NOAA Technical Memorandum NMFS-AFSC-69

Fur Seal Investigations, 1994

by
E. H. Sinclair (editor)

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
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Alaska Fisheries Science Center

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"Pups gather in large groups called..
"I Estmated 500± seals in Sight before we launched the..
"RADIO-tagged adult males traveled...
Pup tagging began in 1940.
"The Russian box has alleviated...
"Length and weight data on...
"All shearers are equipped with a pair of...
"From the catwalks we were able to observe...

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ABSTRACT

The collection of papers contained in this report describes field research conducted in 1994 on northern fur seals (Callorhinus ursinus) by researchers and research associates of the National Marine Mammal Laboratory (NMML), Seattle, Washington. This is the 51st annual or semi-annual publication on northern fur seal research conducted by the NMML and its predecessor the Marine Mammal Biological Laboratory since 1940. Population numbers and factors that influence or indicate fluctuation in population health are monitored annually by NMML on all U.S. breeding rookeries. Northern fur seal research was conducted by NMML in 1994 under Marine Mammal Permit Number 837.

Population parameters of northern fur seals monitored on St. Paul and St. George Islands (Pribilof Islands) in 1994 included direct counts of adult males (15,729, St. Paul; 2,660 St. George), and mark-recapture estimates of the number of pups born (204,995, St. Paul; 22,244, St. George) (Antonelis et al.,this volume). Counts of dead fur seals of all ages were incorporated into population estimates. Adult male counts declined overall in 1994, after 4 years of increasing male counts due to the 1984 cessation of the commercial harvest of juvenile males on St. Paul Island. Population trends, based on pup numbers, remained stable on St. Paul Island and continued to decline on St. George Island.

In addition to population assessment, a new sampling technique was tested for pup estimates on the Pribilof Islands in

1994 (York and Towell, this volume). The new design decreases disturbance to the rookeries and may increase the accuracy of counts, and will probably be employed in future population assessments.

The mean mass, lengths, and sex ratios of pups on St. Paul and St. George Islands were examined in 1994 and compared to previous years as indicators of trends in population health (Towell et al., this volume). Male pups were larger than female pups, but other comparisons between islands and years were less conclusive. Future studies will consider the combined use of length and mass to create condition indices of pups.

Weights of known-age juvenile males taken in the 1991-94 subsistence harvests on St. Paul Island were compared (Caruso and Baker, this volume). Overall, males harvested in 1992 were heavier than those in other years, but bias in size selection during the harvest may have occurred.

Entanglement of male northern fur seals in marine debris appeared to increase throughout the late 60s and early 70s, then peak in 1976. In 1994, island-wide surveys of female northern fur seals on St. Paul Island showed an increase in entanglement rates from 1992 and 1993 (Robson et al., this volume). Similar to observations in previous years, the incidence of entanglement increased as the breeding season progressed, possibly due to the higher rate of entanglement among younger seals that arrive later in the season. All entangled animals were captured and disentangled on an opportunistic basis.

A total of 1,482 northern fur seal pups and 3,691 non-pups were counted on Bogoslof Island in 1994 (Piatt and Goley, this volume). The number of pups is 67% higher than 1993 counts and is consistent with a trend of increasing counts since the late 1980s.

Studies conducted on the San Miguel Island northern fur seal population in 1994 included pup production and condition, and the effects of the 1992-93 El Niño on population growth (Melin et al., this volume) A total of 2,452 live pups were counted representing the highest recorded counts since the San Miguel Island colony was discovered in 1968.

CONTENTS

INTRODUCTION

by

Elizabeth H. Sinclair

Between 1911 and 1984, northern fur seal 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. 1-3) 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 due to declining numbers of animals on St. George Island and a flat trend in population growth on St. Paul Island. A moratorium on commercial harvesting of fur seals was imposed on St. Paul Island in 1984 and on St. George Island in 1973 because of depressed population levels, 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 1994 was conducted under Marine Mammal Permit number 837.

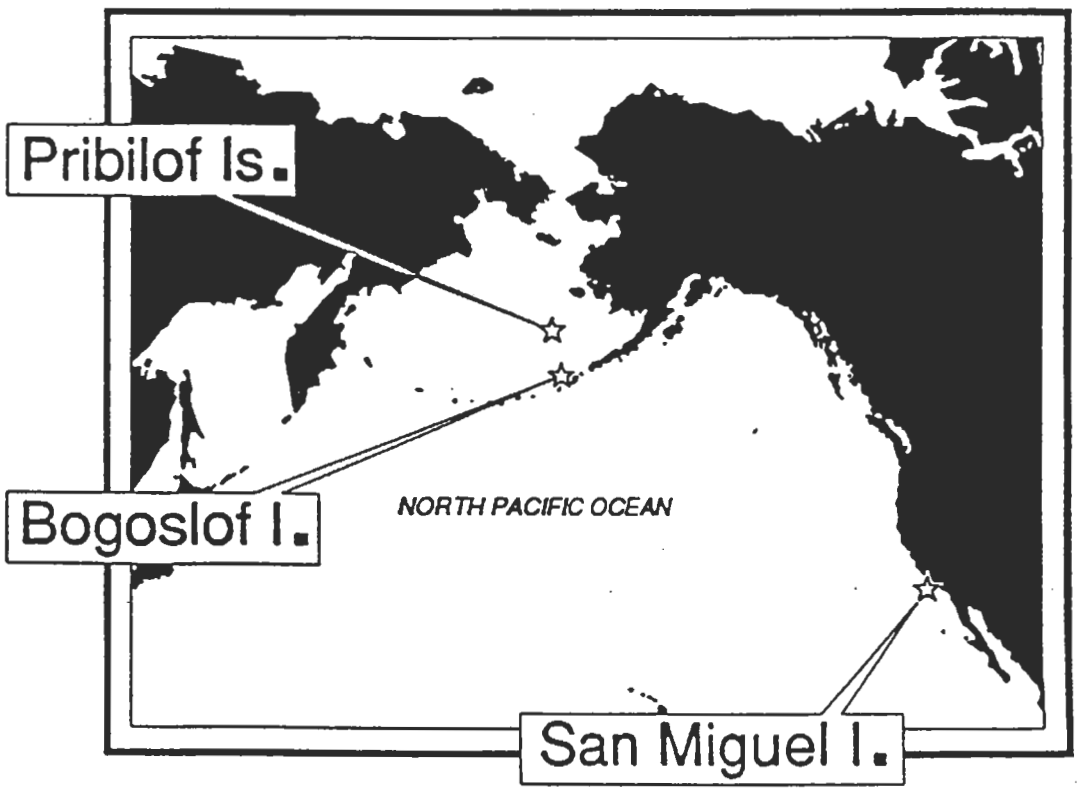


Figure 1. Location of the four northern fur seal breeding rookeries within U.S. waters.

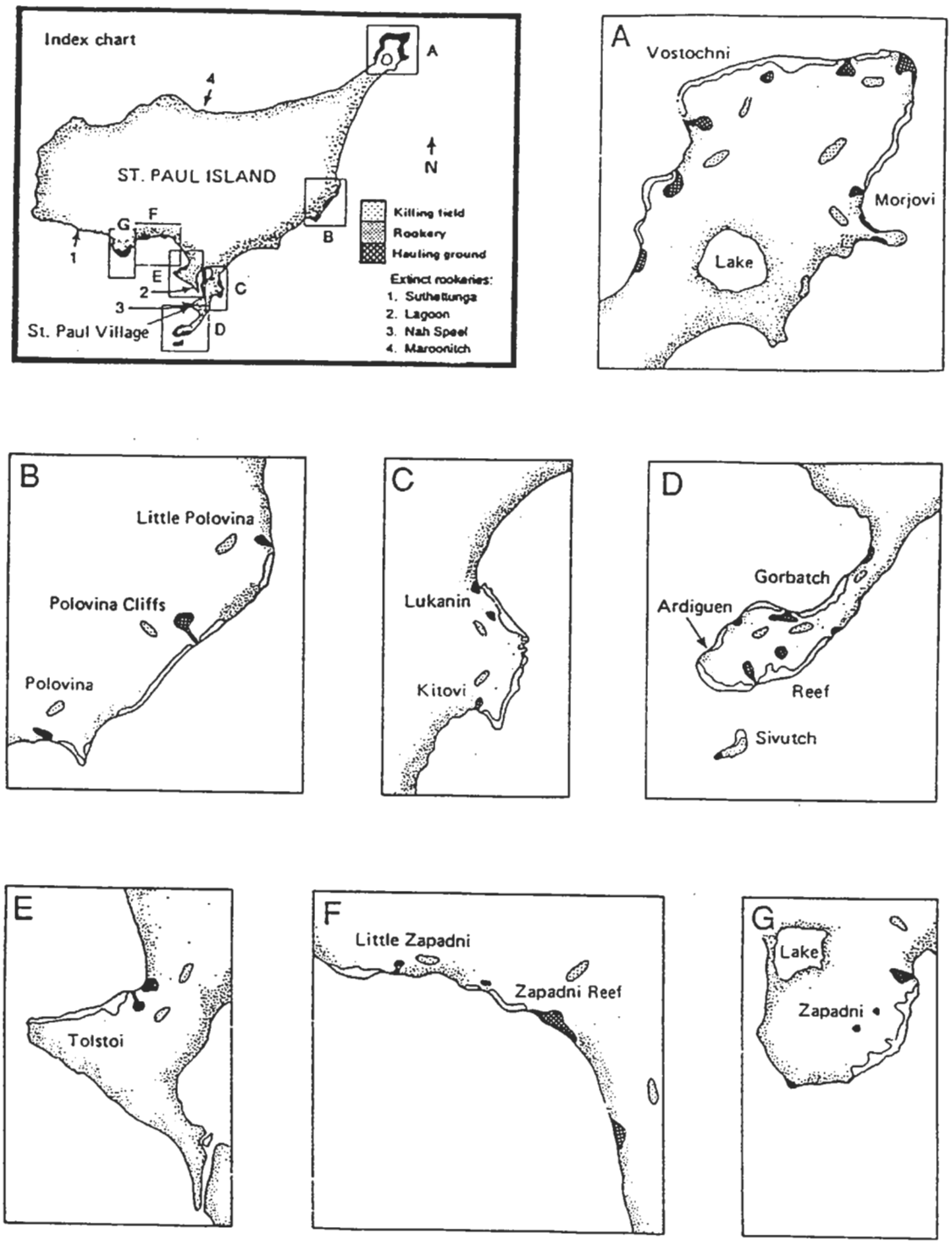


Figure 2.--Location of northern fur seal rookeries (present and extinct), hauling grounds, and harvesting areas, St. Paul Island, Alaska.

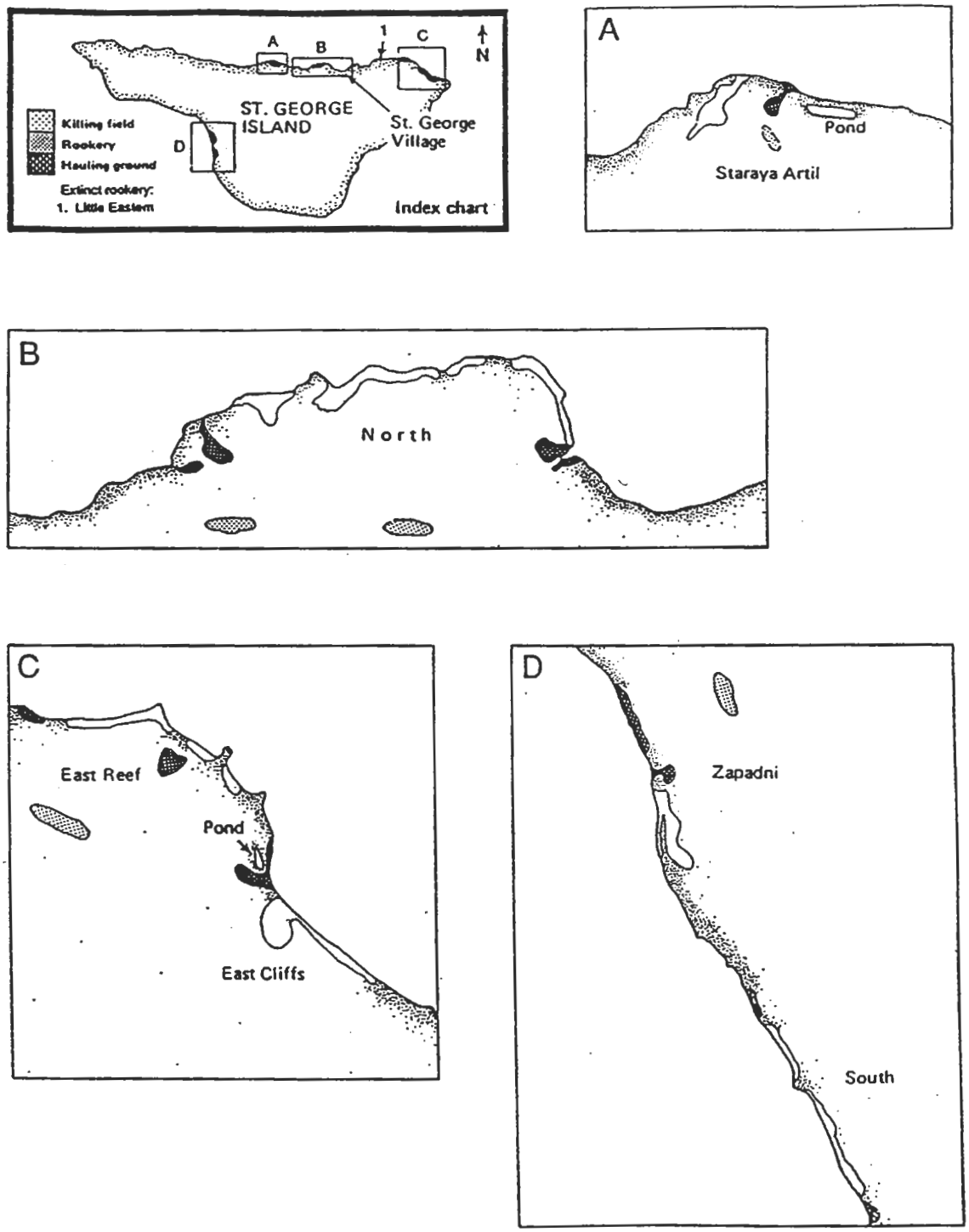


Figure 3.--Location of northern fur seal rookeries (present and extinct), hauling grounds, and harvesting areas, St. George Island, Alaska.

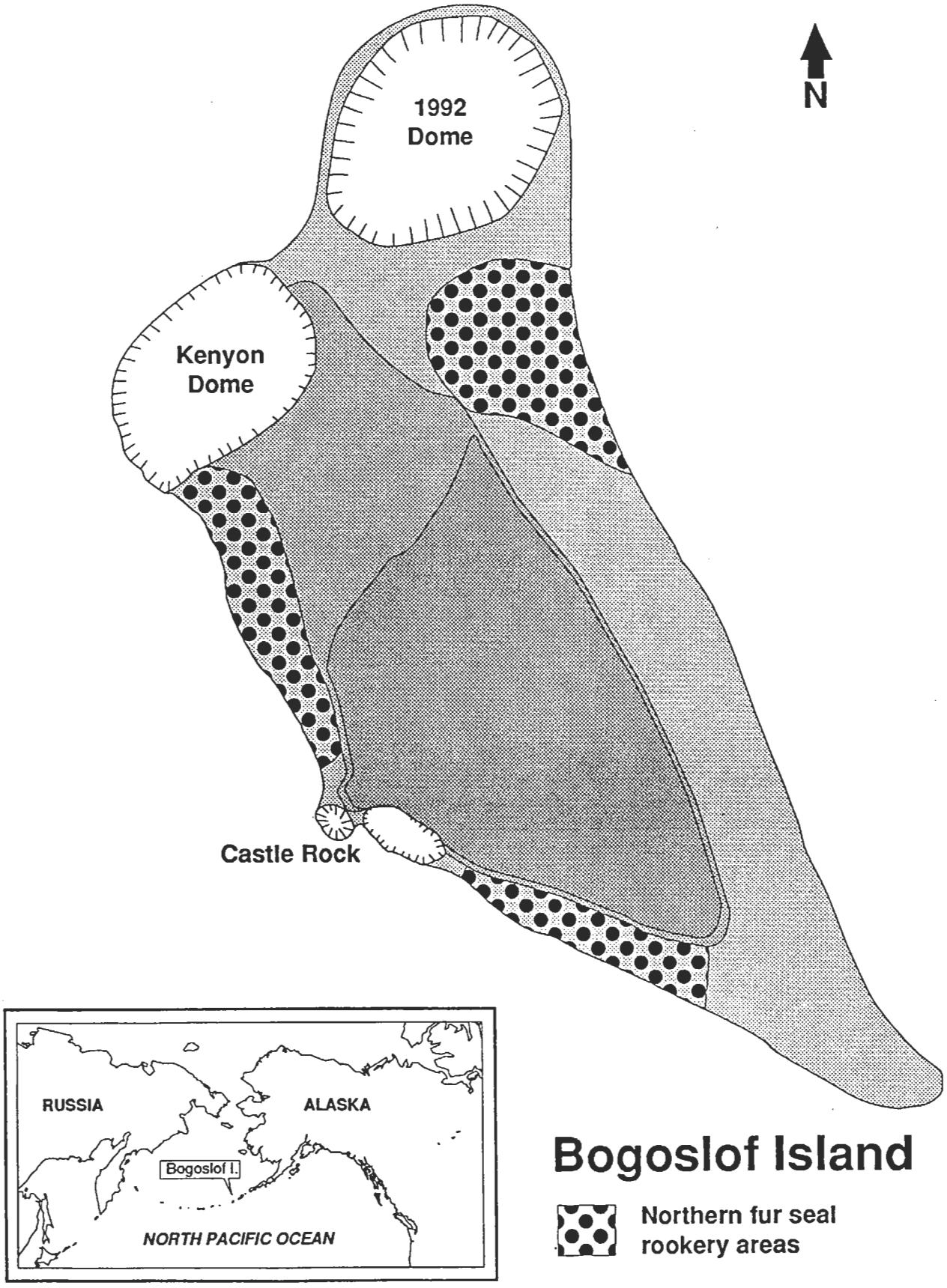


Figure 4.--Fur seal rookeries on Bogoslof Island, Alaska.

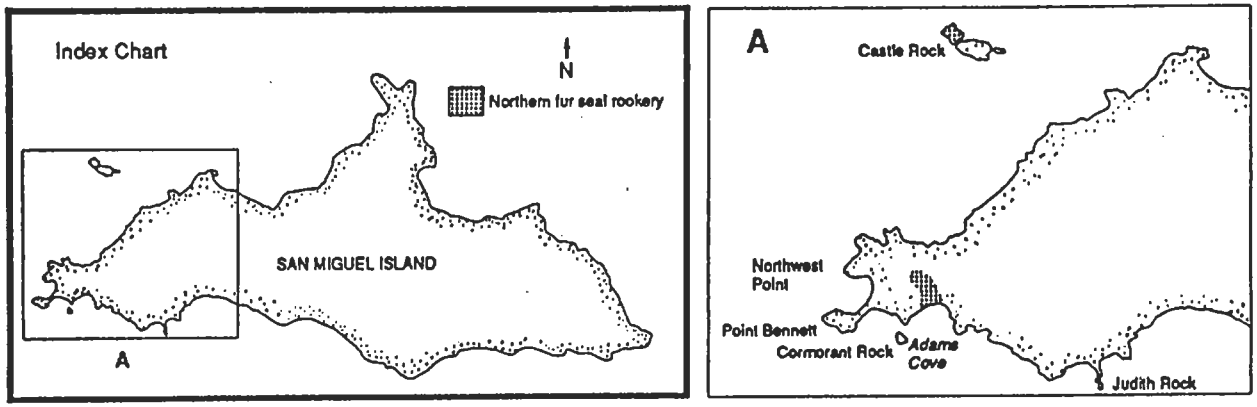


Figure 5. Location of northern fur seal breeding colonies, San Miguel Island, California.

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

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

POPULATION ASSESSMENT, PRIBILOF ISLANDS, ALASKA

by

George A. Antonelis, Anne E. York, Bruce W. Robson, 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) 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 1994 include the numbers of adult males, pups born, and mortalities of fur seals on St. Paul Island and St. George Island.

Sex Composition of Seals Harvested

A total of 1,616 sub-adult male seals were killed in the subsistence harvest by St. Paul Island residents in 1994 (Table 2). One female fur seal was harvested accidentally on St. Paul Island. On St. George Island, 161 sub-adult male seals were taken in the subsistence harvest in 1994 (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

Table 2.--Date, location, and number of subadult male seals killed in subsistence harvest drives on St. Paul Island, Alaska, in 1994.

Date	Rookery	Number Killed
July 27	Reef	28
July 6	Reef	58
July 7	Zapadni Reef	27
July 8	Zapadni	41
July 9	Polovina	56
July 13	Lukanin	77
July 14	Zapadni Reef	50
July 15	Reef	66
July 18	Polovina	46
July 19	Kitovi	54
July 20	Zapadni Reef	69
July 21	Zapadni	56
July 22	Reef	73
July 23	Northeast Point[1]	40
July 25	Polovina[2]	88
July 26	Lukanin	64
July 27	Zapadni Reef	49
July 28	Reef	69
July 29	Zapadni	66
August 1	Polovina	50
August 2	Lukanin	37
August 3	Zapadni[3]	65
August 4	Zapadni	86
August 5	Northeast Point[1]	82
August 6	Reef	219

[1]Includes Vostochni and Morjovi rookeries
[2]1 female accidentally killed
[3]Seals were taken from two locations. There were not enough seals at the first location.

Table 3.--Date, location, and number of subadult male seals killed in subsistence harvest drives on St. George Island, Alaska, in 1994.

Date	Rookery	Number Killed
July 2	North	27
July 6	Zapadni	10
July 7	North	10
July 11	North	18
July 15	Zapadni	21
July 21	Zapadni	18
July 23	North	19
July 26	North	15
August 4	North	7
August 5	North	16

St. Paul Island from 14 to 21 July (Appendix Table B-1). A total of 5,715 harem (class 3) and 10,014 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 1,179 harem (class 3) and 1,481 idle (classes 2 and 5) adult male seals were counted from 11 to 14 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.

