
Tolstoi	8/21	48	91	106	109	130	350	169	133								1136
Zapadni Reef	8/20	252	91														343
Little Zapadni	8/20	6	112	146	180	137	156										737
Total																	3810

* Dead pups from Kitovi Amphitheater are included in sec.1 of Kitovi
**Dead pups removed for necropsies from Vostochni are added but not by section.

Appendix Table B-5.-- Number of northern fur seal pups sheared on each rookery of St. George Island, Alaska, 1996.

Rookery	Section 1	2	3	4	5	Other [1]	Total
South	192	237	233			7	669
North	160	208	302	192	109	20	991
East Reef	173						173
East Cliffs	355	195					550
Staraya Artil	144	60				43	247
Zapadni[2]	324		115			25	464
Total							3,094

[1] Other is the number of special marks put out by other researchers that were used as sheared pups for the pup production studies.
[2] Sections 1 and 2 were treated as one section for the allocation of shear marks.

Appendix Table B-6.--Number of dead northern fur seal pups counted by section on the rookeries of St. George Island, Alaska, 1996. Numbers in parentheses are combined counts of dead sheared and individually marked animals. These numbers are included in section totals.

Rookery	Date	Section					Total
		1	2	3	4	5	
South	8/20	29(1)	46	24(2)			99
North	8/19	44	61	103(1)	27	47	282
East Reef	8/21	11					11
East Cliffs	8/22	83(1)	33(2)				116
Staraya*	8/20	71(3)					71
Zapadni	8/20	38(1)	59(4)	43			140
Total							719

* Dead pups were not counted by section on Staraya Artil.

Appendix Table B-7.--Number of dead northern fur seals counted that were older than pups, Pribilof Islands, Alaska, 1965-1996. Teeth (usually canines) were collected from most of these seals. A dash indicates no data.

Year	Males	St. Paul Island		St. George Island		Total
		Females	Males	Females	Males	Females
1965	158	-	-	-	158	-
1966	181	172	41	55	222	227
1967	108	157	41	28	149	185
1968	98	141	33	22	131	163
1969	94	141	22	29	116	170
1970	52	124	4	53	56	177
1971	39	91	5	37	44	128
1972	46	111	22	30	68	141
1973	61	65	7	30	68	95
1974	33	30	4	15	37	45
1975	92	99	-	-	92	99
1976	46	64	-	-	46	64
1977	60	69	-	-	60	69
1978	57	87	-	-	57	87
1979	56	66	-[a]	-[a]	56	66
1980	102	117	14	65	116	182
1981	44	83	12	61	56	144
1982	47	117	-	-	47	117
1983	57	66	-	-	57	66
1984	66	72	-	-	66	72
1985	5	34	17	35	22	69
1986	24	67	-	-	24	67
1987	20	90[b]	-	-	20	99[b]
1988	56	112	21	29	77	141
1989	55	162	-	-	55	162
1990	97	151	13	31	110	182
1992	97	265	7	19	104	284
1994	84	223[c]	6	19[d]	90	242[f]
1996	20[e]	92[e]	3	20[f]	23	112[f]

[a]A total of 70 dead fur seals of both sexes that were older than pups were counted on the rookeries of St. George Island.

[b]Includes 10 dead fur seals of unknown sex.

[c]Includes 16 dead fur seals of unknown sex.

[d]Includes 2 dead fur seals of unknown sex.

[e]Counts made only on the 6 sample rookeries where dead pups were counted.

[f]Includes 16 dead fur seals of unknown sex.

APPENDIX C

Comparison of mass, length, and sex ratios of northern fur seal pups born on St. Paul and St. George Islands in 1996.

Page

Appendix Table C-l.--Sample sizes (n), mean mass (kg.), and standard deviation (SD) of male and female northern fur seal pups weighed on St. Paul Island, Alaska, August 25 - 27, 1996.

Rookery		Females	Males	Combined
Reef	kg.	8.27	9.60	8.92
27 August	SD	1.36	1.63	1.64
	n	128	123	251
Vostochni	kg.	7.99	9.29	8.70
26 August	SD	1.41	1.59	1.64
	n	122	147	269
Pol. Cliffs	kg.	8.34	9.68	9.13
25 August	SD	1.30	1.58	1.61
	n	110	159	269
Tolstoi	kg.	7.53	8.66	8.16
25 August	SD	1.30	1.53	1.54
	n	160	200	360
Combined	kg.	7.99	9.25	8.68
	SD	1.38	1.63	1.64
	n	520	629	1149

Appendix Table C-2.--Fraction of northern fur seal pups contributed by each sample rookery to total number of pups born on sample rookeries of St. Paul Island, and total pups born on St.George Island, Alaska, for 1992 and 1994-96.