The age structure of male northern fur seals in the Pribilof Island population has achieved most of the change expected following termination of the commercial harvest on St. Paul and St. George Islands in 1984 and 1972, respectively. Although there was a slight increase in the count of territorial males with females (class 3) on St. George Island between 1993 and 1994 (4.5%), the count of these males on St. Paul Island was lower in 1993 than in 1994 (11% less). The total for these males for the Pribilof Islands was therefore lower by about 8.5% in 1994. This decline followed 4 years of increase through recruitment of males that were not killed following the termination of the harvest as they reached the age of reproductive maturity. Evidence of equilibration in the sex ratio among adults is also indicated by the 1994 counts for this

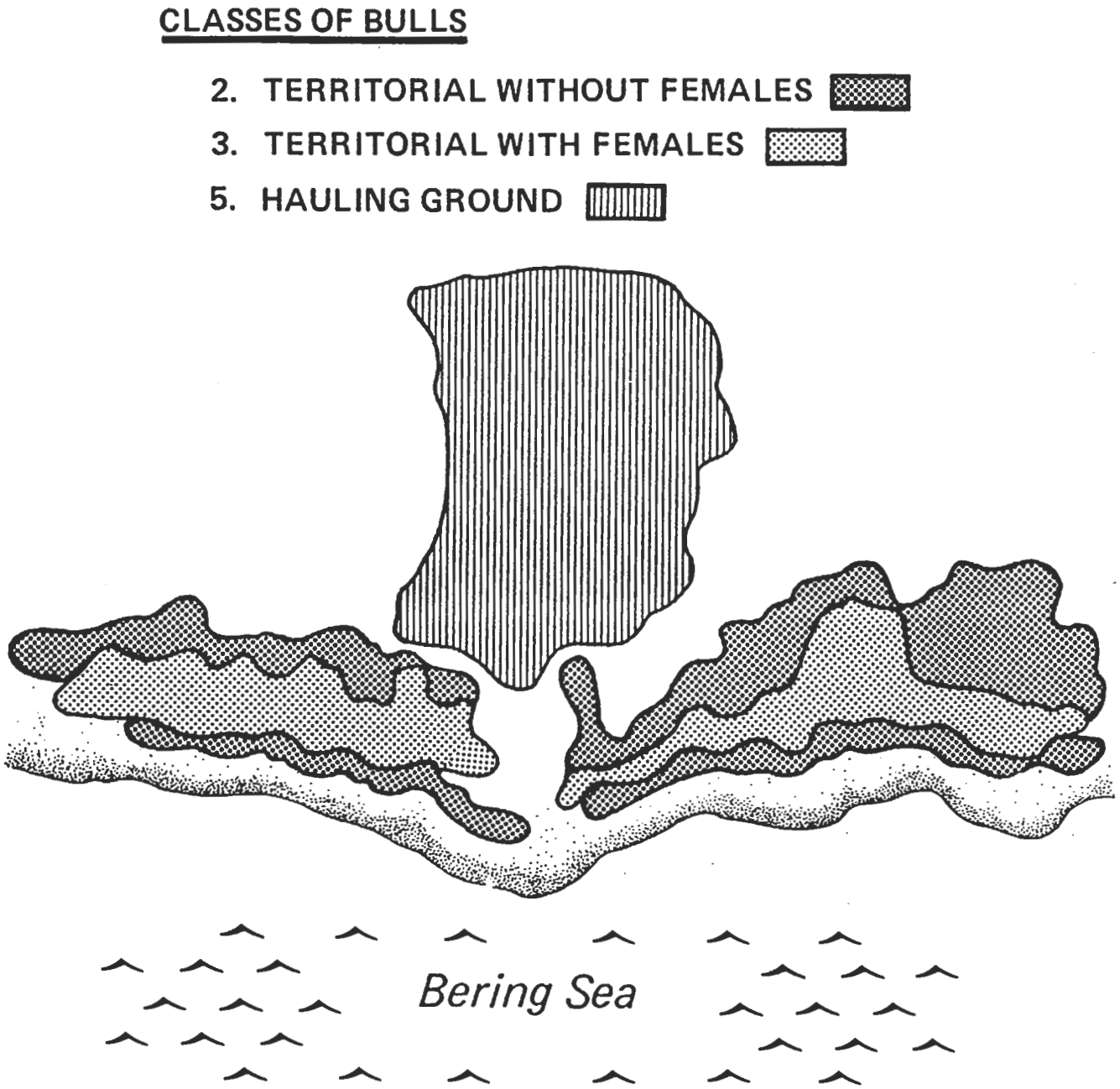


Figure 6. The relative location of the different classes of adult males for a typical fur seal rookery.

Table 4.--Number of adult male northern fur seals counted, by rookery, Pribilof Islands, Alaska, July 1994.

Rookery	Date (July)	Class of Adult Male* 2	3	5	Total
St. Paul Island					
Lukanin	14	91	158	175	424
Kitovi	14	173	244	312	729
Reef	21	346	811	1,088	2,245
Gorbatch	21	180	477	1,334	1,991
Ardiguin	21	31	109	1	141
Morjovi	17	211	297	525	1,033
Vostochni	17	411	861	652	1,924
Little Polovina	20	10	15	577	602
Polovina	20	34	85	386	505
Polovina Cliffs	20	181	589	403	1,173
Tolstoi	15	298	633	554	1,485
Zapadni Reef	19	112	232	319	663
Little Zapadni	19	160	530	360	1,050
Zapadni	18	290	670	800	1,764
Island Total		2,528	5,715	7,486	15,729
St. George Island					
Zapadni					452
South	12	115	217	40	372
North	13	239	453	237	929
East Reef	13	39	73	78	190
East Cliffs	13	114	230	169	513
Staraya Artil	13	70	65	69	204
Island Total		664	1,179	817	2,660

*See glossary for description of adult male seal classes.

category of seals, which has fluctuated on the Pribilof Islands without a discernable trend for the last few years (Table 4).

Number of Pups Born on St. Paul Island in 1994

The number of pups born on St. Paul Island was estimated in August by adding the estimated number of live pups from a shearing/sampling (mark/recapture) study and the total count of dead pups on all rookeries (except Little Polovina rookery on St. Paul Island[1]). The previous estimate of pup production on all rookeries was obtained in 1992. In 1994 the technique used to sample the number of marked pups and calculate the production estimate was revised to reduce the amount of variability in the estimate (York and Towell, this volume). Additional information on the techniques used to estimate pup production are found in York and Kozloff (1987) and Antonelis (1992).

From 10 to 18 August, 20,153 pups were shear-marked. The number of pups sheared on each rookery was approximately 10% of the 1992 pup 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. Counts of harem bulls in 1994 at St. Paul Island were used to determine the allocation of shear marks on pups for each rookery. The ratio of marked to unmarked

[1]A census was not conducted on Little Polovina because the number of pups born there has declined precipitously since 1980, and any disturbance to the rookery was considered inadvisable.

pups was determined by at least three researchers (two of which worked as a pair) on two occasions for each rookery from 19 to 31 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 rookeries except Little Polovina from 19 to 31 August. Numbers of dead pups counted by section are given in Appendix Table B-4. 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 5. The estimated number of pups born, the standard error of the estimate, number of dead pups, counts of harem bulls, and ratios of pups to adult males for all rookeries on St. Paul Island are summarized in Table 6. For each sampled rookery, the standard deviation of the pup estimate is computed from the standard error of the two estimates. The estimate for the total number of pups alive on St. Paul Island at the time of marking was 183,924 (SD = 2,028). The number of dead pups was estimated to be 8,180 (8,158 counted on all rookeries and 22 estimated for Little Polovina rookery); the estimated mortality rate for late August was 4.26%. The total number of pups born on St. Paul Island and the approximate 95% confidence interval was 202,995 ± (2.16 X 2,257) or 202,995 ± 4,875. This

Table 5.--Total number of northern fur seal pups sheared, number of pups estimated to be alive at the time of marking (E1 and E2), mean number alive (Mean) and standard error of the mean (SE), St. Paul Island, Alaska, 1994.

Rookery	Sheared	E1	E2	Mean	SE
Lukanin	406	3,544	3,726	3,635	91.0
Kitovi	765	6,347	6,327	6,337	10.0
Reef	2,249	21,063	21,819	21,441	378.0
Gorbatch	1,710	14,543	14,861	14,702	159.0
Ardiguen	243	2,260	2,576	2,418	158.0
Morjovi	1,401	13,460	12,851	13,156	304.5
Vostochni	3,007	25,221	28,820	27,020	1,799.5
Polovina	276	2,221	2,387	2,304	83.0
Polovina Cliffs	1,839	15,891	16,560	16,225	334.5
Tolstoi	2,416	24,472	24,717	24,595	122.5
Zapadni Reef	722	7,063	7,483	7,273	210.0
Little Zapadni	1,551	15,863	16,671	16,267	404.0
Zapadni	2,572	28,559	27,577	28,068	491.0

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, St. Paul Island, Alaska, 1994. The symbol -- indicates that no data is available.

Rookery	Pups alive at marking	SD	Dead pups[1]	Total pups born	Mortality rate (%)	Idle bulls	Harem bulls	Ratio pups/bulls
Lukanin	3,635	91.0	245	3,880	6.31	266	158	23.01
Kitovi	6,337	10.0	174	6,511	2.67	485	244	25.97
Reef	21,441	378.0	1,088	22,529	4.83	1,434	811	26.44
Gorbatch	14,702	159.0	779	15,481	5.03	1,514	477	30.82
Ardiguen	2,418	158.0	85	2,503	3.40	32	109	22.18
Morjovi	13,156	304.5	362	13,518	2.68	736	297	44.30
Vostochni	27,020	1,799.5	1,026	28,046	3.66	1,063	861	31.38
Polovina	2,304	83.0	54	2,358	2.29	420	85	27.11
Polovina Cliffs	16,225	334.5	380	16,605	2.29	584	589	27.55
Tolstoi	24,595	122.5	1,152	25,747	4.47	852	633	38.85
Zapadni Reef	7,273	210.0	386	7,659	5.04	431	232	31.35
Little Zapadni	16,267	404.0	996	17,263	5.77	520	530	30.69
Zapadni	28,068	491.0	1,431	29,499	4.85	1,090	674	41.64
Little Polovina[2]	483	29.5	22	505	4.36	587	15	32.20
Island Total	183,924	2,028.5	8,180	192,104	4.26	10,014	5,715	32.18
Sea Lion Rock	12,589	989.3	302	12,891	2.34	--	--	--
Total	196,513	2,256.8	8,482	204,995	4.14	10,014	5,715	--

[1]Includes dead pups taken for necropsies; Gorbatch (1), Little Zapadni (1), Reef (134), Polovina cliffs (2), and Vostochni (54).

[2]Pups alive at marking and its standard deviation are calculated from the jackknife ratio estimates of breeding males. Numbers of dead pups are estimated from an average mortality based on all rookeries excluding Little Polovina. Total is estimated from the sum of estimates of live pups and dead pups.

total estimate includes an estimate of 12,891 pups (12,589 = live, 302 = dead) for Sea Lion Rock. Without the Sea Lion Rock estimate, total pup production on St. Paul Island was 192,104; this value is comparable to years when Sea Lion Rock was not evaluated.

The confidence interval for the 1994 estimate of pups born on St. Paul Island was computed by multiplying the standard deviation (calculated as the square root of the sum of the variances for each rookery and assuming counts from the 13 rookeries were independent) by 2.16, the 97.5 percentile of Student's t-distribution with 13 degrees of freedom. Estimates of the number of live pups for Little Polovina rookery were computed from a jackknife estimate of the ratio of pups alive at marking to breeding males on the sampled rookeries (York and Kozloff 1987). The standard deviation of the number of live pups for Little Polovina was then computed from the standard error of the jackknife ratio. An estimate of the number of dead pups at Little Polovina was computed assuming that the mortality rate there was the same as the average mortality of the other rookeries (Table 6). 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 1994 was not significantly different ($P = 0.05$) from the 1990 and 1992 estimates. Appendix Table B-2 summarizes pup production and mortality excluding Sea Lion Rock since 1972.

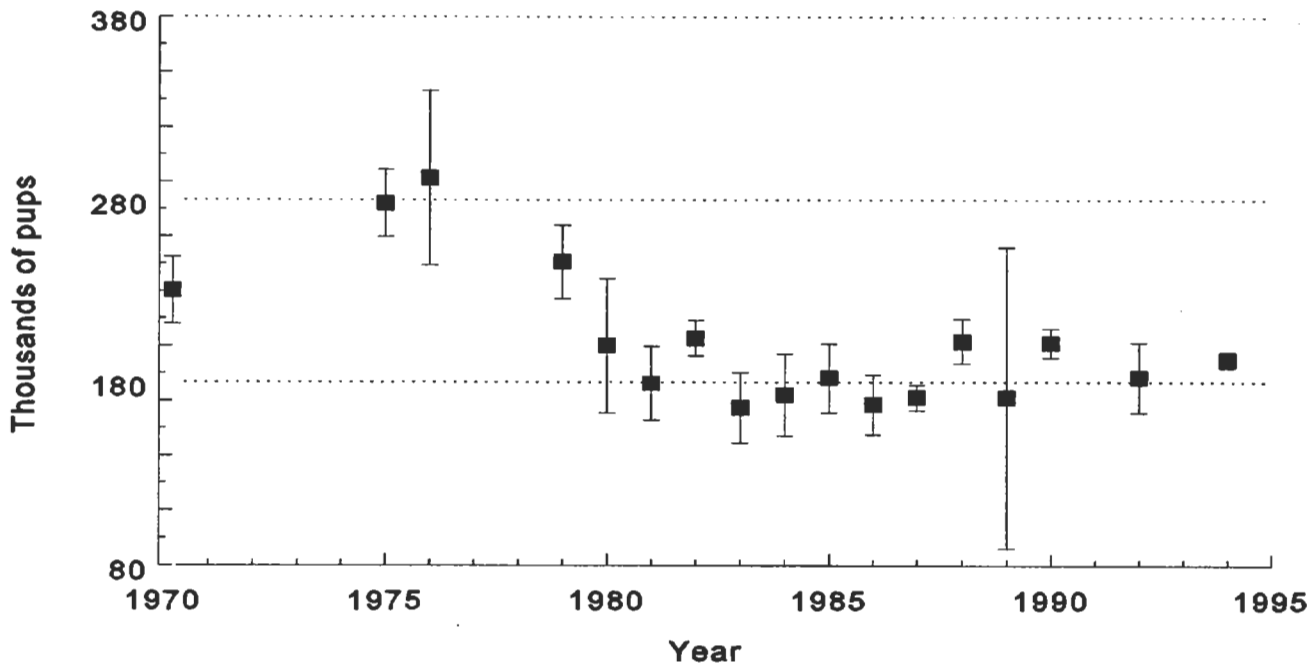


Figure 7.--Number of northern fur seal pups born on St. Paul Island, Alaska, 1970-94. Approximate 95% confidence intervals shown.

The number of pups born and the number of harem bulls at different rookeries on St. Paul Island are highly correlated (Fig. 8). When numbers of pups born are regressed on numbers of harem bulls, the value of R^2 is about 0.90. The intercept of the regression line is not significantly different from zero P = 0.88) and was not included in the regression equation; the slope of the regression line is 32.34 (SE = 1.64), representing an estimate of the ratio of pups : males.

Number of Pups Born on St. George Island in 1994

The number of pups born on St. George Island was also estimated from a shearing-sampling study conducted on all rookeries. The most recent estimate of pup production prior to this study was obtained in 1992. From 18 to 20 August, a total of 2,698 pups were shear-marked on St. George Island. These marks were allocated proportionally on all rookeries according to the fraction of harem bulls counted in 1994 (Appendix Table B-5). The ratio of marked to unmarked pups on each rookery was determined by three researchers on two occasions: once from 21 to 23 August and again from 24 to 25 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 21 to 23 August 1994. The ratio of marked to unmarked pups and the estimate of the number alive was calculated similarly to

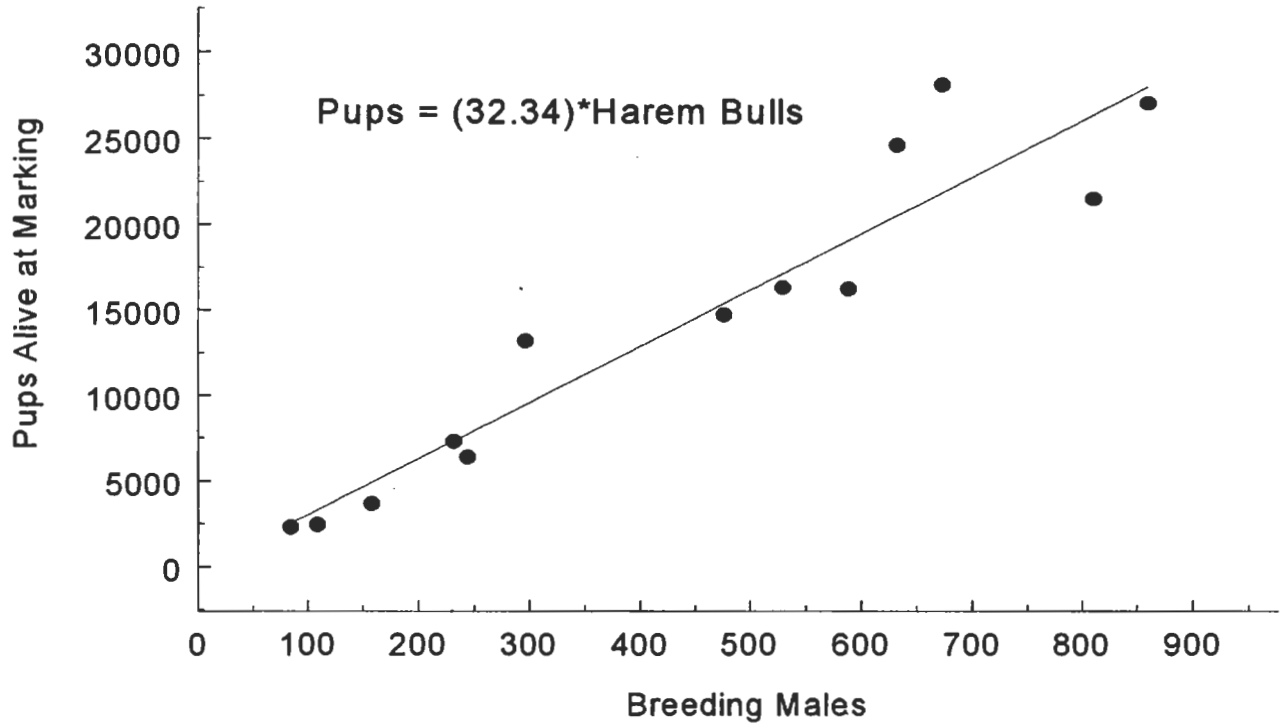


Figure 8.--Number of northern fur seal pups alive at the time of sampling versus number of harem bull fur seals for the rookeries of St. Paul Island, Alaska, 1994.

Table 7.-- Number of pups sheared; number of pups estimated to be alive at the time of marking (E1 and E2), the mean number alive (Mean), and the standard error of the mean (SE), St. George Island, Alaska, 1994.

Rookery	Sheared	E1	E2	Mean	SE
South	430	3,850	4,461	4,156	305.90
North	966	7,559	7,466	7,513	46.47
East Reef	121	1,014	864	939	75.00
East Cliffs	525	4,121	3,718	3,920	201.49
Staraya	237	1,522	1,582	1,552	30.00
Zapadni	419	3,218	3,534	3,376	158.00

the method described for St. Paul Island. 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 estimated total number of pups alive on St. George Island at the time of marking was 21,456 (SD = 410, Table 8). The total number of dead pups was 788 (Appendix Table B-6) and the mortality rate for late August was 3.54%. The total number of pups born on St. George Island and the approximate 95% confidence interval was 22,244 ± (2.447 X 410), or 22,244 ± 1,003. This count is significantly different (P = 0.003) than the 25,160 (SE = 707) observed on St. George Island in 1992. It is not significantly different (P > 0.05) from the predicted number of pups born based on a regression fitted to the 1973-92 data, which showed a 5.0% rate of decline with a predicted number of pups of 20,459 (SE = 1,034). Estimates and 95% confidence intervals of numbers of pups born on St. George Island for 1970-94 are shown in Figure 9. The number of pups born and the number of harem males on St. George Island rookeries are highly correlated (Fig. 10). When the number of pups born are regressed on the number of males, the value of R^2 is about 0.95. The marking intercept of the regression line is not significantly different from zero (P = 0.29) and was not included in the regression equation; the slope of the regression line is 17.49 (SE = 0.92).

Table 8.--Number of pups alive at the time of marking, its standard deviation (SD), numbers 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, 1994.

Rookery	Pups alive at marking	SD	Dead Pups	Total pups born	Mortality rate (%)	Idle Bulls	Harem bulls	Ratio pups/bulls
South	4,156	305.5	117	4,273	2.74	155	217	19.15
North	7,513	46.5	358	7,871	4.55	476	453	16.58
East Reef	939	75.0	12	951	1.26	117	73	12.86
East Cliffs	3,920	201.5	122	4,042	3.02	283	230	17.04
Staraya	1,552	30.0	54	1,606	3.36	139	65	23.88
Zapadni	3,376	158.0	125	3,501	3.57	311	141	23.94
Island Total	21,456	409.4	788	22,244	3.54	1,481	1,179	18.20

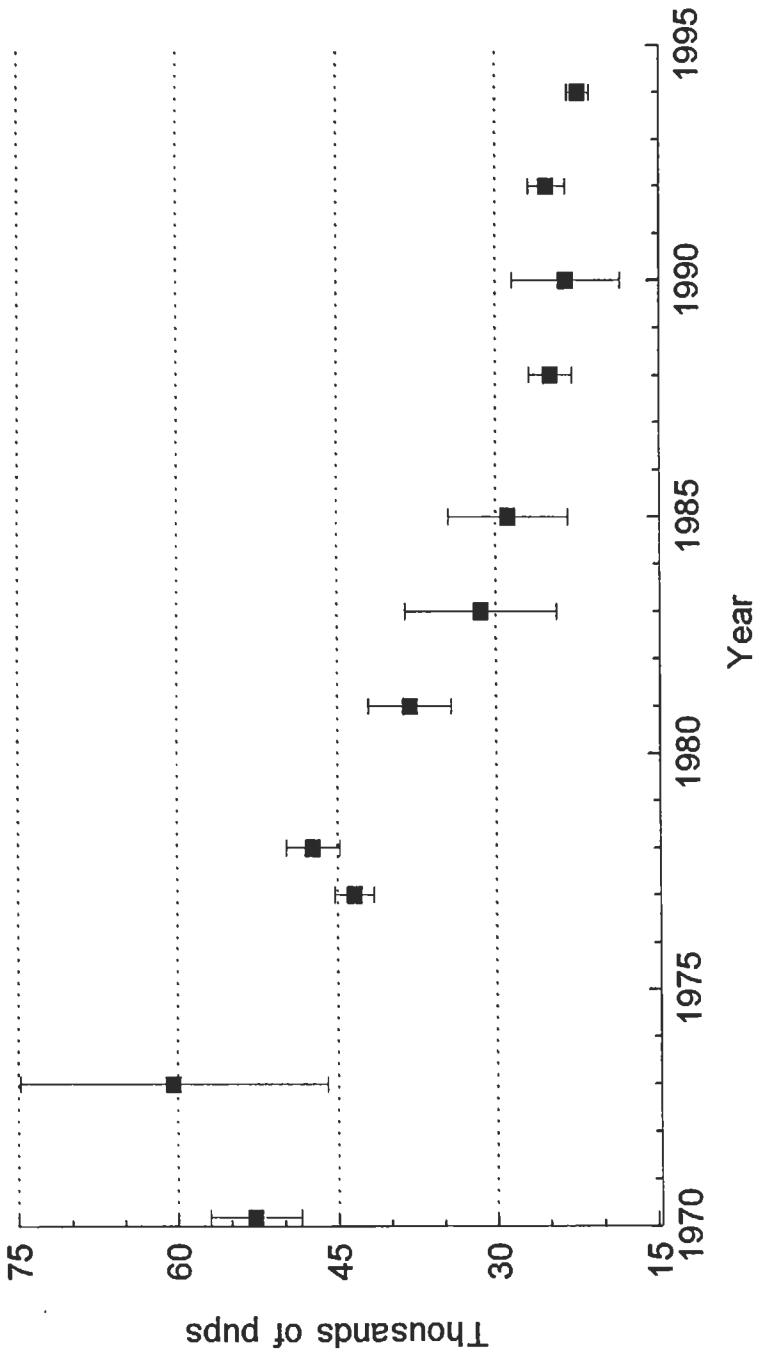


Figure 9.--Number of northern fur seal pups born on St. George Island, Alaska, 1970-94. Approximate 95% confidence intervals are shown.

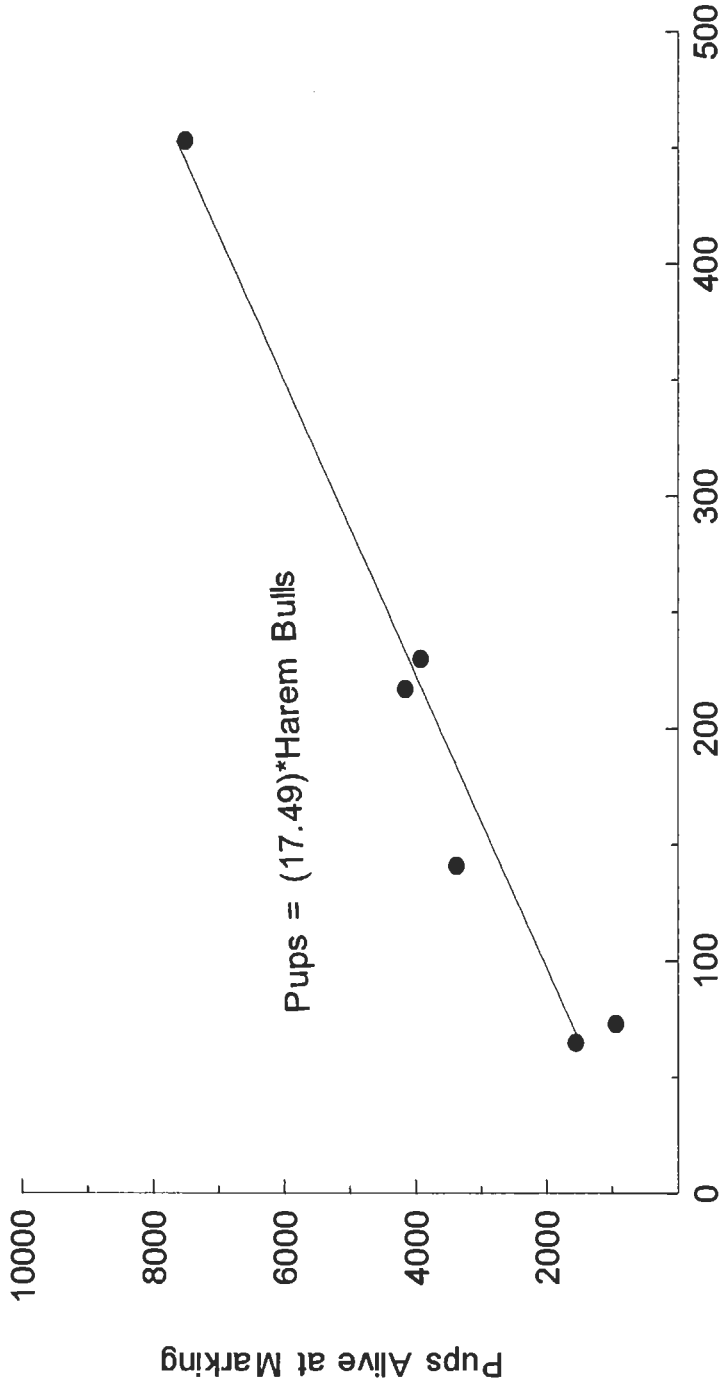


Figure 10.--Number of northern fur seal pups alive at the time of sampling versus number of harem bull fur seals for the rookeries on St. George Island, Alaska, 1994.

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

The rookeries and adjacent beaches of St. Paul and St. George Islands (except Little Polovina) were surveyed for dead fur seals older than pups during July and August 1994 (Table 9). In 1994, tooth samples were collected from a total of 277 (76 males and 201 females) and 23 (6 males and 17 females) animals found dead on St. Paul and St. George Islands, respectively. Tooth samples (usually canines) were collected from all dead fur seals other than pups whenever possible. Appendix Table B-7 summarizes the total number of dead male and female fur seals from which teeth were collected from 1965 to 1994.

Table 9.--Number of animals older than pups found dead on the Pribilof Islands from which teeth were collected during August 1994. Numbers in parentheses are animals with no teeth and sex was identified.

Rookery	Males	Females	No teeth, sex unidentified	Total
St. Paul Island				
Lukanin	5	6	0	11
Kitovi	2(1)	5	0	8
Reef	14(5)	23(2)	6	50
Gorbatch	7	26(2)	3	38
Ardiguen[1]	0	-1	0	1
Morjovi	0	9	0	9
Vcstochni	5	32	3	40
Polovina	2	4	0	6
Polovina Cliffs	2	12	0	14
Tolstoi	6(2)	31(1)	4	44
Zapadni Reef	2	9	0	11
Little Zapadni	7	16	0	23
Zapadni	24	28	0	52
Total St. Paul	84	207	16	307
St. George Island				
South	1	1	0	2
North	3	12	2	17
East Reef	0	0	0	0
East Cliffs	0	0	0	0
Staraya Artil	1	2	0	3
Zapadni	1	2	0	3
Total St. George	6	17	2	25
Total both Islands	90	224	18	332

[1]Teeth for dead adults from Ardiguen were included in Gorbatch.

NEW SAMPLING DESIGN FOR ESTIMATING NUMBERS OF FUR SEAL PUPS ON THE PRIBILOF ISLANDS

by

Anne E. York and Rodney G. Towell

Since 1962, the estimates of the size of the northern fur seal pup population have been obtained using the "shearing-sampling" method (Champman and Johnson 1968, York and Kozloff 1987). The safety of the crew, the accuracy of the estimate, and the minimization of disturbance to rookeries are major concerns; therefore, the work is done as the breeding structure breaks up, but before pups spend most of their time in the water. During early August, large numbers of pups (approximately 10% of the population) are marked by shearing a small patch of hair from the top of the head; this exposes the pale underfur and produces an easily identifiable mark (Antonelis 1992). The marking effort is allocated througout the rookery so that each pup has an approximately equal chance of being marked (Chapman and Johnson 1968).

A few days after shearing (to allow mixing of the marked and unmarked animals), each rookery is sampled to estimate the proportion of marked animals. Samplers proceed through the rookery and sample groups of 25 animals and record the number of sheared animals within the group (Chapman and Johnson 1968). There are many possible ways to allocate the resampling effort. In the past, samplers worked independently and counted different groups of pups. On St. Paul Island, this was important because many of the rookeries are large and this enabled the samplers to

divide the work more easily by working on different parts of a rookery and complete the census in a timely fashion. Generally, the division of sampling on the rookery has been done in two different ways. For narrow rookeries with very little area of inland extensions, the samplers proceed abreast along the length of the rookery. The sampler nearest the water would usually stay 5-10 m ahead of the other sampler(s) so that pups would not be driven into the water before a count was obtained. The samplers typically communicated with each other concerning what groups of pups they were counting and did not count the same groups. For rookeries with large inland extensions, the rookery was divided in advance by picking areas demarcated by obvious landmarks.

The estimate of numbers of pups on the rookery is obtained by dividing the number of animals sheared on that rookery by the fraction of sheared animals observed during the resampling. There are several ways to estimate the variance, but in most cases, we usually estimated the number of pups on two sampling occasions and calculated the standard deviation from the empirical standard error of the estimate (Chapman and Johnson 1968). If two samples were not available, we used the formulas of Chapman (1951) from Seber (1982).

The purpose of this paper is to consider a new sampling design for the resampling portion of the shearing-sampling process. Samplers worked in pairs since we have always been concerned about the potential bias and different variability of individual samplers. Also, we wished to determine if reasonable estimates of the pup population could be obtained by resampling

on only one occasion. Sampling on one occasion would also minimize disturbance to the rookery. The plan was to resample the rookeries as in previous years (sample each rookery on two occasions), but individual teams of two samplers each would do the work together so that their counts could be considered as replicate sample counts of the particular part of the rookery. In this manner, we could compare individual samplers and also assess the effect of using this sampling design but with resampling on only one occasion. In addition, we briefly assess the possibility of using this design as a training vehicle for new observers.

Resampling Design in Detail

Pups were sheared from 10 to 18 August 1994 following techniques used in previous years (Antonelis 1992). Samplers worked in two teams of two persons each that were determined in advance. The four samplers drew their place in a random fashion. There are three sets of distinct teams of two persons each: Set 1: {A,B} and {C,D}, Set 2: {A,C} and {B,D}, and Set 3: {A,D} and {B,C}. The resampling was designed so that each distinct set of teams of two persons each was used approximately the same number of times and so that the first and second resampling of a rookery were done by a different set of teams. For example, if teams {A, B} and {C,D} resampled Reef on occasion 1, then either {A,C} and {B,D} or {A,D} and {B,C} resampled that rookery on occasion 2. Randomization under these requirements resulted in the schedule in Table 10.

Table 10.--Allocation of resighting effort by four samplers (A, B, C, and D) as two teams of two samplers each on two sampling occasions for St. Paul Island, AK, August 1994. The resampling was designed so that each distinct set of teams of two persons each was used approximately the same number of times and so that the first and second resampling of a rookery were done by a different set of teams.

Rookery	First resampling	Second resampling
Vostochni	AD BC	AC BD
Tolstoi	AC BD	AD BC
Gorbatch	AD BC	AB CD
Polovina Cliffs	AB CD	AC BD
Polovina	AB CD	AD BC
Lukanin	AB CD	AD BC
Kitovi	AD BC	AC BD
Reef	AC BD	AD BC
Ardiguen	AD BC	AB CD
Morjovi	AC BD	AB CD
Zapadni Reef	AB CD	AC BD
Zapadni	AC BD	AB CD
Little Zapadni	AC BD	AB CD
Little Polovina	AB CD	AC BD
Sea Lion Rock	AB CD	AD BC

Three of the four samplers were experienced and the fourth was instructed in the basics of resampling. The samplers were instructed to do the resampling as before; that is, the teams could "hip-hop" or divide up the rookery using landmarks and not overlap each other, but within the team, the samplers could resample the same animals. It was not necessary for them to specify which animals they were counting, only the general area. It was desirable for each member of the sampling team to have about the same number of subsamples. The teams needed to discuss this in advance so that they would work more or less consistently over the resampling period but they were instructed to not compare counting results so as to keep their observations as independent as possible. The previous requirement for each sample is the same as before: each pup should have an approximately equal chance of appearing in a sub-sample and the sub-samples by each team should be disjointed.

Calculation of the Estimate

The formulas for the estimates of the number and standard deviation of pups on a rookery under the new sampling plan are simple adjustments to the previously published estimates. Under the old sampling plan, with two samplers, the estimate for a given rookery and sampling occasion is calculated in the following way. Let X_1, X_2, .. X_n be counts of numbers of sheared animals in n groups of 25 animals by sampler 1, and Y_1, Y_2, ... Y_m

be the counts by sampler 2; recall that the counts are non-overlapping and disjointed, so that in some cases m and n could be different. The estimate of the fraction of sheared is the total number of sheared animals counted divided by the total number of animals resampled. In this case, this is

$$f=(\sum_{i=1}^{n} x_i+\sum_{i=1}^{m} y_i)/25(m+n) \quad . \tag{1}$$

The estimate of the number of pups alive at the time of sampling for that occasion is $\hat{N} = s/f$. There are several ways to estimate the variance of $\hat{N}$. In the past, we have usually followed the advice of Chapman and Johnson (1968) and determined the fraction of marked animals on two occasions. The estimate of the number of live pups is the mean of the two resulting estimates and the variance is the empirical variance from two sampling occasions: if f_1 and f_2 are estimates of the fraction of marked animals on occasions 1 and 2, then $\hat{N}_1 = s/f_1$ and $\hat{N}_2 = s/f_2$,

$$\begin{aligned} \hat{N} &= .5(\hat{N}_1+\hat{N}_2) \\ \mathrm{Var}(\hat{N}) &= .5\sum_{i=1}^{2}(\hat{N}_i - \hat{N})^2 = .25(\hat{N}_1-\hat{N}_2)^2 \quad . \end{aligned} \tag{2}$$

When estimates were not available from two (or more) sampling occasions, $\hat{N} = s/f$ and the variance of the estimate was calculated using the following formula:

$$\mathrm{Var}(\hat{N}) = \frac{(s+1)(t+1)(s-r)(t-r)}{(r+1)^2(r+2)} \quad ; \tag{3}$$

s is the total number of sheared animals, t is the total number of animals resampled, which is equivalent to the denominator in Equation (1), and r is the number of sheared animals that were resighted, which is equivalent to $\Sigma x_i + \Sigma y_i$, the numerator in Equation (1) above.

To adjust the above estimates under the new sampling design, we apply Equation (1) to the two-team design. To weigh each observer equally, we use the sum of the mean number of sheared pups in the numerator instead of using the sum of the total observations for the observers within the team. Likewise, we use the mean number of samples for the team (averaged over the team members) for the denominator. These formulas easily generalize to the cases in which there are more than two team members, or if the teams do not have the same number of members. Conceptually the form of the equation is:

$$f = \frac{\textit{Average total sheared pups Team 1} + \textit{Average total sheared pups Team 2}}{25(\textit{Average number of resamples Team 1} + \textit{Average number of resamples Team 2})} .$$

For the case of two teams with two members each, let $X_{1,1}$, $X_{1,2}$, .. $X_{1,n1}$ be counts of sheared pups among 25 pups for team 1 observer 1, $X_{2,1}$, $X_{2,2}$, ... $X_{2,n2}$ counts for team 1 observer 2, $Y_{1,1}$, $Y_{1,2}$, .. $Y_{1,m1}$ for team 2 observer 1, and $Y_{2,1}$, $Y_{2,2}$, .. $Y_{2,m2}$ for team 2 observer 2 for a given rookery and sampling occasion. Let $m = .5(m_1 + m_2)$ be the mean of m_1 and m_2, $n = .5(n_1+n_2)$ the mean of n_1 and n_2. The average number of sheared animals seen by team 1 is $t_1 = .5(\Sigma x_{i1} + \Sigma x_{i2})$ and $t_2 = .5(\Sigma y_{i1} + \Sigma y_{i2})$ for team 2. When resampling is done on two occasions, two estimates $\hat{N}_1$ and $\hat{N}_2$ are

available and an estimate of the number and standard deviation of pups are the empirical mean and the standard error, respectively (identical to Equation 2). These formulas were used to compute the pup estimates on each rookery of St. Paul Island (Table 11).

If resampling is done on only one occasion, it is still possible to estimate the population size and standard deviation. We compare three methods for variance estimation to investigate the effect of resampling only once. The first method repeats what has been done in the past when only one sample is available (Equation 3) except that we replace t, the total number of resampled seals by the mean number of resampled seals (calculated across teams) and r, the total number of marked animals that are resampled with its mean (again calculated across teams). The second is a bootstrap method wherein we resample (with replacement) counts by individual samplers, compute the estimated numbers of pups on the rookery for each subsample, and use the variance of those numbers as the estimated variance of the number of pups born on the rookery. In the third, we consider the work by each team member as a replicate and compute estimates of the mean and variance for each team and sum those to obtain the estimates for the rookery. We compare these methods for the first and second resampling for 1994 to the estimates based on both samples.

Results

The mean number of sheared animals in the 25 pup samples is shown for each sampler (Fig. 11). One sampler (D) consistently

Table 11.--Numbers of pups marked by shearing on each rookery, estimates of pup abundance for each sampling occasion (Est. 1 and Est 2), average number of groups of 25 pups in resighting samples, estimates of standard error (SE1, based on the bootstrap, SE2 based on adjustment to formula 2, and SE3 calculated assuming each team's estimate is a replicated estimate for the rookery (See text for details), and fraction of marked animals appearing in the resamples.

Rookery	Sheared	Est1	Samples	Fraction	SE1	SE2	SE3	Est2	Samples	Fraction	SE1	SE2	SE3	Est
Lukanin	406	3,544	94.5	0.23	204.05	294.82	568.47	3,726	79.0	0.19	494.60	346.99	107.77	3,635
Kitovi	769	6,347	183.5	0.24	377.21	380.01	167.08	6,327	137.5	0.18	431.43	452.22	418.96	6,337
Reef	2,255	21,063	389.5	0.17	865.87	913.38	92.97	21,819	328.5	0.15	943.35	1,047.75	102.39	21,441
Gorbatch	1,714	14,543	275.0	0.16	766.51	749.15	923.35	14,861	221.5	0.13	817.65	869.02	126.75	14,702
Ardiguen	243	2,260	43.0	0.18	173.89	283.18	52.60	2,576	40.5	0.17	337.29	332.52	16.83	2,418
Morjovi	1,404	13,460	222.5	0.16	658.96	776.77	1,040.73	12,851	256.0	0.18	632.68	681.00	9.31	13,156
Vostochni	3,013	25,221	556.0	0.18	781.76	903.09	608.44	28,820	525.5	0.17	1,074.68	1,077.26	1,726.53	27,020
Polovina	278	2,221	60.5	0.22	251.88	229.51	159.49	2,387	76.5	0.28	246.78	213.47	172.23	2,304
Polovina Cliffs	1,846	15,891	469.0	0.25	546.17	592.85	1.55	16,560	363.5	0.20	685.30	730.24	470.28	16,225
Tolstoi	2,426	24,472	354.0	0.15	1,080.61	1,135.33	1,825.97	24,717	331.5	0.14	1,018.36	1,194.17	107.26	24,595
Zapadni Reef	723	7,063	195.5	0.27	407.45	404.97	721.43	7,483	114.5	0.16	564.12	600.34	325.66	7,273
Little Zapadni	1,551	15,863	303.5	0.20	726.05	773.17	278.37	16,671	273.5	0.18	808.48	864.68	227.61	16,267
Zapadni	2,578	28,559	334.0	0.13	1,126.32	1,384.17	1,044.54	27,577	303.0	0.12	1,238.58	1,408.68	768.23	28,068
Total	19,206	180,507			2,467.39	2,738.02	2,777.95	186,375			2,780.60	3,001.67	2,050.69	183,441

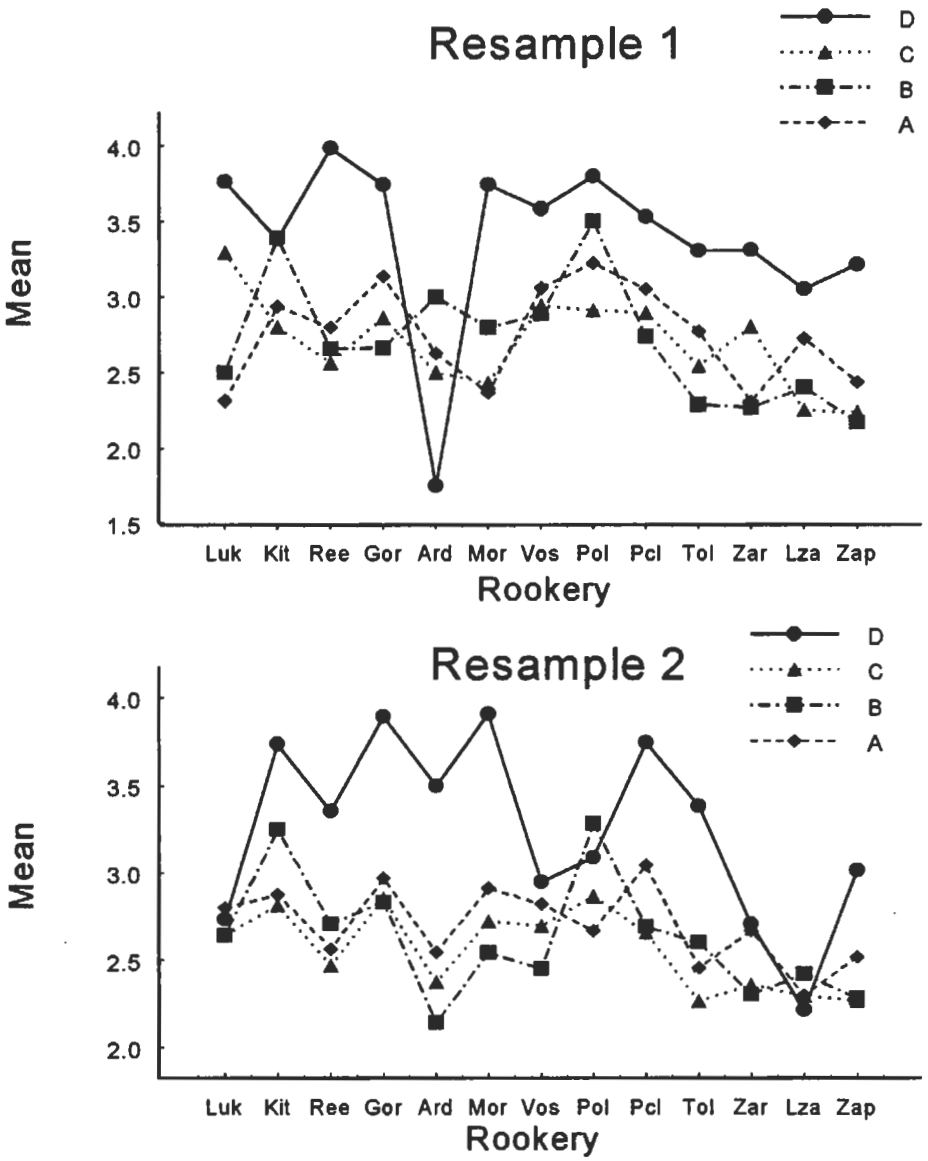


Figure 11.--Mean number of sheared animals resampled by each observer on each rookery on two sampling occasions.

recorded the largest fraction of sheared animals so the data were not used in further calculations.

The estimates of standard error of the pup numbers based on two resampling occasions are smaller than those based on only one sampling occasion (Table 11). This is expected since the standard error declines inversely to the square root of the sample size and theoretically, the standard error of pups numbers based on one subsample should be about $2^{.5}$, or 1.414 times that based on two subsamples.