Rookery	Fraction			
St. Paul	1992	1994	1995	1996
Reef	0.238	0.242	0.254	0.231
Vostochni	0.328	0.302	0.329	0.374
Polovina Cliffs	0.178	0.179	0.215	0.181
Tolstoi	0.256	0.277	0.202	0.214
St. George				
East Reef		0.046	0.067	0.052
East Cliffs		0.194	0.215	0.182
North		0.379	0.368	0.323
Staraya Artil		0.077	0.052	0.087
Zapadni		0.169	0.110	0.142
South		0.135	0.188	0.214

Appendix Table C-3.--Sample sizes (n), mean length (cm.), and standard deviation (SD) of male and female northern fur seal pups weighed on St. Paul Island, Alaska August 25-27, 1996.

Rookery		Females	Males	Combined
Reef	cm.	76.53	80.00	78.23
27 August	SD	4.47	4.36	4.74
	n	128	123	251
Vostochni	cm.	75.07	78.48	76.93
26 August	SD	4.03	3.95	4.32
	n	122	147	269
Pol. Cliffs	cm.	77.13	79.94	78.79
25 August	SD	4.03	4.64	4.61
	n	110	159	269
Tolstoi	cm.	75.15	78.05	76.76
25 August	SD	4.05	4.00	4.27
	n	160	200	360
Combined	cm.	75.89	79.00	77.60
	SD	4.23	4.31	4.54
	n	520	629	1149

Appendix Table C-4.--Sample sizes (n), mean mass (kg.), and standard deviation (SD) of male and female northern fur seal pups weighed on St. George Island, Alaska, August 24-27, 1996.

Rookery		Females	Males	Combined
South	kg.	8.22	9.61	9.04
24 August	SD	1.34	1.42	1.54
	n	63	91	154
North	kg.	8.28	10.25	9.39
27 August	SD	1.31	1.83	1.89
	n	52	67	119
East Reef	kg.	8.67	9.91	9.32
26 August	SD	1.23	1.53	1.52
	n	51	56	107
East Cliffs	kg.	8.43	10.40	9.59
26 August	SD	1.67	1.70	1.94
	n	45	65	110
Staraya Artil	kg.	8.76	10.02	9.40
27 August	SD	1.38	1.54	1.59
	n	64	65	129
Zapadni	kg.	8.06	9.49	8.87
25 August	SD	1.26	1.47	1.55
	n	56	74	130
Combined	kg.	8.41	9.92	9.25
	SD	1.37	1.60	1.68
	n	331	418	749

Appendix Table C-5.--Sample sizes (n), mean length (cm.), and standard deviation (SD) of male and female northern fur seal pups weighed on St. George Island, Alaska, 24-27 August 1996.

Rookery		Females	Males	Combined
South	cm.	76.11	79.57	78.15
24 August	SD	4.76	3.87	4.57
	n	63	91	154
North	cm.	78.44	82.66	80.82
27 August	SD	3.57	4.04	4.36
	n	52	67	119
East Reef	cm.	78.14	81.70	80.00
26 August	SD	3.75	3.76	4.14
	n	51	56	107
East Cliffs	cm.	79.20	83.57	81.78
26 August	SD	4.71	4.09	4.84
	n	45	65	110
Staraya Artil	cm.	78.06	82.11	80.10
27 August	SD	3.92	3.41	4.18
	n	64	65	129
Zapadni	cm.	78.23	81.76	80.24
25 August	SD	3.87	3.62	4.11
	n	56	74	130
Combined	cm.	77.95	81.75	80.07
	SD	4.20	4.00	4.51
	n	331	418	749

Appendix Table C-6.--Calculated t-statistics for comparison between years of mean mass of northern fur seals on St. Paul Island and St. George Island, Alaska. Significantly different years are in bold text.

	St. Paul			St. George		
	1994	1995	1996	1994	1995	1996
Females						
SP92	**-6.15**	**-10.32**	**-9.65**	**12.71**	-2.16	**-5.52**
SP94		**-4.38**	**-4.30**	**18.73**	2.27	-0.48
SP95			-0.50	**22.52**	**5.17**	2.68
SP96				**21.11**	**5.18**	2.85
SG94					**-12.25**	**-15.78**
SG95						-2.31
Males						
SP92	1.11	**-8.70**	**-6.87**	**16.44**	-1.74	0.17
SP94		**-11.08**	**-8.68**	**16.61**	-2.68	-0.73
SP95			1.15	**24.80**	**4.66**	**7.35**
SP96				**22.34**	3.60	**5.99**
SG94					**-15.25**	**-14.44**
SG95						1.71

Appendix Table C-7.--Calculated t-statistics for comparison between years of mean length of northern fur seals on St. Paul Island and St. George Island, Alaska. Significantly different years are in bold text.