There is some evidence that the second sample estimate is greater than the first; for example, on 10 out of 13 rookeries, a higher estimate resulted from the second sample. The probability that we would observe 10 or more second estimates as being larger, if they were not different, is 0.09 (exact binomial test). However, the level of the difference is statistically significant (P = 0.05) on one rookery using the theoretical and bootstrap standard errors and on three rookeries using the empirical standard error. The total population sizes are not significantly different from each other (based on any of the three estimates of standard error). The fraction of sheared animals that appeared in the resamples was greater during the first resampling period than the second period for 11 out of 13 rookeries (Fig. 12), probably due to decreased sampling effort during the second period (Table 11) as measured by the average number of 25-pup groups for each sampling time. The three estimates of standard errors for the estimates are somewhat different. Both the bootstrap and theoretical estimates are

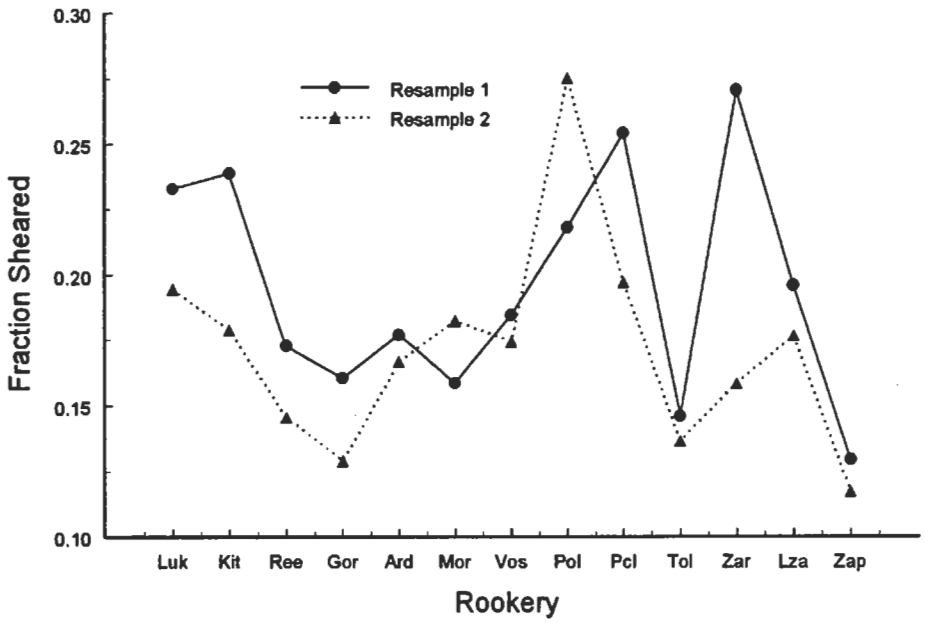


Figure 12.--Fraction of sheared animals resampled on the first and second sampling occasions.

highly correlated with the number of pups on the rookery, while the empirical estimates are not (Fig. 13). The bootstrap and second resamples are highly correlated ($r = 0.981$ and $r = 0.983$) (Fig. 13), whereas this is not the case for the empirical standard errors ($r = 0.01$). The standard errors for the total number of pups on all the rookeries are similar. For standard errors are generally lower than the theoretical standard errors, and the empirical standard errors more variable (Fig. 14). The bootstrap and theoretical standard errors for the first the first resampling, they range between 2,467 (bootstrap), 2,738 (theoretical), and 2,778 (empirical) and for the second resampling, 2,051 (empirical), 2,780 (bootstrap), and 3,002 (theoretical).

Discussion

The great difference between the observations of the experienced and inexperienced observers emphasizes the importance of training samplers. This type of design can be easily used as a vehicle for the training of samplers -- samplers in training could be paired with different experienced observers; they could be taught various techniques for obtaining unbiased estimates and their results could be compared with the experienced observers at the end of every day. Although one could argue that the experienced observers are consistent because they "know" what the answer should be, observations of the first author and others indicate that inexperienced samplers tend to see higher fractions of marked animals. This "cheating observer" question could be

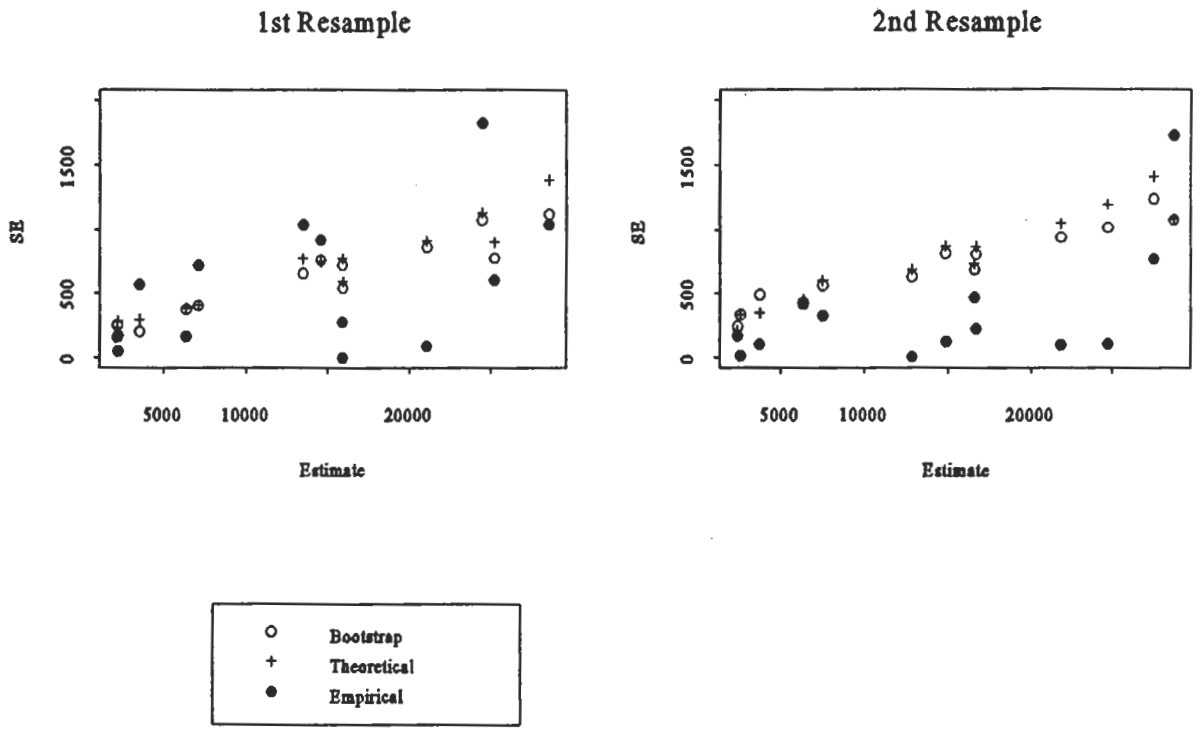


Figure 13.--Relationship between the estimated numbers and standard errors of the estimates of the numbers of northern fur seal pups born on each rookery of St.Paul Island, Alaska during the summer of 1994 for the first and second sampling occasion and three methods of estimating standard errors. Each point represents a rookery.

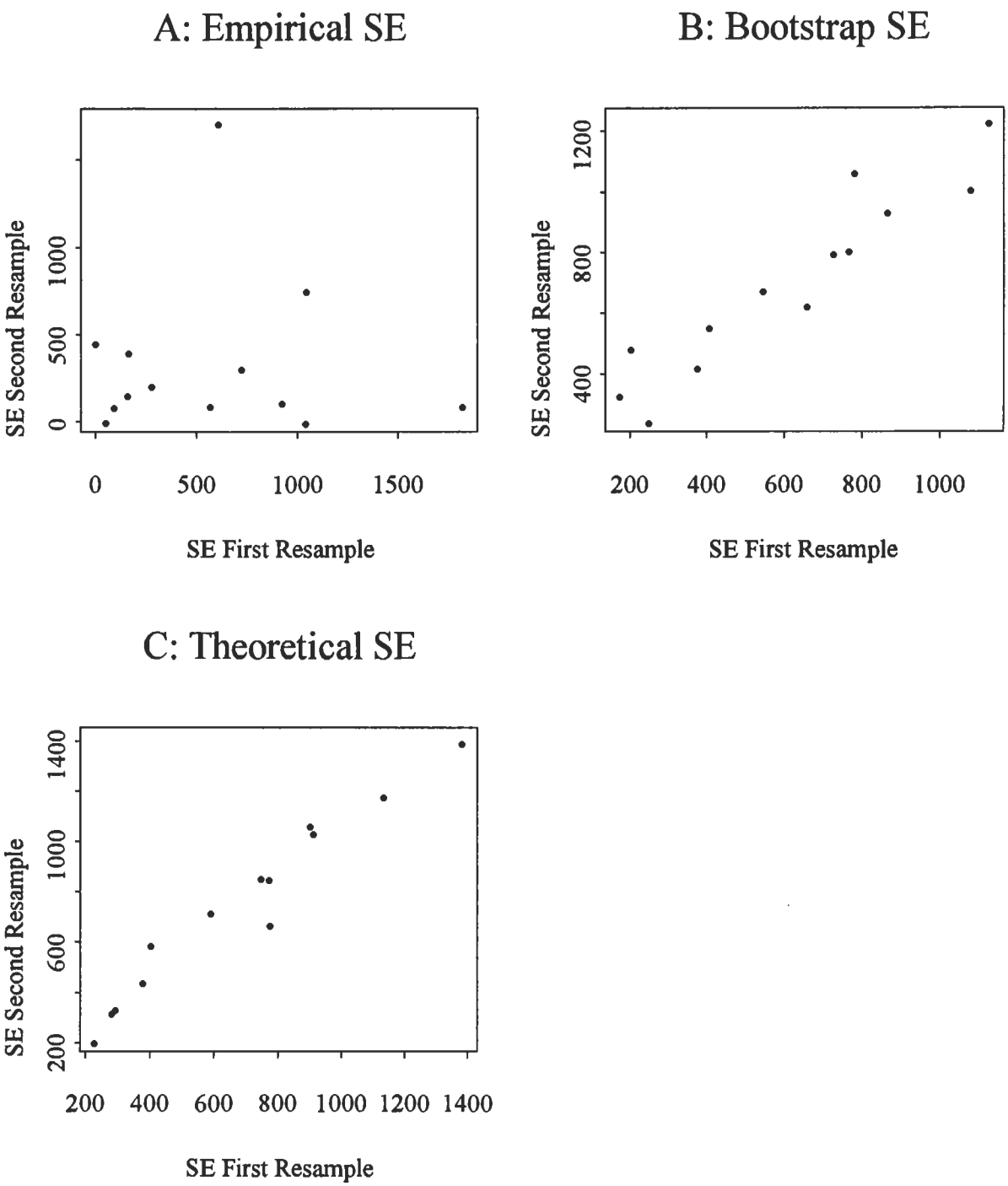


Figure 14.--Relationship between the estimated standard errors of the estimates of the numbers of northern fur seal pups born on each rookery of St. Paul Island, AK during the summer of 1994 for the first and second sampling occasion and three methods of estimating standard errors. Each point represents a rookery. A: empirical standard error based on variability across teams, B:bootstrap standard error, C: theoretical standard errors, from formula 3.

addressed directly by varying the approximate fraction of marked animals on different rookeries.

Resampling on one occasion appears to be a viable method for obtaining pup population estimates. The trade-off for only resampling once and minimizing disturbance is a slightly higher estimate of the standard error.

MASS, LENGTH, AND SEX RATIOS OF NORTHERN FUR SEAL PUPS ON ST. PAUL AND ST. GEORGE ISLANDS, 1992-94

by

Rodney G. Towell, George A. Antonelis, Anne E. York, Bruce W. Robson, and Michael T. Williams

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 of male and female pups from Tolstoi, Vostochni, Polovina, and Reef rookeries on St. Paul Island (1992, 1994), all rookeries on St. George Island (1992, 1994) and Staraya, North, and South rookeries on St. George Island in 1993.

Methods

Pups were randomly sampled in mid-to late August using techniques described for tagging, sexing and weighing (Antonelis 1992), and length measuring (Robson et al. 1994). On two occasions on St. Paul Island in 1994, however, warm weather conditions made it necessary to release a portion of the pups before they succumbed to heat prostration. Sex was determined from a random sample (Antonelis et al. 1994) of approximately 20% and 10% of the dead pups counted in 1992 and 1994, respectively. Mass was recorded to the nearest 0.25 kg, and length to the nearest centimeter. Variations in mass and length of pups on St. Paul and St. George Islands were analyzed using analysis of variance (ANOVA) on sex, rookery, and shearing status (sheared or non-sheared). Here we limit statistical comparisons to

information collected on similar dates (i.e., within a couple of days) during the breeding season between islands in 1994, and between 1992 and 1994 at St. Paul Island. The data for St. George Island (1992 and 1993) were not used since they were collected approximately 10 days earlier in August than in the other years.

Results and Discussion

Pup Mass and Length

Mean mass, length, and 95% confidence intervals by rookery for male and female northern fur seal pups are illustrated in Figures 15 and 16 for St. Paul Island. Sample sizes, mean mass, mean length and standard deviations for each rookery by sex and year are shown in Appendix Tables C-1 and C-3 for St. Paul Island. The ANOVA of the mass by sex and rookery on St. Paul Island in 1992 and 1994 indicated that there was a significant difference between sexes ($P = 0.01$, Table 12) and rookeries ($P = 0.06$ in 1992, $P = 0.01$ in 1994, Table 12). Significant differences in length measurements of pups on St. Paul Island were also detected in 1992 and 1994 between sex ($P = 0.01$, Table 13) and rookery ($P = 0.01$, Table 13).

Mean mass, length, and 95% confidence intervals by rookery for male and female northern fur seal pups are illustrated in Figures 17 and 18 for St. George Island. Sample sizes, mean mass, mean length and standard deviations for each rookery by sex

Table 12.--Analysis of variance of mass northern fur seal pups on St. Paul Island, Alaska, 1992 and 1994. The most parsimonious (see text for details) model based on sex, shearing status and rookeries is shown.

Source	SS	df	MSS	F	p
St. Paul 1992					
Total	3629.395	1117			
Sex	689.414	1	689.414	267.566	1.000
Shearing	53.234	1	53.234	20.661	1.000
Rookery	32.365	3	10.788	4.187	0.994
Rookery X Shearing	10.138	3	3.379	1.312	0.731
Sex X Shearing	2.360	1	2.360	0.916	0.661
Sex X Rookery	0.773	3	0.258	0.100	0.040
Sex X Rookery X Shearing	1.687	3	0.562	0.218	0.116
Residual	2839.424	1102	2.577		
St. Paul 1994					
Total	5791.679	1924			
Sex	604.758	1	604.758	239.653	1.000
Rookery	241.120	3	80.373	31.850	1.000
Shearing	74.188	1	74.188	29.399	1.000
Rookery X Shearing	23.072	3	7.691	3.048	0.972
Sex X Rookery	19.015	3	6.338	2.512	0.943
Sex X Shearing	0.011	1	0.011	0.004	0.052
Sex X Rookery X Shearing	12.214	3	4.071	1.613	0.816
Residual	4817.301	1909	2.523		

Table 13.--Analysis of variance of length of northern fur seal pups on St. Paul Island, Alaska, 1992 and 1994. The most parsimonious (see text for details) model based on sex, shearing status and rookeries is shown.

Source	SS	df	MSS	F	p
St. Paul 1992					
Total	23999.12	1117			
Sex	3157.295	1	3157.295	199.884	1.000
Rookery	2863.885	3	954.628	60.436	1.000
Shearing	404.343	1	404.343	25.598	1.000
Sex X Rookery	87.659	3	29.220	1.850	0.864
Sex X Shearing	16.164	1	16.164	1.023	0.688
Rookery X Shearing	40.984	3	13.661	0.865	0.541
Sex X Rookery X Shearing	21.959	3	7.320	0.463	0.292
Residual	17406.83	1102	15.796		
St. Paul 1994					
Total	40593.47	1924			
Sex	3428.905	1	3428.905	192.574	1.000
Rookery	2441.148	3	813.716	45.700	1.000
Shearing	426.315	1	426.315	23.943	1.000
Rookery X Shearing	198.776	3	66.259	3.721	0.989
Sex X Rookery	98.061	3	32.687	1.836	0.861
Sex X Shearing	0.147	1	0.147	0.008	0.073
Sex X Rookery X Shearing	9.217	3	3.072	0.173	0.085
Residual	33991.90	1909	17.806		

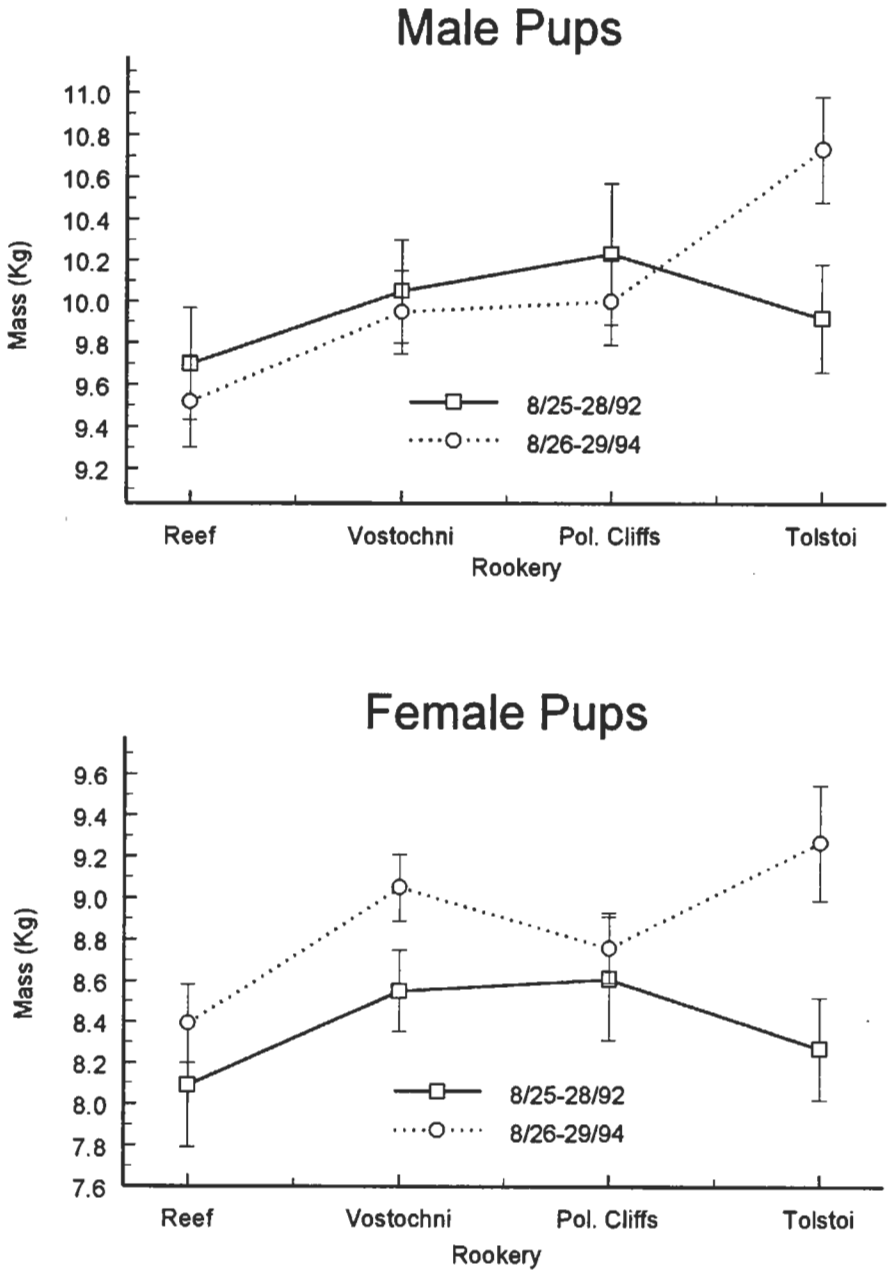


Figure 15.--Mean mass with 95% confidence intervals of northern fur seal pups weighed during August 1992 and 1994, St. Paul Island, Alaska.

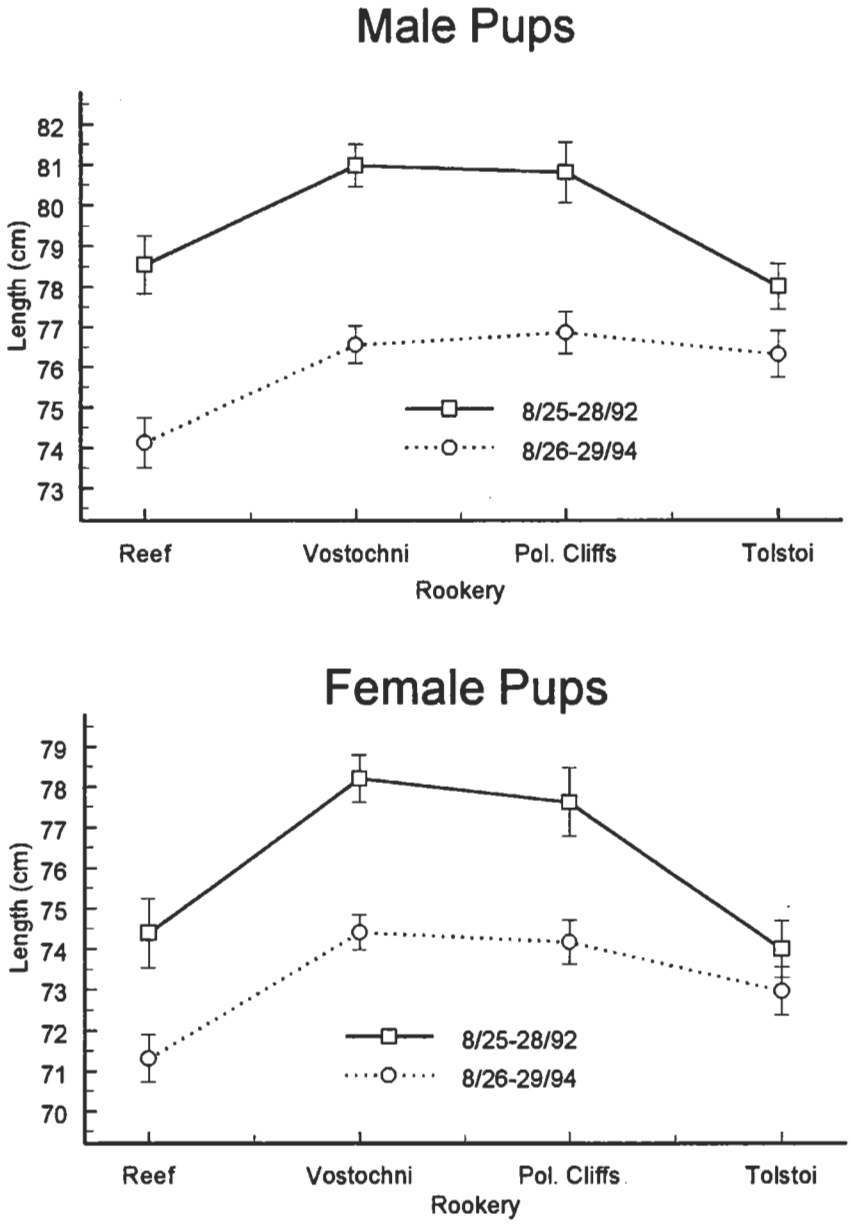


Figure 16.--Mean length with 95% confidence intervals of northern fur seal pups weighed during August 1992 and 1994, St. Paul Island, Alaska.

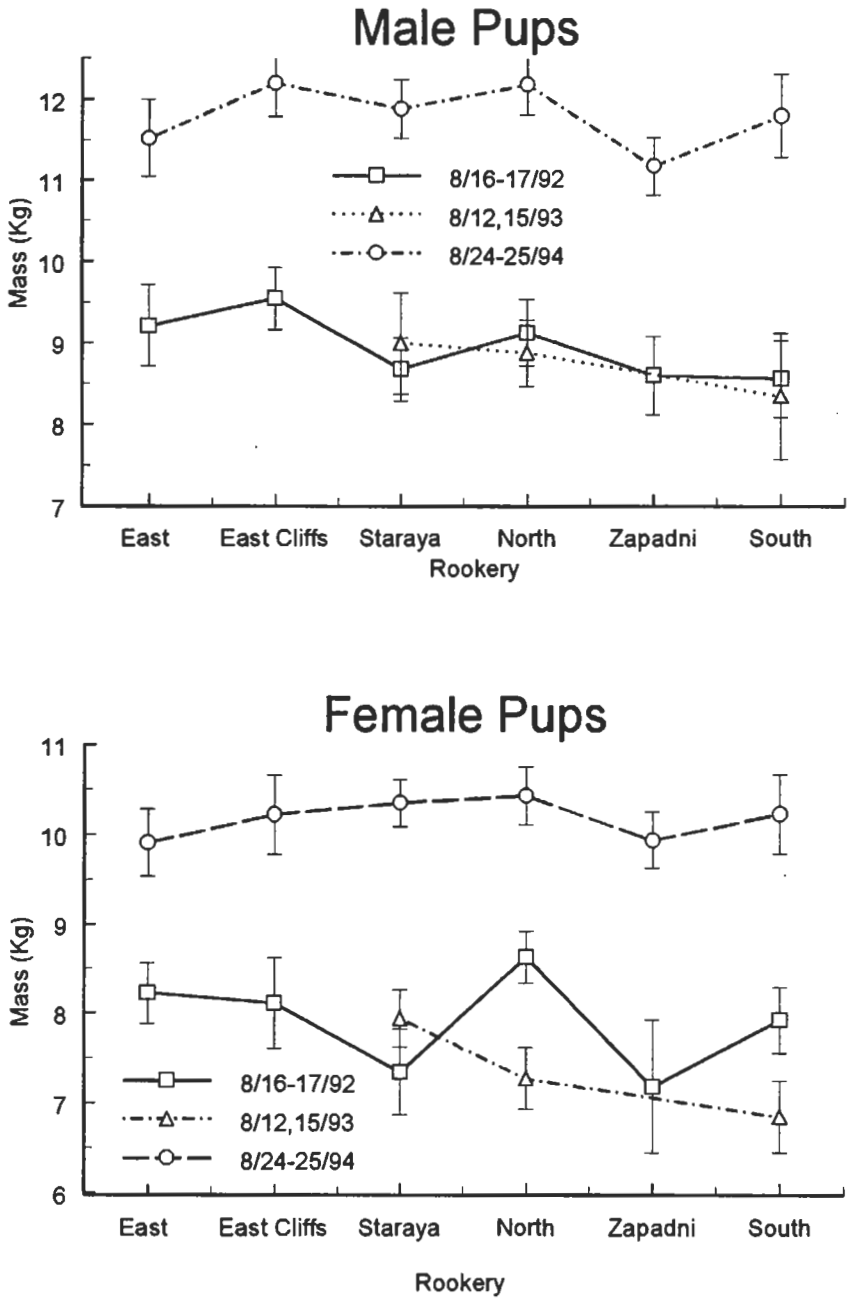


Figure 17.--Mean mass with 95% confidence intervals of northern fur seal pups measured during August 1992, 1993, and 1994, St. George Island, Alaska.

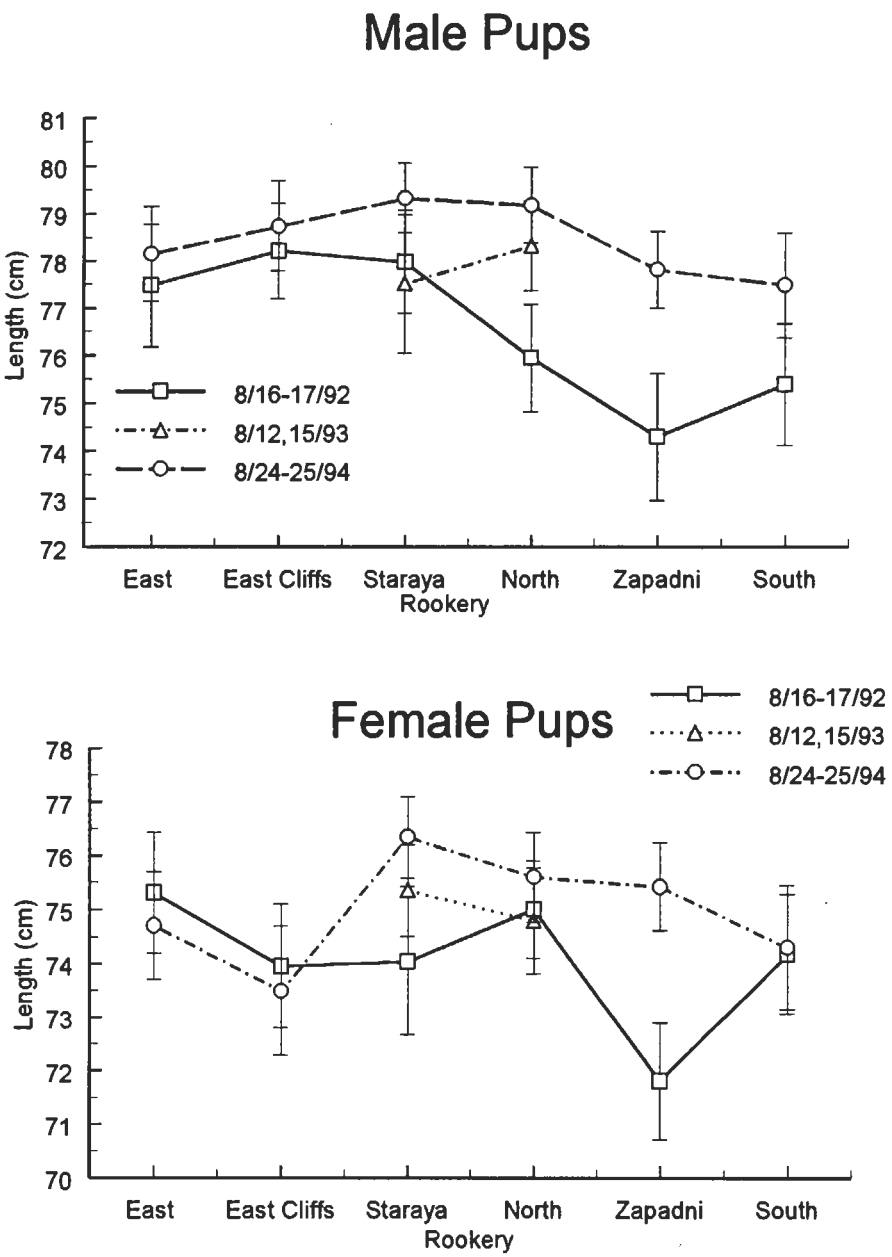


Figure 18.--Mean length with 95% confidence intervals of northern fur seal pups measured during August 1992, 1993, and 1994, St. George Island, Alaska.

and year are shown in Appendix Tables C-2 and C-4 for St. George Island. The ANOVA for mass indicated that there was a significant difference between sexes ($P < 0.001$ in 1992, 1993, and 1994; Table 14) and rookeries ($P < 0.001$ in 1992 and 1994, $P = 0.001$ in 1993; Table 14) in all three sample years. The ANOVA for lengths for all sample years also indicated significant differences by sex ($P < 0.001$ in 1992, 1993, and 1994; Table 15) and by rookery ($P < 0.001$ in 1992 and 1994; Table 15).

Interactions between shearing status, sex, and rookery are considered in our analysis (Tables 12 through 15). Significant differences are likely due to biases associated with selection of lighter pups during the shearing activities (Roppel et al. 1981) or large differences in mean length and mean weight of sheared versus non-sheared pups of either sex on a given rookery.

A separate analysis was conducted to compare the mass and length of pups with similar sample dates, within 3 to 5 days, between islands in 1994 and between years (1992 and 1994) on St. Paul Island. The data for St. George Island was collected approximately 10 days earlier in 1992 and 1993 and was not included in this analysis. The proportion of pups sampled on each rookery was not the same for all years of data collection. Therefore, mean mass for all pups on St. Paul Island was calculated for males and females for 1992 and 1994 by weighing sums of the means for each sampled rookery on the basis of the pup production of that rookery. This was done for each island by weighing the mean according to the fraction of pups that were

Table 14.--Analysis of variance of mass northern fur seal pups on St. George Island, Alaska, 1992-94. The most parsimonious (see text for details) model based on sex, shearing status, and rookeries is shown.

Source	SS	df	MSS	F	p
St. George 1992					
Total	1695.872	632			
Sex	169.860	1	169.86	74.573	1.000
Rookery	82.197	5	16.439	7.217	1.000
Shearing	7.999	1	7.999	3.512	0.937
Rookery X Shearing	25.631	5	5.126	2.251	0.952
Sex X Rookery	17.946	5	3.589	1.576	0.835
Sex X Shearing	0.347	1	0.347	0.152	0.303
Sex X Rookery X Shearing	4.721	5	0.944	0.415	0.161
Residual	1387.170	609	2.297		
St. George 1993					
Total	759.285	272			
Sex	124.457	1	124.457	55.319	1.000
Rookery	30.025	2	15.013	6.673	0.999
Sex X Rookery	4.100	2	2.050	0.911	0.597
St. George 1994					
Total	3059.410	885			
Sex	594.554	1	594.554	218.526	1.000
Rookery	68.937	5	13.787	5.068	1.000
Shearing	15.283	1	15.283	5.617	0.982
Sex X Shearing	2.244	1	2.244	0.825	0.636
Sex X Rookery	11.143	5	2.229	0.819	0.464
Rookery X Shearing	10.262	5	2.052	0.754	0.417
Sex X Rookery X Shearing	11.699	5	2.340	0.860	0.492
Residual	2345.287	862	2.721		

Table 15.--Analysis of variance of length northern fur seal pups on St. George Island, Alaska, 1992-94. The most parsimonious (see text for details) model based on sex, shearing status, and rookeries is shown.

Source	SS	df	MSS	F	p
St. George 1992					
Total	13470.87	633			
Sex	1075.413	1	1075.413	59.449	1.000
Rookery	849.131	5	169.826	9.388	1.000
Shearing	38.621	1	38.621	2.135	0.856
Sex X Rookery	234.534	5	46.907	2.593	0.975
Rookery X Shearing	193.576	5	38.715	2.140	0.941
Sex X Shearing	12.265	1	12.265	0.678	0.589
Sex X Rookery X Shearing	32.537	5	6.507	0.360	0.124
Residual	11034.79	610	18.090		
St. George 1993					
Total	3602.694	218			
Sex	466.596	1	466.596	32.247	1.000
Rookery	0.423	1	0.423	0.029	0.136
Sex X Rookery	24.790	1	24.790	1.713	0.808
Residual	3110.885	215	14.469		
St. George 1994					
Total	16453.07	885			
Sex	2470.125	1	2470.125	162.208	1.000
Rookery	394.076	5	78.815	5.176	1.000
Shearing	96.075	1	96.075	6.350	0.988
Sex X Rookery	144.283	5	28.857	1.895	0.907
Sex X Shearing	29.610	1	29.610	1.944	0.836
Rookery X Shearing	55.628	5	11.126	0.731	0.399
Sex X Rookery X Shearing	135.965	5	27.193	1.786	0.887
Residual	13126.68	862	15.228		

contributed by that rookery to the total number of pups born on the island, for St. George Island, and for the total number of pups for rookeries sampled on St. Paul Island.

These fractions are considered representative of the size of the pup 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 1992 pup production estimates on the four St. Paul rookeries where studies were conducted during 2 years (1992 and 1994). Let $W_{i,j}$ 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-1. Let $V_{i,j}$ be the variance for $W_{i,j}$; $V_{i,j}$ is calculated as the square of the standard deviation (Appendix Tables C-1 and C-2) divided by the sample size (Appendix Tables C-1 and C-2). For example, for females in 1992 the calculation was $V(1,1) = (1.62)^2/116$. For each rookery, i, the fraction of pups (f_i) contributed by that rookery is computed as:

$$4f_i = B_i \,/\, \sum_{i=1} B_i \quad . \tag{1}$$

Then the weighted mean (M) for sex j is

$$M_j = \sum_{i=1} f_i \, W_{i,j} \quad , \tag{1}$$

with variance:

$$S^2_j = \sum_{i=1}^{4} f^2_i \, V_{i,j} \quad . \tag{1}$$

Similar calculations were made for lengths of pups on St. Paul Island and for mass and length of pups on St. George Island where B_i is replaced by P_i = number of pups (on a given rookery i). Significant differences between two means can be assessed by comparing the difference in the two means divided by the square root of the sum of the two corresponding variances to a Student's t-distribution. Degrees of freedom are determined to be the total number of sample points (pups) in year 1, plus the total number of sample points in year 2, less the number of rookeries in year 1, less the number of rookeries in year 2.

The weighing factors (f_i in the above equations) are shown for 1992 in Appendix Table C-5 for St. Paul Island and in Appendix Table C-6 for St. Paul and St. George Islands in 1994. The estimated mean mass of pups and standard error for each sex for 1992-94 from St. Paul Island and for 1994 from St. George Island are presented in Table 16. The estimated mean length of pups and standard error for each sex for 1992-94 from St. Paul Island and 1994 from St. George Island are shown in Table 17. The calculated t-statistics for each year comparison are summarized for mass (Appendix Table C-7) and length (Appendix Table C-8). The mass of male pups was significantly heavier on St. George Island in 1994 than on St. Paul Island in 1992 and

Table 16.--Estimated mean mass (kg) (with its standard error) for northern fur seal female and male pups, St. Paul Island, Alaska 1992-94 and St. George Island, Alaska, 1994.

	St. Paul		St. George
	1992	1994	1994
Females	8.90	8.38	10.25
SE	0.065	0.054	0.084
Males	9.97	10.07	11.91
SE	0.070	0.057	0.095

Table 17.--Estimated mean length (cm)(with its standard error) for northern fur seal female and male pups, St. Paul Island, Alaska 1992-94 and St. George Island, Alaska,1994.

	St. Paul		St. George
	1992	1994	1994
Females	76.11	73.21	75.00
SE	0.185	0.138	0.225
Males	79.59	75.95	78.60
SE	0.158	0.141	0.208

1994, however, there was no significant difference in the mass of males on St. Paul Island between 1992 and 1994. Female pups were also significantly heavier ($P < 0.001$) on St. George Island in 1994 than on St. Paul Island in 1994 or 1992, and female pups on St. Paul Island were significantly heavier ($P < 0.001$) in 1994 than 1992. Males and females on St. Paul Island were significantly longer in 1992 compared to 1994 on St. Paul Island and St. George Island ($P < 0.001$). Male and female lengths on St. George Island in 1994 were significantly greater than lengths on St. Paul Island in 1994 ($P < 0.001$).

Sex Ratios

The fraction of female fur seal pups (live and dead) sampled on St. Paul and St. George Islands are summarized by rookery in Tables 18 and 19. On two occasions on St. Paul Island, it was necessary to release pups before they succumbed to heat prostration. This may have introduced biases to the sex ratio analysis. An analysis of the sex ratios by rookery was conducted by using a General Linear Interactive Modelling (S-Plus) program assuming that the fraction of females in each section was a binomial random variable. The logit of the fraction of females [$\log(p/(1-p))$] was modelled as a linear function of rookery and year of sample. The results from that analysis (Table 20) can be interpreted like an ANOVA 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.

Table 18.--Numbers of female pups, total number of pups, and fraction (that are female) of northern fur seal pups sampled during pup weighing on St. Paul Island, Alaska, August 1992-94. The fraction of females is significantly greater than 50% (P = 0.95) for bold items.

	1992			1994		
Rookery	Females	Total	Fraction	Females	Total	Fraction
Reef	116	250	0.464	217	462	0.470
Vostochni	**171**	**383**	**0.446**	301	632	0.476
Pol. Cliffs	92	200	0.460	202	427	0.473
Tolstoi	**115**	**285**	**0.404**	206	405	0.509
Total	**494**	**1118**	**0.442**	926	1926	0.481
East Reef	48	102	0.471	73	139	0.525
East Cliffs	**37**	**100**	**0.370**	41	99	0.414
Staraya Artil	51	113	0.451	85	164	0.518
North	41	100	0.410	100	219	0.457
Zapadni	51	106	0.481	84	156	0.538
South	63	113	0.558	47	109	0.431
Total	**291**	**634**	**0.459**	430	886	0.485

Table 19.--Numbers of female pups, total number of pups, and fraction (that are female) of northern fur seal pups sampled during dead pup counts on St. Paul Island, Alaska, August 1992 and 1994. The fraction of females is significantly greater than 50% (P = 0.95) for bold items.

	1992[1]			1994[2]		
Rookery	Females	Total	Fraction	Females	Total	Fraction
Reef	**139**	**342**	**0.406**	99	196	0.505
Vostochni	**87**	**210**	**0.414**	64	142	0.451
Pol. Cliffs	36	82	0.439	14	22	0.636
Tolstoi	96	214	0.449	40	82	0.488
Total	**358**	**848**	**0.422**	217	442	0.491
East Reef	-	-	-	1	1	1.000
East Cliffs	**4**	**22**	**0.182**	11	16	0.688
Staraya Artil	31	68	0.456	7	9	0.778
North	22	44	0.500	25	60	0.417
Zapadni	28	59	0.475	9	20	0.450
South	21	44	0.477	10	17	0.588
Total	106	237	0.447	63	123	0.512

[1]Includes the following dead pups taken for mortality studies: Reef 70 females, 93 males; Vostochni 23 females, 37 males; Staraya 27 females, 33 males; Zapadni 12 females, 15 males.
[2]Includes the following dead pups taken for mortality studies: Reef 65 females, 64 males; Vostochni 26 females, 31 males; Tolstoi 1 female, 1 male.

Table 20.--Analysis of deviance for dependence of sex-ratio on rookery and year sampled of northern fur seal pups on the Pribilof Islands, Alaska 1992-94. Fraction of females modeled 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
St. Paul Island					
Grand Mean	15	19.654			
Year	14	9.127	1	10.527	0.001
Rookery	11	8.651	3	0.476	0.924
St. George Island					
Grand Mean	22	35.452			
Rookeries	17	24.332	5	11.121	0.049
Year	16	21.863	1	2.468	0.116

When all categories are considered simultaneously, the addition of the year term for St. Paul Island reduces the deviance significantly ($P = 0.001$). That is, one rejects the null hypothesis of no significant difference in the fraction of females among the years (i.e., the fraction of females was significantly different from 50% in 1992 ($P < 0.001$), but not in 1994 ($P = 0.064$).

On St. George Island, there is no significant difference in the fraction of females between rookeries for 1992 and 1994 ($P = 0.088$). The percentage of female pups (45.6%) in 1992 was significantly different than 50% ($P = 0.005$); however, in 1994, the percentage of female pups (48.9%) was not significantly different from 50% ($P = 0.224$). Analysis for St. George Island was also done without including data from South rookery. From plots of live and dead pup sex ratios for 1992 and 1994 (Fig. 19), South rookery looked to be quite different than all other rookeries on St. George Island. Year becomes a significant factor ($P = 0.027$) when South rookery is not included in the analysis. There is no significant difference in the two models ($P = 0.027$): the model with and the model without South Rookery included.

The fraction of females (all rookeries combined) sampled in 1992 and 1994 on St. Paul Island and St. George Island are presented in Table 21. The ordering of frequency of females is shown below. A line joins groups whose sex ratios were not

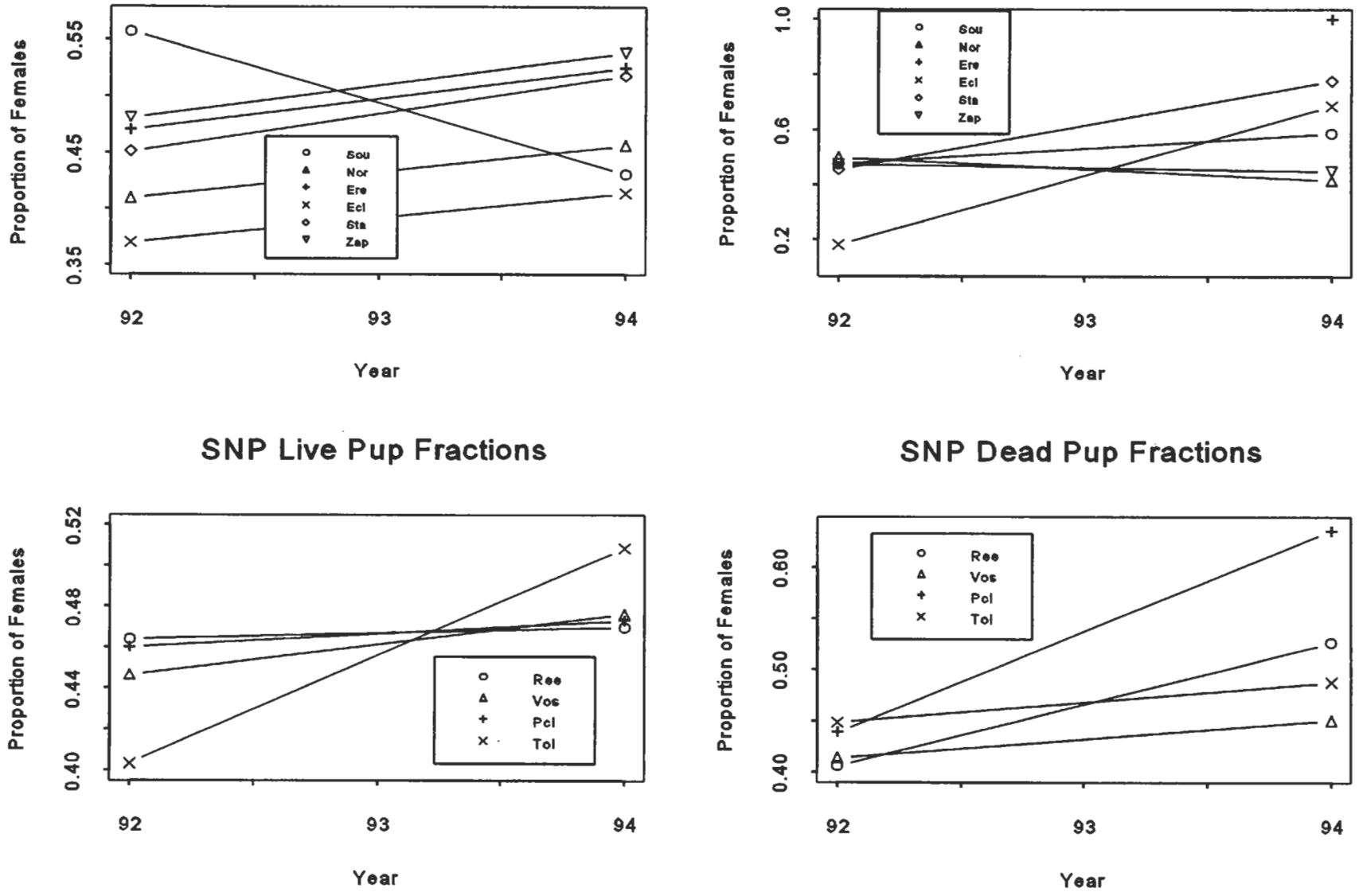
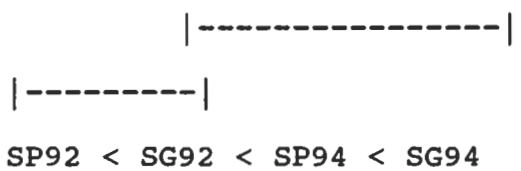


Figure 19.--Fraction of female pups, live and dead, on the Pribilof Islands, Alaska, 1992 and 1994.