	St. Paul			St. George		
	1994	1995	1996	1994	1995	1996
Females						
SP92	**-12.56**	**-19.10**	-1.17	-3.81	**9.35**	**5.95**
SP94		**-8.24**	**10.99**	**6.78**	**19.50**	**16.37**
SP95			**17.48**	**12.81**	**24.42**	**23.01**
SP96				-2.71	**10.18**	**6.85**
SG94					**11.84**	**8.76**
SG95						-3.21
Males						
SP92	**-17.19**	**-25.39**	-2.49	-3.79	**10.56**	**8.75**
SP94		**-9.03**	**13.48**	**10.54**	**23.84**	**23.15**
SP95			**21.25**	**17.63**	**30.07**	**29.87**
SP96				-1.46	**12.14**	**10.50**
SG94					**12.66**	**11.11**
SG95						-2.18

APPENDIX D

Scientific staff engaged in northern fur seal field research in 1996

National Marine Mammal Laboratory (NMML)
Howard W. Braham, Director
Robert V. Miller, Deputy Director
Thomas R. Loughlin, Leader, Alaska Ecosystem Program
Jason Baker, Leader, Northern Fur Seal Program

Name	Affiliation
Employees	
Jason Baker	NMML
Robert Caruso	NMML
Robert DeLong	NMML
Charles Fowler	NMML
Rolf Ream	NMML
Sharon Melin	NMML
Bruce Robson	NMML
Elizabeth Sinclair	NMML
Rod Towell	NMML
Anne York	NMML
Research Associates and Cooperators	
Aquilina Lestenkof-Bourdukofsky	PISP
Kimberlee Beckman	UAF
Benny	PISP
Tara Bourdukofsky	PISP
Tim Brod	SPVP
Lisa Climo	IND
Tabitha Collins	IND
Marc Daniels	IND
Mary Engle	UCSC
John Fratis	TCSP
Eric Galaktionoff	PISP
Tom Gannon	IND
Chris Gburski	IND
Michael Goebel	UCSC
Malory Graham	SPVP
Francis Gulland	MMSC
Alfay Hanson Sr.	PISP
Andrionick Hanson	TCSP

Appendix D.--continued.

Name	Affiliation
Henry Hanson	TCSP
John Hapoff	PISP
Karen Holzer	PISP
Steve Insley	SI
Kirill Jarikov	RA
Jennifer Jolly	UCSC
Gilbert Kashevarof	TCSG
Chihiro Kawai	NRIFS
Masa Kiyota	NRIFS
Ayako Kobayashi	NRIFS
Jason Kozloff	TCSP
Joseph Kozloff	PISP
Carolyn Kurle	IND
Alexander Kushin	CSP
Eran Lederman	IND
Shawn Lekanof	CSG
Dimitri Lestenkoff	CSG
Todd Lestenkoff	CSG
Maxim Malavansky	CSG
Victor Malavansky	CSG
Mariamna Melovidov	NMFS
Robert Melovidov	TCSP
Steve Melovidov	TCSP
Grace Merculief	CSG
T. J. Merculief	TCSP
Stacy Merculief	PISP
Marissa Merculief	WPI
Linh Pham	UCSC
Dave Robson	IND
Marilyn Robson	IND
Isiah Shabolin	CSG
Terry Spraker	WPI
Jeremy Sterling	UCSC
Mark Tetoff	TCSP
Sacha Vignieri	IND
Jessica Wachtel	USFWS
Richard Warner	TCSP
Mike Williams	NMFS
Nicolai Deon Zacharof	TCSP
Richard Zacharof	TCSP

Appendix D.--continued

Affiliation Code
CSG - City of St. George, St. George Island, Alaska
CSP - City of St. Paul, St. Paul Island, Alaska
IND - Independent
MMSC - Marine Mammal Stranding Center, Sausalito, California
NMFS-NMFS
NMFSJ - National Marine Fisheries Service Regional Office, Juneau, Alaska
NRIFS - National Research Institute of Far Seas Fisheries, Shimizu, Japan
PISP - Pribilof Island Stewardship Program
RA - Russian Affiliate
SI - Smithsonian Institution, Washington, D.C.
TCSG - Tribal Council, St. George Island, Alaska
TCSP - Tribal Council, St. Paul Island, Alaska
UAF - University of Alaska, Fairbanks, Alaska
UCSC - University California at Santa Cruz
USFWS - U.S. Fish and Wildlife Service
WPI - Wildlife Pathology International

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