Table 21.--Numbers of female pups, total number of pups, and fraction (that are female) of live northern fur seals pups captured during weighing operations and dead pups counted during dead pup counts on St. Paul Island and separate samples on St. George Island, Alaska, for the years 1992-94.

Location	1992			1994		
	Females	Total	Fraction	Females	Total	Fraction
Live						
St. Paul	494	1118	0.442	926	1926	0.481
St. George	291	634	0.459	430	886	0.485
Dead						
St. Paul	358	848	0.422	217	442	0.491
St. George	106	237	0.447	63	123	0.512
All						
St. Paul	852	1966	0.433	1143	2368	0.483
St. George	397	871	0.456	493	1009	0.489

significantly different from each other. For example, the fraction of female pups in the sample from St. Paul Island in 1994 and from St. George Island in 1994 (SP94, SG94) was significantly greater than St. Paul Island in 1992 (SP92) sample.



Significant differences between two frequencies were assessed by comparing the difference in the two frequencies divided by the square root of the sum of the two corresponding variances to a Student's T-distribution with degrees of freedom equal to the sum of the sample size in each group minus 2 (Fleiss 1973).

Summary

Consistent with earlier evaluations of pup mass data (York and Antonelis 1990, York and Towell 1993), the only clear pattern of how mass of pups varied is by sex: males outweighed females. Also, male pups are longer than female pups. Female pups on St. George Island in 1994 outweighed male pups on St. Paul Island in the same year. This may be an island difference since the male pups on St. George Island in 1994 were heavier than the female pups. Significant differences between islands in 1994 and between years on the same island were demonstrated for mass and length of pups. On St. Paul Island, the mass of male pups in

1994 was not significantly different than 1992, however, the length of male and female pups was significantly greater on St. Paul Island in 1992 than on St. George Island in 1994. The mass of male pups on St. George Island in 1994 was significantly greater than males on St. Paul Island in 1992 and 1994. The mass of female pups on St. Paul Island in 1992 was significantly less than female pups on St. Paul and St. George Islands in 1994. Male and female pups on St. George Island in 1994 were significantly longer than male and female pups on St. Paul Island in 1994. Significant differences in the sex ratio of pups between years and islands were usually indicated in most instances by a percentage of females that was less than 50%. 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 for the differences detected in this study. Future studies will be designed to minimize possible sources of biases due to methodology and explore the combined use of length and mass to create condition indices of pups.

WEIGHTS OF KNOWN-AGE SUBADULT MALE NORTHERN FUR SEALS TAKEN IN THE ST. PAUL ISLAND SUBSISTENCE HARVEST, 1991-94

by

Robert V. Caruso and Jason D. Baker

Total body weight and age of subadult male northern fur seals killed during the 1991-94 St. Paul Island subsistence harvest were compared to determine whether there were weight differences between those years for 2-, 3- and 4-year-old males sampled. Subadult males were sampled opportunistically during the 1991-94 subsistence harvests. Immediately following death, each seal was weighed to the nearest kilogram and the upper snout removed for the extraction of the canine teeth (Antonelis 1992). To estimate ages, the number of annual dentin layers were counted on each canine tooth following the methods of Scheffer (1950).

Weights and ages were determined for 12.2% (n = 201), 18.1% (n = 269), 18.8% (n = 285), and 18.6% (n = 300) of the subadult males killed during the subsistence harvests in 1991 through 1994, respectively (Table 22).

A two-factor ANOVA of weight with factors of year and age showed that weight varied significantly with age ($P < 0.001$) and between years ($P < 0.01$). There was no significant interaction between year and age ($P = 0.42$). To determine which year's weight differed for particular ages, single-factor ANOVA were conducted for each age class and the results analyzed with multiple contrasts using the Student-Newman-Keuls test (Zar 1974).

Table 22.--Weights of subadult male northern fur seals taken in the subsistence harvest on St. Paul Island, Alaska 1991-94.

Year		Age			
1991		2	3	4	Combined
	n	89	105	7	201
	% of sample	44.2	52.2	3.5	100
	mean weight (kg)	21.4	25.9	32.7	24.2
	SD	2.7	3.6	3.7	4.2
1992		2	3	4	Combined
	n	109	148	12	269
	% of sample	40.5	55.0	4.5	100
	mean weight (kg)	22.3	26.4	31.1	24.9
	SD	2.8	3.1	3.5	3.8
1993		2	3	4	Combined
	n	125	156	4	285
	% of sample	43.8	54.7	1.4	100
	mean weight (kg)	20.9	25.8	32.0	23.8
	SD	3.1	3.6	4.2	4.3
1994		2	3	4	Combined
	n	125	172	3	300
	% of sample	41.7	57.3	1.0	100
	mean weight (kg)	21.5	25.2	35.3	23.8
	SD	3.0	3.4	5.2	3.9
All		2	3	4	Combined
	n	448	581	26	1055
	% of sample	42.5	55.1	2.5	100
	mean weight (kg)	21.5	25.8	32.2	24.1
	SD	3.0	3.4	4.0	4.1

Comparing years for all ages combined, 1992 weights were significantly heavier than 1991 ($P < 0.05$), 1993, and 1994 ($P < 0.01$). Weights of harvested males in 1991, 1993, and 1994 did not differ significantly.

Two-year-olds sampled in 1992 were significantly heavier than those sampled in 1991 ($P < 0.05$) and 1993 ($P < 0.01$). Although the mean weight in 1994 was about the same as in 1991, no significant difference could be detected between 1992 and 1994.

Three-year-olds sampled in 1992 were significantly heavier than those sampled in 1994 ($P < 0.05$). However, 3-year-olds in 1992 did not differ significantly from those in 1991 and 1993, and weights of 3-year-olds in 1991, 1993, and 1994 did not differ significantly.

There was no significant difference in the mean weight of 4-year-olds among years. Sample sizes for this age class were very small (Table 22).

Males harvested in 1992 were heavier on average than those in 1991, 1993, and 1994. This difference was most notable in the 2-year-old age class and may reflect either a change in size selection among the sealers, a real difference in weight of available males, or a combination of both factors.

SUMMARY OF ACTIVITIES RELATED TO NORTHERN FUR SEAL ENTANGLEMENT IN MARINE DEBRIS

by

Bruce W. Robson, Masashi Kiyota, George A. Antonelis, Mariamna D. Melovidov, and Michael T. Williams

Entanglement of northern fur seals (Callorhinus ursinus) in marine debris has been studied since the early 1980s by the National Marine Mammal Laboratory (NMML) in cooperation with the National Research Institute of Far Seas Fisheries (NRIFSF), the Aleut community of St. Paul Island, and other organizations (Fowler and Baba 1991, Fowler et al. 1992). Surveys of entanglement among subadult male fur seals were conducted in conjunction with the commerical harvest until 1985 (Scordino and Fisher 1983, Scordino 1985) and using research roundups after the cessation of the commercial harvest (Fowler 1987, 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). Rates of entanglement for males appeared to increase from the mid-1960s to the mid-1970s reaching a peak in 1976 at 0.76% among subadult males (Fowler 1987, Fowler et al. 1992, Kiyota and Fowler 1994). Entanglement studies from 1988 to 1992 indicate a decline in the rate of entanglement among both subadult males and females (Fowler and Ragen 1990, Fowler et al. 1992, Kiyota and Fowler 1994).

Here we report on the type of entangling debris and the number of fur seals that were disentangled in 1994. We also

provide information on seasonal and annual (1991-94) rates of entanglement among adult female fur seals.

Methods

During the course of the 1994 northern fur seal research activities on St. Paul and St. George Islands, fur seals entangled in marine debris were captured and debris was removed. Efforts begun in 1993 to remove debris from seals rounded up during the subsistence harvest were continued in 1994 in cooperation with Aleut community members on both islands. Fur seals were also disentangled during the counts of adult males, pup production studies, female foraging studies and other miscellaneous research activities from July to October. Tags were applied to entangled seals of the size historically taken during the commercial harvest (Fowler et al. 1992) for use in assessing the entanglement rate and survival. Information on type of entangling debris and the degree of wounding was recorded.

In 1994, 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 15 to 21 July. Two study sites on Reef rookery were surveyed on 21 July, 31 July, and 10 August to detect changes in the rate of female entanglement between years and during the course of the breeding season. Locations of entangled females were recorded and attempts were made to locate and disentangle

these seals using a portable blind or later in the season during pup production studies.

Results and Discussion

A total of 93 fur seals were disentangled on St. Paul Island and 26 on St. George Island during the 1994 field season (Appendix Table D-1). Approximately equal numbers of male seals were captured during the early (n = 47, 27 June-8 August) and late (n = 46, 10 August-2 September, 24 September-10 November) portions of the field season (Appendix Table D-2) on St. Paul Island. More adult females were captured during the late season (St. Paul n = 15, St. George n = 4) than the late season (St. Paul n = 1, St. George n = 0) due to greater accessibility to females on breeding areas during pup production and late-season foraging studies.

Comparisons between numbers of seals disentangled during research activities during 1993 and 1994 field seasons are difficult due to variable effort and methods between years. During bull counts on St. Paul Island, where an effort was made to disentangle seals in both years, 14 seals were disentangled in 1993 and 17 in 1994. During the subsistence harvest, 10 seals were disentangled in 1993 and 17 in 1994. Prior to the initiation of efforts to capture seals and remove debris in 1993, 5 entangled seals were observed but the debris was not removed. It is possible that these seals were captured and disentangled at a later date and therefore the total of 10 entangled seals represents a minimum estimate for 1993.

For all age and sex categories of seals, trawl net was the most frequently removed type of debris on both islands (Appendix Table D-3) found on 55.2% (n = 48) and 45.5% (n = 10) of all seals in 1994 on St. Paul and St. George Islands, respectively. Plastic packing bands, the second most numerous debris type, were removed from 23.0% (n = 20) of all seals on St. Paul Island and 31.8% (n = 7) on St. George Island. During 1993, trawl net accounted for 41.2% (n = 14) and packing bands for 38.2% (n = 13) of entangling debris removed from all seals on St. Paul Island (Appendix Table D-4). On St. George Island, trawl net was removed from 8 seals (88.9%) and a loop of string from 1 seal (11.1%) while no seals entangled in packing bands were observed in 1993.

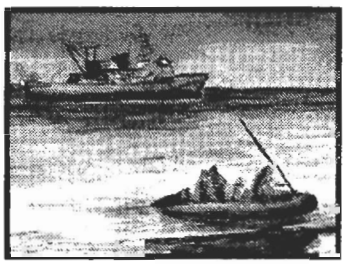
The incidence of trawl net and packing bands on subadult males on St. Paul Island during all research activities was 60.4% and 18.7% in 1994, compared with 47.5% and 22.5% for the same two categories of debris in 1992 during the roundups of subadult males. This suggests a possible increase in the proportion of trawl net found on subadult males since 1992, however differences in methodology (e.g., roundups vs. visual inspection of haul outs from a distance) may account for differences observed in 1993-94.

Twenty female fur seals were disentangled during the course of the research season, most (n = 18) during pup production studies. Trawl net (30%), miscellaneous line (30%), and packing bands (20%) were the most common debris types removed from females (Appendix Table D-3).

Plastic bait bags used in the Bering Sea crab fishery were observed for the first time in 1994 and removed from three seals (a pup, a 4-5 year old male, and an adult male) on St. Paul Island. This debris consists of a lightweight plastic mesh bag hanging from a loop of synthetic line attached to a plastic hook.

Seven entangled and 10 scarred (evidence of previous entanglement) adult female fur seals were observed during female entanglement surveys (Appendix Table D-5). The rate of entanglement among females was calculated at 0.023% for entangled females, 0.033% for scarred females and 0.056% for the two categories combined. The 1994 data show an increase in the observed rate of entangled and entangled and scared females combined from 1992 and 1993 (Appendix Table D-5) (Kiyota and Fowler 1994, Kiyota unpublished data). As in previous years, the observed incidence of entanglement increased as the breeding season progressed (Appendix Table D-6). This may be due to a higher rate of entanglement among younger seals (Kiyota and Fowler 1994, Croxall et al. 1990), which tend to haul out later in the season.

EXPONENTIAL GROWTH OF THE NORTHERN FUR SEAL POPULATION ON BOGOSLOF ISLAND, ALASKA 1976-94



by

John F. Piatt and P. Dawn Goley

Northern fur seals (Callorhinus ursinus) were censused on Bogoslof Island, eastern Aleutians, on 18 August 1994. A total of 1,482 pups (including 10 dead pups) and 3,691 non-pups (adult and subadult fur seals) were observed on beaches. Three fur seals were observed with monofilament line around their necks, and two fur seals with flipper tags were observed. A total of 90 Steller sea lions (Eumetopias jubatus) were counted on beaches and in the water at the southeast tip of the island. The number of pups counted represented a 67% increase over counts conducted in 1993, and continues an exponential increase in pup production at Bogoslof Island that began in the late 1980s.

Methods

During the course of studies on the diet and breeding ecology of Tufted Puffins (Fratercula cirrhata) on Bogoslof Island, Alaska, on 18 August 1994, we conducted a population census of northern fur seals. We used methods suggested by J. Baker (pers. comm.) and described by Ream and Towell (1993). Fur seals were distributed along beaches on the east, west, and south side of the island. Pups were concentrated in three areas: south of the 1992 Dome on the east side; south of Kenyon Dome on

the west side, and east of Castle Rock on the south side (Fig. 4).

Fur seals were counted directly while walking next to or through all rookeries and haul-out areas on the island, except for a small area on the north end of the island between Kenyon Dome and the 1992 Dome. In all areas, animals were categorized as pups or non-pups (1 year of age or older). Owing to limitations on time, no attempt was made to differentiate various age or sex classes of non-pup fur seals.

Counts were made by three observers. One censused pups only, one censused non-pups, while one person recorded data and helped search for pups. East and south side beaches were censused between 0930 and 1230 h. The west beach was censused between 1400 and 1830 h. Pup counts on the east side were relatively straightforward as the beach is sandy and all animals were viewed easily. Pup counts on the west and south sides were more laborious as the beaches are composed of large boulders and pups were usually in hollows among the boulders, making counts difficult. Censusing of non-pups was difficult in all areas because of their large numbers and rapid movements on the beach. We tried to count non-pups in discrete blocks ahead of us as we approached them, and before they scrambled down the beach toward the water. Estimates of non-pups were likely conservative for all areas. Pup counts were probably conservative on the west and south beaches.

Results

Overall, a total of 5,173 northern fur seals were counted on beaches at Bogoslof Island; including 3,691 adults and sub-adults, and 1,482 pups (10 dead).

On the east and south beaches, a total of 2,515 adult and sub-adult fur seals were counted on beaches and in the water. Three animals had monofilament line around their necks, and one tagged animal was observed. The tag could not be read, but it was a monel tag attached to the front flipper. At the northeast rookery (south of 1992 Dome), a total of 253 live and 2 dead pups were observed. The mean group size was 7.91 pups (± 10.2 SD, n = 32). No pups were observed along most of the east side south of this rookery. On the south beach (east of Castle Rock), 209 live pups were counted. The mean group size was 13.1 pups (± 13.0 SD, n = 16).

On the west beach between Kenyon Dome and Castle Rock, a total of 1,176 adult and sub-adult fur seals were counted. These counts were minimum estimates. One seal with a monel tag on a front flipper was observed, but the tag could not be read. At this rookery, a total of 1,010 live and 8 dead pups were counted. The mean group size was 7.16 pups (± 9.24 SD, n = 141).

A total of 90 Steller lions were counted. Most (n = 66) were on the beach or in the water (n = 18) at the southeast tip of the island, while a few (n = 6) were on the west beach near Castle Rock. No other species of marine mammal were observed.

Discussion

The population of northern fur seal pups at Bogoslof Island is continuing to increase exponentially (Fig. 20). After initial colonization in the early 1980s, the pup population grew at a rate of 57% per annum up to 1988 (Loughlin and Miller 1989). Between 1990 and 1993, the pup population exploded at a rate of about 130% per annum (Ream and Towell 1993). Our data suggest that the rate of increase has tapered off, being only 67% between 1993 and 1994. We counted pups carefully, so this apparent decline in rate of increase is probably real and not an artifact of survey effort.

Data unavailable to Ream and Towell (1993) and included in Figure 20 is a census of fur seals conducted at Bogoslof on 28 August 1991 by A. Manville and J. Hague (memo to G.V. Byrd, Alaska Maritime National Wildlife Refuge). They counted 4,839 adults and juveniles and 413 pups of the year for a total of 5,252 fur seals. At least 10 fur seals were seen entangled in trawl net fragments.

Presumably, most of the growth in pup production has resulted from immigration of breeding adults from the Commander and Pribilof Islands (Loughlin and Miller 1989). Our census of non-pups suggested a decline in populations between 1993 and 1994, but this must be considered as tenatative because of the difficulty in counting these animals, and the relatively minimal effort that we expended in counting non-pups compared to the effort in 1993 (Ream and Towell 1993). On the other hand,

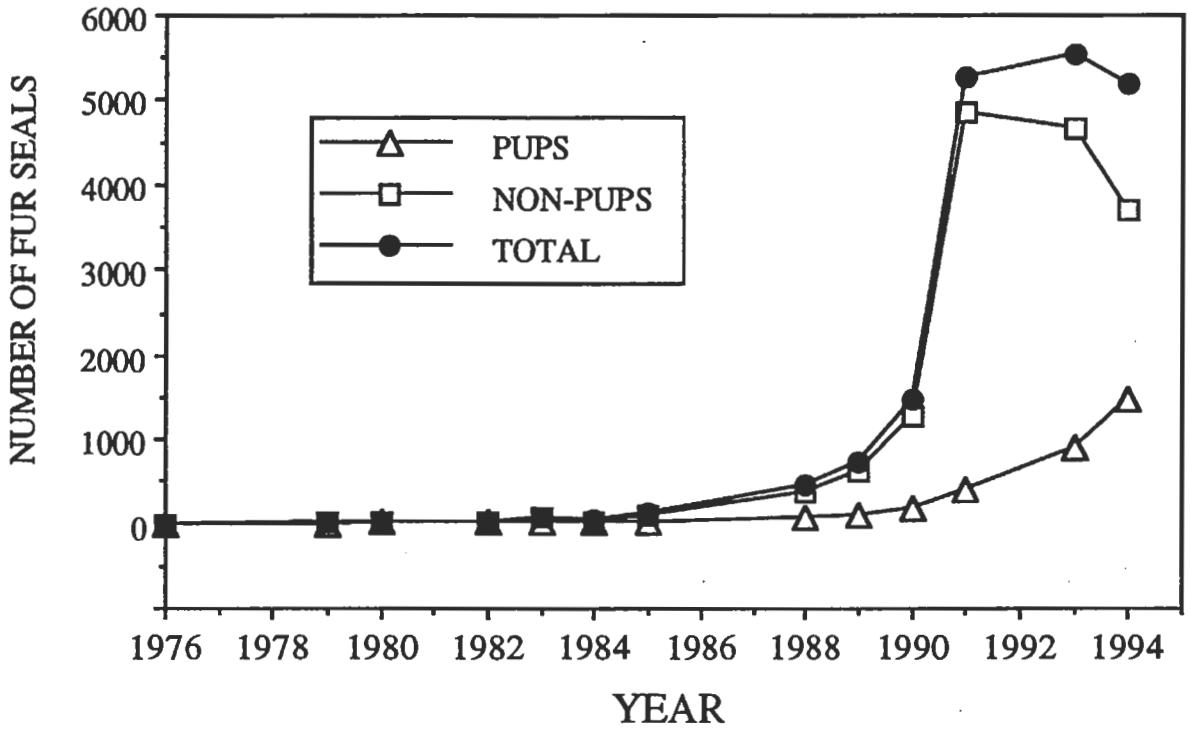
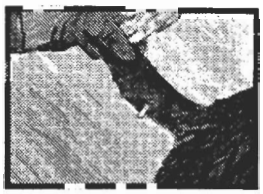


Figure 20.--Number of northern fur seals (Callorhinus ursinus) observed on Bogoslof Island, Alaska, 1976-1994.

unpublished estimates from 1991 suggest that the non-pup population may have peaked in 1991 and is now declining or stabilizing. Given the many sources of error in counting non-pups, more annual counts are needed to resolve the trend.

Steller sea lions appear to be continuing their decline at Bogoslof Island (Merrick et al. 1987, Loughlin et al. 1992). Numbers have decreased from a high of 3,300 in 1979, to 1,300 in 1985, to 682 in 1989, to our count of 90 in 1994. However, as our count was conducted late in the breeding season, it must represent a minimum number.

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



by

Sharon R. Melin, Robert L. DeLong, and James R. Thomason

Population monitoring studies of the northern fur seal population at San Miguel Island, California (34°01'N, 120°26'W) have been conducted since the discovery of the colony in 1968. The San Miguel Island northern fur seal rookery is located at the southern extreme of the northern fur seal's range and although it is located in the Southern California Bight, San Miguel Island remains cool and windy under normal environmental conditions and provides suitable habitat for northern fur seals. However, the Southern California Bight is periodically affected by strong El Niño events, such as the 1982-83 El Niño event, which caused sea surface temperatures to increase 1-3° C above normal for extended periods of time (DeLong and Antonelis 1991, DeLong and Melin 1992).

In January 1992, El Niño conditions similar to the 1982-83 El Niño occurred along the California coast. Sea surface temperatures near San Miguel Island were elevated throughout 1992 and 1993 and returned to normal in 1994. Similar to the effects of the 1982-83 El Niño, the fur seal population at San Miguel Island experienced decreased pup production, high pup mortality and lower weights of pups at 3 months of age in the 1992 breeding season (Melin and DeLong 1994). However, unlike the 1982-83 event, pup production returned to pre-El Niño levels the

following year, indicating that adult female survival probably did not decrease significantly during this event (Melin et al. 1994). Although pup production was high in 1993, pup weights remained depressed suggesting that adult females were still experiencing difficulty in obtaining food during the 1993 breeding season (Melin et al. 1994). Monitoring studies conducted in 1994 continued to investigate the effects of the 1992-93 El Niño event on the population growth and health of the northern fur seals at San Miguel Island. Estimates of pup production, condition, and mortality were determined. Survival of tagged individuals was also monitored.

Methods

Observations and Census of Adults

Daily observations of northern fur seals at San Miguel Island began 11 May and continued through 8 July 1994 in Adams Cove. Observations were conducted from two blinds overlooking the Adams Cove rookery (approximately 20 m above and 40 to 300 m horizontal distance from the breeding animals). One blind was located at the northeast edge and the other at the southeast edge of the rookery.

Observations were made using a 60 mm zoom scope or binoculars. Every 1 to 3 days during the observation period, territorial bulls (class 2 and 3) were counted. Arrival dates of territorial bulls and females were also recorded.

Live Pup Census and Pup Mortality

Live pup counts were conducted on 31 July in Adams Cove and on 7 August at Castle Rock. The live pup census in Adams Cove was conducted by two observers using binoculars and counting pups in each breeding group. At Castle Rock, geographic markers were used as boundaries for counting pups in groups. The mean was calculated from the total counts of the two observers. The standard error was calculated using the sum of the variances from the two independent counts for each group of pups.

Three fur seal pup mortality surveys, one each in June, July, and August 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. In the July and August surveys, pups were collected from the entire fur seal rookery. Each dead pup was counted, removed from the territory, and then stacked in an area away from the survey area to minimize the possibility of counting the same pup twice during the season. At Castle Rock, dead pups were counted once during the live pup census. The total dead pup count at each location, Adams Cove and Castle Rock, is the sum of the dead pups counted by each observer at each area.

Pup Tagging and Growth

On 6 October, 300 northern fur seal pups were tagged with pink plastic roto tags in Adams Cove. Tags with the same number were placed on both foreflippers of each pup. Each pup was sexed, weighed, and measured (length and girth).

Resight Effort

Efforts to resight tagged juvenile and small adult male fur seals at San Miguel Island were conducted regularly throughout the season. Resight efforts for tagged females were conducted on 9 July, 31 July, and 4 August. Tagged individuals were identified by reading tags on the foreflippers. Observations of tagged individuals were conducted using binoculars, a 60 mm zoom scope or a high-power reflective scope. The tag numbers, behavior, and general condition of tagged individuals were recorded.

Results

Observation and Census of Adults

In 1994, the first territorial male arrived on 11 May at Adams Cove on San Miguel Island. The maximum number of territorial males with females in their territory was 97 on 3 July. An additional 46 territorial males held territories without females on this date.

The first adult female arrived 26 May and gave birth the next day. Other females began arriving on 29 May and the onset of pupping occurred on 30 May.

Pup Census

A total of 2,452 live pups were counted in Adams Cove and at Castle Rock (Table 23). In Adams Cove, the mean count was 1,572 (SE = 10.7) pups. A mean of 880 pups (SE = 15.4) was calculated for pups on Castle Rock. These counts are the highest recorded since the discovery of the colony (Fig. 21).

Table 23.--Northern fur seal pup counts at Adams Cove and Castle Rock, San Miguel Island and total for San Miguel Island 1994. Number live and dead is the minimum number of pups in the population.

Location	Date[1]	Mean Number Live	SE	Number Dead[2]	Total	% Mortality[3]
Adams Cove	Jul 31	1,572	10.7	120	1692	7.1
Castle Rock	Aug 7	880	15.4	62	942	6.6
Total		2,452		182	2634	6.9

[1]Date of live pup count.
[2]Number of dead pups is a cumulative count over the season, beginning at the end of June; does not include mortalities early in the season.
[3]Should be used only as an index of pup mortality.

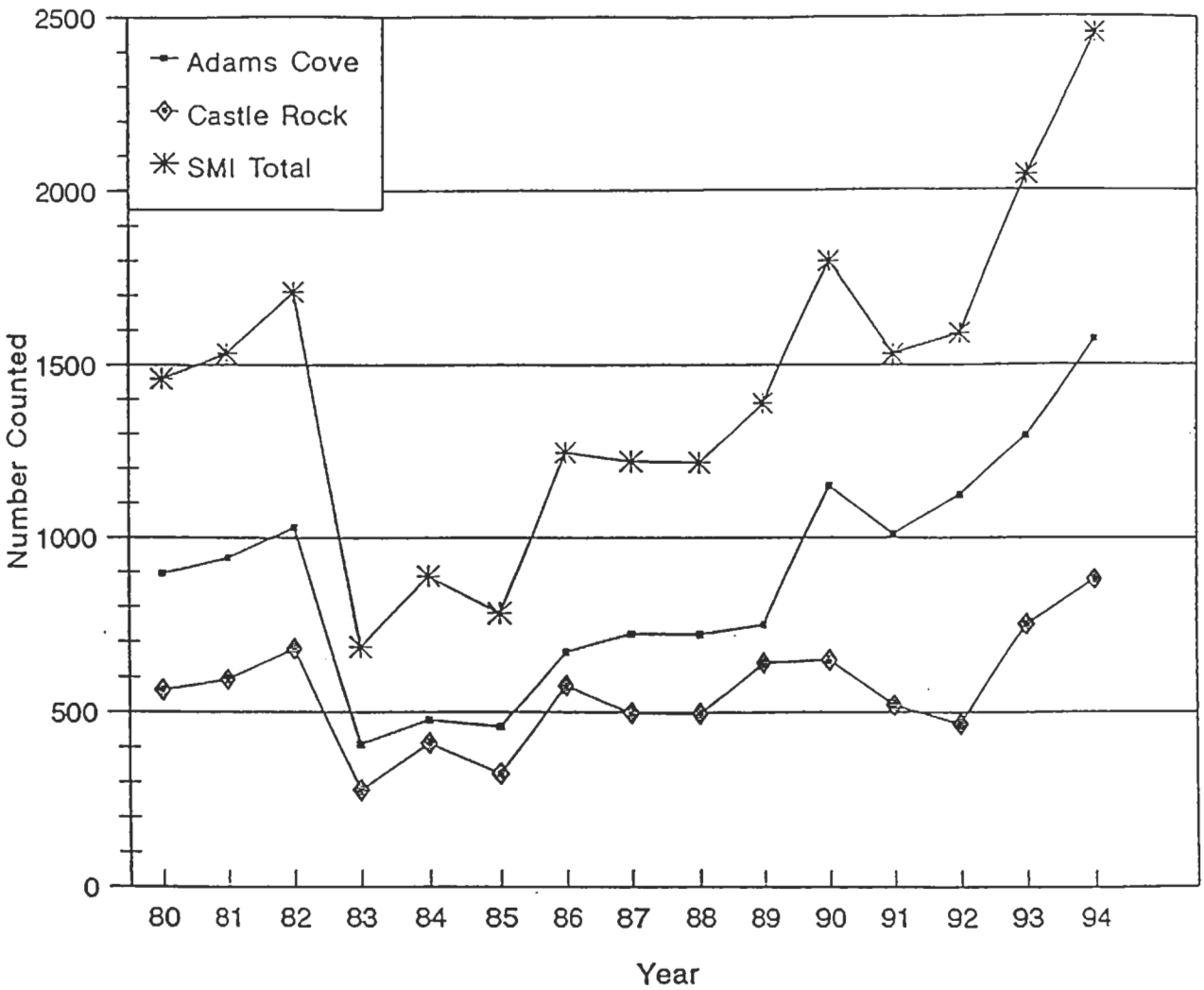


Figure 21. Northern fur seal pup counts at Adams Cove and Castle Rock and the total pup count for San Miguel Island, California, 1980-1994.

A minimum of 120 dead pups in Adams Cove were counted over the study season (Table 23). Several factors affect the accuracy of the dead pup counts in Adams Cove: 1) fur seals give birth near the beach crest and dead pups may get washed to sea between surveys, 2) Adams Cove is a sandy beach and dead pups may be buried between surveys and 3) pup mortality in June has not been assessed because California sea lions are also pupping and breeding at this time and are sensitive to disturbance. Therefore, it is important to note that the mortality estimate reported here is only useful in detecting trends in mortality over time. The minimum mortality rate for northern fur seal pups using the dead pup survey estimate was 7.1% for the Adams Cove population in 1994.

At Castle Rock, 62 dead pups were counted during a single survey (Table 23). The observed mortality rate of fur seal pups on Castle Rock was 6.6%. Castle Rock is a rocky substrate and dead pups are more likely to remain on the rookery for longer periods of time. However, a mortality estimate from a single survey may also underestimate the mortality because of decomposition of carcasses and because the survey is conducted a full month after the highest period of mortality has occurred.

Pup Growth

In 1994, the mean weights of male (x = 11.6 kg) and female (10.2 kg) pups were significantly greater than pups in 1993 (ANOVA, males: $F = 37.25$, $P < .000$, females: $F = 16.9$, $P < .000$)

(Table 24). Although the lengths were not different for pups in 1993 and and 1994, the girth of males was significantly lower for pups in 1993 (ANOVA, $F = 15.5$, $P < .000$) (Table 24). The girths of female pups were lower in 1993 but the difference was not significant.

Resight Effort

Fifty-four tagged female and 82 tagged male fur seals were sighted throughout the season (Table 25). Nine cohorts were represented by the tagged individuals. Of the nine cohorts represented, over half of the resighted females were 5 or 6 years old (53.4%) and most of the males were between 4 and 6 years old (71.1%) (Table 25). The 14-year-old females were the oldest tagged animals sighted and two of these females were attending pups.

Discussion

Population Monitoring

The northern fur seal population at San Miguel Island continued to increase in 1994. Territorial bull counts and live pup counts, as indices of population growth, showed significant increases over 1993, at 28.6% and 16%, respectively. These increases, along with increased pup weights and girths, indicate that the northern fur seal population was no longer experiencing negative effects from the 1992-93 El Niño.

The arrival of females and the onset of pupping during the last week of May is similar to the dates observed in other

Table 24.--Length and girth of northern fur seal pups three months of age at Adams Cove, San Miguel Island in 1993 and 1994. P-value is derived from a one-way analysis of variance (ANOVA) by years.

Sex	n	Mean Length (cm)	P-value	Mean Girth (cm)	P-value	Mean Weight (kg)	P-value
Females							
1993	74	76.4±3.7		52.6±4.1		9.2±1.6	
1994	144	76.7±3.8	.61	53.7±4.3	0.08	10.2±1.7	0.00*
Males							
1993	71	78.6±3.6		53.6±4.5		9.7±1.9	
1994	155	79.5±4.0	.12	56.2±4.6	0.00*	11.6±2.0	0.00*

* Significant at $\propto$ = .05 1994, the girth of males was significantly lower for pups in 1993 compared to 1994 (ANOVA, $F = 15.5$, $P < .000$). The girths of female pups were lower in 1993 relative to 1994, but the difference was not significant.

Table 25.--Number of tagged northern fur seals sighted at, Cove, San Miguel Island, California from May through August 1994.

Cohort	Females				Males			
	n	Number sighted	Percent of cohort sighted	Percent of 1994 sightings	n	Number sighted	Percent of cohort sighted	% of 1994 sightings
1981	102	4	3.92	7.41	104	0	----	----
1985	43	2	4.65	3.70	56	4	7.14	4.88
1986	51	4	7.84	7.41	48	4	8.33	4.88
1987	56	3	5.36	5.56	43	5	11.63	6.10
1988	192	15	7.81	27.78	195	16	8.21	19.51
1989	159	16	10.06	29.63	195	30	15.38	36.58
1990	85	5	5.88	9.26	114	13	11.40	15.85
1991	159	5	3.14	9.26	142	9	6.34	10.98
1992	163	0	----	----	136	1	0.01	1.22

non-El Niño years (Antonelis et al. 1988, Antonelis and DeLong 1985). During 1983 and 1993, the onset of pupping occurred after the first week of June, 1 week later than in normal years (Antonelis and DeLong 1985, Melin and DeLong 1994). Temte (1985) suggested that a specific photoperiod is required for implantation to occur in northern fur seal females. In years affected by El Niño conditions, the warmer sea surface temperatures may shift the distribution of northern fur seals farther north in search of prey. If females are distributed far enough north that the photoperiod required for the stimulation of hormones to initiate implantation is a week later, then the date of first birth would also be approximately a week later. Physical condition probably also plays a role in the timing of reproductive events. Poorer physical condition during El Niño years may also affect implantation and gestation. The occurrence of the arrival of adult females and the first birth at approximately the same time in 1994 as in other non-El Niño years suggests that implantation occurred within the normal time period. This may be a reflection of a shift in the pelagic distribution of females to their normal feeding areas during the winter, improved physical condition of females, or a combination of these conditions during the winter of 1994.

The 1994 pup mortality rate in Adams Cove (7.1%) was the same as the 1993 mortality rate (Melin, unpublished data) but was lower than the 24% mortality rate observed in 1992 (Melin and DeLong 1994). The mortality rates for both Adams Cove and Castle Rock are higher than those observed for the Pribilof Island

population in 1990 (4.5%) (York and Fowler 1992) but lower than those reported by DeLong (1982) for San Miguel Island in the 1970s (22%). The difference in the mortality rates between the Pribilof and San Miguel Island populations may be due to differences in habitat. During each breeding season at San Miguel Island, at least 2 days and often more are extremely hot (in excess of 30° C). If these hot days occur early in the season, fur seal pups may die due to heat prostration (DeLong 1982). In addition, the majority of fur seal breeding territories are located along the beach crest and during periods of high tides. These tides may flood the breeding territories and pups may be washed to sea before they are able to swim efficiently. Neither of these conditions are characteristic of the Pribilof Island rookeries which perhaps accounts for the higher natural mortality rate seen at San Miguel Island.

The apparent difference in pup mortality rates for San Miguel Island between the 1970s and 1990s may be due to differences in survey methods. DeLong (1982) reported that during the period from 1969 to 1978, most pup mortalities (70%) occurred early in the season before the mean birthing date, and approximately 50% of all pup mortalities occurred within the first week of life. However, in these years, the fur seal population was small and breeding groups were located close to the blind site allowing accurate observation of births and deaths of individual pups. Because of redistribution of most of the fur seal territories far from the observation blinds in the 1980s, the method of assessing pup mortality has changed from assessing

mortality of individuals over the season to assessing overall mortality over periods of time. If most pups still die shortly after birth or within the first week, it is probable that a high percentage of pups that die were not observed during the first survey in each year in the 1990s. Therefore, the pup mortality rates reported for the 1990s should be used as indices of pup mortality only and an underestimate of the actual mortality. Since pup mortality has been assessed by the same methods in 1992, 1993, and 1994, the mortality rates reported for these years provide comparable estimates for assessing the trend in mortalities over the last 3 years.

The increase in the mean pup weight in 1994 from 1993 provides further evidence that the population was recovering from the effects of the El Niño. Mean pup weights are used as an index of pup health. Pup weights also reflect the health of the female because the weight gain is almost exclusively due to the volume and fat content of the female's milk. The return of pup weights to pre-El Niño levels supports the suggestion that females found sufficient prey during their foraging trips through the lactation period and were probably in better physical condition in 1994 than in 1993.

Girth is also an index of the physical condition of pups. The increase in pup girths in 1994 is further evidence that pups were in better condition in 1994 than in 1993 at 3 months of age. The similarity in lengths of pups in the 2 years suggests that pup growth was not retarded in 1993 despite El Niño conditions.

Assessment of survival of tagged northern fur seals at

San Miguel Island has become increasingly difficult because the population continues to establish territories along the beach crest, far from the observation blinds. In addition, the sympatric distributions of California sea lions and northern fur seals in Adams Cove has precluded tag reading early in the breeding season (in an attempt to minimize disturbance). Therefore, when evaluating the tag resight data, the lack of sightings of animals from specific cohorts does not necessarily mean that the animals were not present.

In 1994, resight efforts for tagged adult females were conducted on 3 days, but since a proportion of females are always at sea, not all tagged females in the population were observed. However, the distribution of females sighted from individual cohorts may represent their relative presence in the population. For example, the number of females sighted in 1994 from the 1989 cohort may suggest that these females occur in a higher proportion within the population than females from other cohorts.

Sub-adult and juvenile males are accessible throughout the season because they haul out in areas outside the California sea lion breeding areas. The lack of sighting of males from specific cohorts may more accurately reflect the absence of these cohorts on the rookery.

The low frequency of sighting older animals of either sex may be a result of relatively high tag loss on older animals (many individuals with only one tag or tag scars on both flippers). In addition, if animals retain their tags, the numbers are often worn and unreadable on older animals.

The absence of sightings of animals from the 1982-84 cohorts during 1994 is interesting. DeLong and Antonelis (1991) reported a complete loss of the 1983 cohort of northern fur seals, and to date no animals have been resighted from this cohort. The lack of sightings of animals from the 1982 and 1984 cohorts is difficult to explain, but may reflect of survival or more probably higher tag loss among older animals. The relationship of age and tag loss in fur seals is currently under investigation.

Fur Seals and El Niño

Although the 1992-93 El Niño exhibited similar oceanographic characteristics to the 1982-83 El Niño, it did not severely impact the northern fur seal population at San Miguel Island. The northern fur seal population experienced decreased pup production and high pup mortality in 1992, but in 1993, pup production increased and pup mortality decreased. In 1994, the increasing trend in population growth continued.

The question of survival of the 1992 and 1993 cohorts remains unanswered. These cohorts may experience a higher mortality in their first year because they were weaned at lower weights. These data should be obtained by the end of the 1996 breeding season.

The northern fur seal population at San Miguel Island provides a unique opportunity to study the population dynamics of a species breeding at the extreme of its range. In addition, northern fur seals at San Miguel Island are competing with another successful pinniped species (California sea lions) for

rookery space and forage resources. Current studies of the northern fur seal population at San Miguel Island focus on density-dependent (interspecific competition) and non-density-dependent (El Niño events) mechanisms of northern fur seal population regulation. These studies are important in understanding the dynamics of a rapidly expanding population that may potentially conflict with other species for the resources of the California Current ecosystem.

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APPENDIX A

Glossary

The terms defined below are used in fur seal research and management on the Pribilof Islands, Bogoslof Island, San Miguel Island, and Castle Rock.

Bachelor — Young male seals aged 2-5 years

Classification of adult male fur seals

Class 1 (shoreline) — Full-grown males apparently attached to "territories" spaced along the water's edge at intervals of 10-15 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 counts, their pups are used as a basis for putting the adult male into Class 3 rather than Class 2.
Class 4 (territorial with females)	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 grounds)	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. Male sincluded in ths count are approximatley 7 years of age and older.
Drive	The act of surrounding and moving groups of seals form one locatin 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 detemine 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, 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, 14-21 July 1994. 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	54	37	-	-	-	-	-	-	-	-	-	-	-	-	91
3	84	74	-	-	-	-	-	-	-	-	-	-	-	-	158
5	142	33	-	-	-	-	-	-	-	-	-	-	-	-	175
Kitovi[b]															
2	23(11)	12	28	65	34	-	-	-	-	-	-	-	-	-	173
3	35(18)	15	51	64	61	-	-	-	-	-	-	-	-	-	244
5	44(48)	6	21	6	187	-	-	-	-	-	-	-	-	-	312
Reef															
2	53	18	57	28	42	34	20	34	27	32	1	-	-	-	346
3	109	80	94	88	77	103	27	97	72	55	9	-	-	-	811
5	9	47	97	17	307	19	70	79	73	227	143	-	-	-	1,088
Gorbatch															
2	44	43	32	2	36	23	-	-	-	-	-	-	-	-	180
3	140	79	108	1	71	78	-	-	-	-	-	-	-	-	477
5	808	14	149	309	0	54	-	-	-	-	-	-	-	-	1,334
Ardiguen															
2	31	-	-	-	-	-	-	-	-	-	-	-	-	-	31
3	109	-	-	-	-	-	-	-	-	-	-	-	-	-	109
5	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Moriovi[c]															
2	18(21)	37	41	22	47	25	-	-	-	-	-	-	-	-	211
3	34(26)	42	52	36	70	37	-	-	-	-	-	-	-	-	297
5	207(20)	21	7	70	21	179	-	-	-	-	-	-	-	-	525
Vostochni															
2	22	17	23	22	17	76	22	23	23	9	19	28	74	36	411
3	42	31	39	50	32	129	51	68	42	28	42	71	144	92	861
5	17	20	9	67	113	43	27	15	41	10	2	101	93	94	652
Little Polovina															
2	10	-	-	-	-	-	-	-	-	-	-	-	-	-	10
3	15	-	-	-	-	-	-	-	-	-	-	-	-	-	15
5	577	-	-	-	-	-	-	-	-	-	-	-	-	-	577
Polovina															
2	25	9	-	-	-	-	-	-	-	-	-	-	-	-	34
3	60	25	-	-	-	-	-	-	-	-	-	-	-	-	85
5	297	89	-	-	-	-	-	-	-	-	-	-	-	-	386
Polovina Cliffs															
2	18	18	13	24	21	50	37	-	-	-	-	-	-	-	181
3	57	51	50	89	71	142	129	-	-	-	-	-	-	-	589
5	182	43	15	29	28	57	49	-	-	-	-	-	-	-	403
Tolstoi															
2	29	30	16	14	32	63	61	53	-	-	-	-	-	-	298
3	79	66	54	79	83	102	90	80	-	-	-	-	-	-	633
5	20	23	16	2	19	35	67	372	-	-	-	-	-	-	554
Zapadni Reef															
2	96	16	-	-	-	-	-	-	-	-	-	-	-	-	112
3	170	62	-	-	-	-	-	-	-	-	-	-	-	-	232
5	32	287	-	-	-	-	-	-	-	-	-	-	-	-	319
Little Zapadni															
2	8	23	38	22	30	39	-	-	-	-	-	-	-	-	160
3	14	78	117	113	84	124	-	-	-	-	-	-	-	-	530
5	58	36	32	44	26	164	-	-	-	-	-	-	-	-	360
Zapadni[d]															
2	32(0)	35	41	58	42	29	45	8	-	-	-	-	-	-	290
3	68(0)	108	56	124	106	80	107	25	-	-	-	-	-	-	674
5	0(68)	29	30	46	51	74	46	456	-	-	-	-	-	-	800

[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, 1975-94. A double-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

Appendix Table B-3--Number of northern fur seal pups sheared on each rookery of St. Paul Island and Sea Lion Rock, Alaska, 1994.

Rookery	Section														Total
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	
Ardiguen	182	61													243
Gorbatch	486	322	389	0	245	272									1,714
Kitovi *	122 (61)	48	158	190	190										769
Lukanin	198	208													406
Morjovi *	199(120)	195	241	168	313	168									1,404
Polovina Cliffs	160	157	173	261	218	426	451								1,846
Polovina	207	71													278
Reef	300	225	276	240	248	272	69	260	196	145	24				2,255
Tolstoi	285	198	205	285	305	421	386	341							2,426
Vostochni	150	105	135	180	108	461	196	240	113	88	159	227	529	322	3,013
Little Zapadni	47	229	335	327	249	364									1,551
Zapadni	259	387	291	467	393	303	392	86							2,578
Zapadni Reef	536	187													723
Seal Lion Rock	266	409	272												947
Total**															20,153

* Numbers in () are for Kitovi Amphitheater and 2nd Point South of Morjovi.

** Total pups to be sheared is 10% times the total number of pups born in the previous pup estimate. Marks are allocated to section based on the number of harem bulls.

Appendix Table B-4--Number of dead northern fur seal pups counted by section on each rookery of St. Paul Island, Alaska (including Sea Lion Rock), 1994.

Rookery	Date	Section															Total
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	necropsies	
Morjovi	8/24	51	74	79	50	55	27										336
Sea Lion Neck	8/24	26															26
Zapadni Reef	8/21	299	87														386
Tolstoi	8/21	85	139	75	81	172	251	195	154								1152
Gorbatch	8/20	223	153	227	5	94	76									1	779
Little Zapadni	8/25	8	119	151	282	147	288									1	996
Vostochni	8/19	23	48	16	53	55	134	75	78	29	19	42	68	234	98	54	1026
Reef	8/23	92	111	188	108	104	157	26	59	67	37	5				134	1088
Ardiguen	8/20	57	28														85
Polovina	8/22	36	18														54
Polovina Cliffs	8/22	30	26	16	64	60	126	56								2	380
Zapadni	8/25	74	132	191	289	203	259	192	91								1431
Lukanin	8/20	117	128														245
Kitovi	8/23	18	7	43	68	38											174
Sea Lion Rock	8/31	104	116	82													302
Total																	8460

Dead pups from Kitovi Amphitheater (1) are included in sec.1 of Kitovi
Dead pups removed for necropsies from Reef and 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, 1994.

Rookery	Section 1	2	3	4	5	Total
South	107	171	152			430
Zapadni	73	205	141			419
East Cliffs	360	165				525
East Reef	121					121
Staraya Artil	137	100				237
North	154	203	304	161	144	966
Total						2,698

Appendix Table B-6.--Number of dead northern fur seal pups counted by section on the rookeries of St. George Island, Alaska, 1994.

Rookery	Date	Section 1	2	3	4	5	Total
E. Reef	8.21	12					12
E. Cliffs	8.22	101	21				122
North	8.22	41	107	109	68	33	358
Staraya	8.23	33	21				54
Zapadni	8.23	38	62	25			125
South	8.23	49	47	21			117
Total							788

Appendix Table B-7.--Number of dead northern fur seals counted that were older than pups, Pribilof Islands, Alaska,1965-94. Teeth (n=88) (usually canines) were collected from most of these seals. A double-dash indicates no data.

	St. Paul Island		St. George Island		Total	
Year	Males	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

[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.

APPENDIX C

Sample size, mean weights, and standard deviation for male and female northern fur seal pups.

Appendix Table C-1.--Sample size (n), mean weights (w) and standard deviation (sd) for a sample of male and female pups on St. Paul Island, Alaska during August 1992 and 1994.

		St. Paul 1992 (Aug. 25 - 28)		St. Paul 1994 (Aug. 26 - 29)	
Rookery		Male	Female	Male	Female
Reef	n	134	116	245	217
	w	9.70	8.09	9.52	8.39
	sd	1.61	1.62	1.74	1.44
Vostochni	n	212	171	331	301
	w	10.05	8.55	9.95	9.05
	sd	1.85	1.33	1.82	1.43
Pol. Cliffs	n	108	92	225	202
	w	10.23	8.61	10.00	8.76
	sd	1.77	1.47	1.60	1.24
Tolstoi	n	170	115	199	206
	w	9.92	8.27	10.73	9.27
	sd	1.70	1.37	1.81	2.02
Combined	n	624	494	1000	926
	w	9.97	8.39	10.01	8.87
	sd	1.75	1.45	1.79	1.57

Appendix Table C-2.--Sample size (n), mean weights (w) and standard deviation (SD) for a sample of male and female pups on St. George Island, Alaska during August 1992-94.

Rookery		St. George 1992 (Aug. 16 - 17)		St. George 1993 (Aug. 12, 15)		St. George 1994 (Aug. 24 - 25)	
		Male	Female	Male	Female	Male	Female
East Reef	n	54	48			66	73
	w	9.21	8.22			11.52	9.91
	SD	1.68	1.17			1.94	1.60
East Cliffs	n	63	37			58	41
	w	9.54	8.11			12.20	10.22
	SD	1.51	1.54			1.55	1.38
Staraya Artil	n	62	51	41	60	79	85
	w	8.67	7.34	8.99	7.94	11.88	10.35
	SD	1.55	1.69	1.95	1.22	1.61	1.22
North	n	59	41	66	52	119	100
	w	9.12	8.63	8.87	7.27	12.18	10.43
	SD	1.56	0.91	1.66	1.23	2.02	1.59
Zapadni	n	55	51			72	84
	w	8.59	7.18			11.17	9.94
	SD	1.79	2.64			1.54	1.43
South	n	50	63	23	31	62	47
	w	8.55	7.92	8.34	6.84	11.79	10.23
	SD	1.66	1.48	1.7	1.09	2.02	1.49
Combined	n	343	291	130	143	456	430
	w	8.96	7.86	8.81	7.46	11.83	10.19
	SD	1.65	1.74	1.78	1.27	1.84	1.47

Appendix Table C-3.--Sample size (n), mean length (l) and standard deviation (sd) for a sample of male and female pups on St. Paul Island, Alaska during August 1992 and 1994.

Rookery		St. Paul 1992 (Aug. 25 - 28) Male	St. Paul 1992 (Aug. 25 - 28) Female	St. Paul 1994 (Aug. 26 - 29) Male	St. Paul 1994 (Aug. 26 - 29) Female
Reef	n	134	116	245	217
	l	78.54	74.39	74.13	71.31
	sd	4.25	4366	4.96	4.40
Vostochni	n	212	171	33	300
	l	80.97	78.20	76.55	74.40
	sd	3.88	3.95	4.37	3.83
Pol. Cliffs	n	08	92	225	202
	l	80.79	77.62	76.85	74.16
	sd	3.91	4.11	4.02	3.92
Tolstoi	n	170	115	199	206
	l	77.98	73.99	76.30	72.96
	sd	3.74	3.77	4.10	4.27
Combined	n	624	494	1000	925
	l	79.60	76.22	75.97	73.30
	sd	4.15	4.53	4.52	4.26

Appendix Table C-4.--Sample size (n), mean length (l) and standard deviation (sd) for a sample of male and female pups on St. George Island, Alaska during August 1992-94.

Rookery		St. George 1992 (Aug. 16 - 17)		St. George 1993 (Aug. 12, 15)		St. George 1994 (Aug. 24 - 25)	
		Male	Female	Male	Female	Male	Female
						66	73
East Reef	n	54	48				
	l	77.48	75.31			78.15	74.70
	sd	4.75	3.84			4.08	4.29
East Cliffs	n	63	37			58	41
	l	78.21	73.95			78.74	73.49
	sd	4.00	3.44			3.61	3.80
Staraya Artil	n	62	51	41	60	79	85
	l	77.98	74.04	77.51	75.35	79.33	76.34
	sd	4.34	4.91	4.65	3.30	3.25	3.51
North	n	59	41	66	52	119	100
	l	75.95	75.00	78.32	74.79	79.18	75.60
	sd	4.35	2.85	3.86	3.53	4.36	4.19
Zapadni	n	55	51			72	84
	l	74.29	71.80			77.81	75.42
	sd	4.88	3.89			3.48	3.74
South	n	50	63			62	47
	l	75.38	74.17			77.48	74.30
	sd	4.50	4.39			4.37	3.91
Combined	n	343	291	107	112	456	430
	l	76.62	74.01	78.01	75.09	78.55	75.21
	sd	4.66	4.14	4.18	3.41	3.96	4.00

Appendix Table C-5.--Fraction of northern fur seal pups contributed by each sample rookery to total number of pups born on St. Paul Island, Alaska, 1992.

Rookery	Fraction
Reef	0.238
Vostochni	0.328
Polovina Cliffs	0.178
Tolstoi	0.256

Appendix Table C-6.--Fraction of northern fur seal pups contributed by each sample rookery to total number of pups born on St. Paul Island and St. George Island,Alaska, 1994.

Rookery	Fraction
St. Paul	
Reef	0.242
Vostochni	0.302
Polovina Cliffs	0.179
Tolstoi	0.277
St. George	
East Reef	0.046
East Cliff	0.194
North	0.379
Staraya Artil	0.077
Zapadni	0.169
South	0.135

Appendix Table C-7.--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 1994	St. George 1994
St. Paul Females		
1992	**-6.150**	**12.710**
1994		**18.730**
St. Paul Males		
1992	1.110	**16.440**
1994		**16.600**

Appendix Table C-8.--Calculated t-statistics for comparison between years of mean lengths of northern fur seals on St. Paul Island and St. George Island, Alaska. Significantly different years are in bold text.

	St. Paul 1994	St. George 1994
St. Paul Females		
1992	**-12.560**	**-3.810**
1994		**6.780**
St. Paul Males		
1992	**-17.189**	**-3.790**
1994		**10.540**

APPENDIX D

Removal of debris from entangled seals

Appendix Table D-1.--Removal of entanglement debris from northern fur seals during research activities and subsistence harvests on St. Paul and St. George Islands, Alaska.

Date	Location	Sex	Age	Debris type	Activity	Tag no.
St. Paul Island						
6/27/94	Reef	male	juv	unk	harvest	-
6/27/94	Reef	male	juv	unk	harvest	-
7/1/94	Zapadni Sands	male	4-5	bait bag	misc.	-
7/1/94	Zapadni Sands	male	4	trawl net	misc.	-
7/6/94	Reef	male	3	trawl net	harvest	1651
7/6/94	Zapadni Reef	male	3-4	trawl net	misc.	1653
7/7/94	Zapadni Sands	male	adult	bait bag	misc.	-
7/13/94	Lukanin	male	4	packing band	harvest	-
7/13/94	Lukanin	male	5	packing band	harvest	-
7/14/94	Zapadni Reef	male	2-3	trawl net	harvest	1654
7/17/94	Morjovi	male	5	trawl net	misc.	-
7/17/94	Morjovi	male	3	trawl net	bull counts	1712
7/17/94	Vostochni	male	4-5	trawl net	bull counts	-
7/17/94	Vostochni	male	2	trawl net	bull counts	1714
7/17/94	Vostochni	male	6-7	packing band	bull counts	-
7/17/94	Vostochni	male	6	trawl net	bull counts	-
7/17/94	Vostochni	male	4	trawl net	bull counts	-
7/17/94	Vostochni	male	2-3	trawl net	bull counts	1713
7/18/94	Zapadni	male	6	trawl net	bull counts	-
7/18/94	Zapadni	male	4	trawl net	bull counts	-
7/18/94	Polovina	male	5	trawl net	harvest	-
7/18/94	Polovina	male	4	trawl net	harvest	-
7/19/94	Reef	male	3-4	trawl net	misc.	1715
7/19/94	L. Zap	male	5	packing band	bull counts	-
7/19/94	Zap. Reef	male	3	packing band	bull counts	1717
7/19/94	Zap. Reef	male	5	packing band	bull counts	-
7/20/94	Polovina	male	5	twine	bull counts	-
7/20/94	Polovina	male	6	packing band	bull counts	-
7/21/94	Zolotoi	male	2	trawl net	bull counts	1718

Appendix Table D-1.--Continued.

Date	Location	Sex	Age	Debris type	Activity	Tag no.
7/21/94	Reef	male	3	trawl net	bull counts	1719
7/22/94	Poly Cliffs	female	4-5	trawl net	misc.	-
7/28/94	Vostochni	male	6	trawl net	misc.	-
7/31/94	Zolotoi	male	8	packing band	misc.	-
8/1/94	Polovina	male	3	packing band	harvest	1657
8/2/94	Lukanin	male	4	trawl net	harvest	1658
8/3/94	Zapadni Reef	male	5	trawl net	harvest	18152
8/4/94	Zapadni	male	4	trawl net	harvest	-
8/4/94	Zapadni	male	2	trawl net	harvest	1660
8/4/94	Zapadni	male	5	trawl net	harvest	1659
8/4/94	Zapadni	male	3	trawl net	harvest	-
8/6/94	Zolotoi	male	3	trawl net	harvest	1735
8/6/94	Zolotoi	male	3	trawl net	harvest	1734
8/10/94	Gorbatch	male	3	trawl net	shearing	-
8/10/94	Zolotoi	male	4	trawl net	shearing	-
8/10/94	Gorbatch	female	7+	net	shearing	-
8/11/94	Vostochni	male	2-3	packing band	shearing	-
8/11/94	Vostochni	male	3	misc	shearing	-
8/11/94	Vostochni	male	2	misc	shearing	-
8/11/94	Vostochni	unk.		net	shearing	-
8/11/94	Vostochni	male	2	trawl net	shearing	-
8/11/94	Vostochni	male	2	packing band	shearing	1736
8/13/94	Poly Cliffs	male	4	trawl net	shearing	-
8/13/94	Poly Cliffs	female	7+	misc line	shearing	-
8/13/94	Poly Cliffs	male	juv	plastic line	shearing	1737
8/18/94	Reef	male	3	trawl net	shearing	-
8/20/94	Ardiguen	female		trawl net	shearing	-
8/21/94	Tolstoi	female	4	twine	shearing	-
8/21/94	Tolstoi	female	7+	line	shearing	-
8/22/94	Polovina	female	5-6	line	shearing	-
8/22/94	Polovina	female	4	packing band	shearing	-

Appendix Table D-1.--Continued.

Date	Location	Sex	Age	Debris type	Activity	Tag no.
8/23/94	Reef	male	2-3	packing band	shearing	-
8/23/94	Reef	female	4	gillnet	shearing	-
8/24/94	Morjovi	unk.	pup	trawl net	shearing	-
8/24/94	Gorbatch	female	5-6	trawl net	shearing	-
8/25/94	L. Zap	male	5	packing band	shearing	-
8/25/94	L. Zap	female	5-6	misc	shearing	-
8/25/94	L. Zap	male	3-4	packing band	shearing	-
8/26/94	Reef	female	5-6	misc	shearing	-
8/26/94	Vostochni	male	2	packing band	shearing	-
8/26/94	Lukanin	male	2	packing band	shearing	-
8/26/94	Lukanin	male	2	trawl net	shearing	-
8/26/94	Reef	male	3-4	trawl net	shearing	-
8/26/94	Reef	male	3	cord	shearing	-
8/26/94	Reef	male	4	trawl net	shearing	-
8/26/94	Reef	female	4	trawl net	shearing	-
8/26/94	Vostochni	male	juv	line	shearing	-
8/26/94	Reef	male	2	trawl net	shearing	-
8/30/94	Zap	male	2	packing band	shearing	-
9/2/94	Reef	female	2	packing band	shearing	-
9/24/94	Reef	male	2	trawl net	misc	-
9/24/94	Reef	male	2	trawl net	misc	-
9/28/94	Vostochni	unk.	pup	misc	misc	-
9/29/94	Vostochni	female		packing band	misc.	-
10/4/94	Reef	male	6	trawl net	misc	-
10/10/94	Vostochni	male	2	trawl net	misc	-
10/10/94	Vostochni	unk.	pup	bait bag	misc	-
ST. GEORGE ISLAND						
7/6/94	Zapadni	male	3-4	rope	harvest	-
7/21/94	East Cliffs	male	3	trawl net	shearing	1724
8/4/94	North	male	2-3	packing band	harvest	-

Appendix Table D-1.--Continued.

Date	Location	Sex	Age	Debris type	Activity	Tag no.
8/5/94	North	male	2-3	glove cuff	harvest	-
8/5/94	North	male	5-6	packing band	harvest	-
8/19/94	East Cliffs	male	2	packing band	shearing	1721
8/19/94	East Cliffs	female	5-6	packing band	shearing	-
8/19/94	East Cliffs	male	4	misc. net	shearing	-
8/20/94	Zapadni	female	adult	rope	shearing	-
8/21/94	North	male	4	trawl net	shearing	-
8/21/94	East Reef	male	3	trawl net	shearing	1723
8/21/94	East Reef	male	2	trawl net	shearing	1722
8/22/94	North	male	4	plastic line	shearing	-
8/22/94	North	male	4	trawl net	shearing	-
8/22/94	East Cliffs	male	4	trawl net	shearing	-
8/23/94	Staraya	male	adult	Misc net	shearing	-
8/23/94	Staraya	male	3	packing band	shearing	-
8/23/94	Staraya	male	2-3	packing band	shearing	-
8/24/94	East Reef	male	3	packing band	shearing	-
8/24/94	East Reef	male	3	trawl net	shearing	-
8/24/94	North	female	adult	trawl net	shearing	-

Appendix D-2.--Removal of debris from Northern fur seals on St. Paul and St. George Islands, Alaska, in 1994 listed by research activity .

	Subadult Male	Adult Male	Female	Pup	Unknown
St. Paul					
Bull counts	8	9	--	--	--
Harvest	15	4	--	--	--
Pup production	22	1	14	1	--
Misc.	8	6	2	2	--
St. George					
Bull counts	--	--	--	--	--
Harvest	6	1	--	--	--
Pup production	14	--	4	--	1
Misc.	--	--	--	--	--

Appendix Table D-3.--Debris removed from northern fur seals in 1993 shown by number and percent of total[1] (in parentheses) for different age and sex categories.

	Trawl net fragments	Packing bands	Cord, rope and string	Monofilament net fragment	Crab pot bait bags	Misc. items
St. Paul Island						
Subadult males	32 (60.4)	10 (18.7)	6 (11.3)	-	-	5 (9.4)
All seals[2]	48 (55.2)	20 (23.0)	11 (12.6)	1 (1.1)	3 (3.4)	8 (9.2)
St. George Island						
Subadult males	9 (40.9)	5 (22.7)	2 (9.1)	-	-	1 (4.5)
All seals	10 (45.5)	7 (31.8)	4 (18.2)	-	-	1 (4.5)
St. Paul and St. George Islands						
Females[3]	6 (30.0)	4 (20.0)	6 (30.0)	1 (5.0)	-	2 (10.0)

[1]Net debris not identified specifically by material or gear type (unidentified net) was not used in percentage calculations (removed from 5 seals on St. Paul and 4 seals on St. George).

[2]Males and females from all age classes.

[3]Total number of females for both islands combined.

Appendix Table D-4.--Number of dead northern fur seal pups counted by section on rookeries of St. Paul Island, Alaska(including Sea Lion Rock), 1994.

Rookery	Date	Section															Total
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	necropsies	
Morjovi	8/24	51	74	79	50	55	27										336
Sea Lion Neck	8/24	26															26
Zapadni Reef	8/21	299	87														386
Tolstoi	8/21	85	139	75	81	172	251	195	154								1152
Gorbatch	8/20	223	153	227	5	94	76									1	779
Little Zapadni	8/25	8	119	151	282	147	288									1	996
Vostochni[2]	8/19	23	48	16	53	55	134	75	78	29	19	42	68	234	98	54	1026
Reef[2]	8/23	92	111	188	108	104	157	26	59	67	37	5				134	1088
Ardiguen	8/20	57	28														85
Polovina	8/22	36	18														54
Polovina Cliffs	8/22	30	26	16	64	60	126	56								2	380
Zapadni	8/25	74	132	191	289	203	259	192	91								1431
Lukanin	8/20	117	128														245
Kitovi[1]	8/23	18	7	43	68	38											174
Sea Lion Rock	8/31	104	116	82													302
Total																	8460

[1]Dead pups from Kitovi Amphitheater (1) are included in sec.1 of Kitovi

[2]Dead pups removed for necropsies from Reef and Vostochni are added but not by section.

Appendix Table D-5.--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 + Scarred
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

Appendix Table D-6.--Change in entanglement among females at Reef Rookery during July and early August, 1992-94.

Date	Count	Entangled	Scarred	Ent (%)	Ent + Scar (%)
7/11/92	4687	0	1	0	0.021
7/22/92	2811	1	1	0.036	0.071
8/2/92	2561	0	4	0	0.156
7/13/93	3528	0	1	0	0.028
7/23/93	2594	0	1	0	0.039
8/2/93	2152	0	1	0	0.046
7/21/94	4279	1	1	0.023	0.047
7/31/94	3350	0	0	0	0
8/10/94	2278	1	3	0.044	0.176

APPENDIX E

Scientific staff engaged in northern fur seal field research in 1994

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

Name	Affiliation	Assignment
Employees		
Jason Baker	NMML	Life History
Mike Cameron	NMML	Population Assessment
Robert Caruso	NMML	Population Assessment
Robert DeLong	NMML	Population Assessment
Charles Fowler	NMML	Population Dynamics
Chris Gburski	NMML	Population Assessment
Rolf Ream	NMML	Foraging Ecology
Sharon Melin	NMML	Population Assessment
Bruce Robson	NMML	Foraging Ecology
Elizabeth Sinclair	NMML	Foraging Ecology
Rod Towell	NMML	Population Dynamics
Anne York	NMML	Population Dynamics
Research Associates and Cooperators		
Mary Engle	UCSC	Foraging Ecology
Steve Claussen	IND	Population Assessment
Craig Comen	COR	Population Assessment
David Cormany	NMFSJ	Resource Management
Michael Goebel	UCSC	Life History
Dawn Goley	UCSC	Population Assessment
Henry Hanson	CSP	Population Assessment
Phil Hunter	IND	Population Assessment
Masashi Kiyota	NRIFS	Reproduction Studies
Adam Kochutin	CSP	Population Assessment
Nicolai Kozloff	CSP	Population Assessment
Phillip Lekanof	CSP	Population Assessment
Dimitri Lestenkof	CSG	Population Assessment
Todd Lestenkof	CSG	Population Assessment
Rick Minter	IND	Population Assessment
John Melovidov	CSP	Population Assessment

Appendix Table E.--continued.

Name	Affiliation	Assignment
Research Associates and Cooperators		
Mariamna Melovidov	CSP	Population Assessment
Vladimir Melovidov	CSP	Population Assessment
Gary Merculief	CSG	Population Assessment
Patricial Paulus	CSP	Population Assessment
John Piatt	NBS	Population Assessment
Isah Shabolin	CSP	Population Assessment
Robert Small	NSF	Population Assessment
Terry Spraker	WPI	Pup Disease and Mortality
Frank Summers	IND	Population Assessment
Michael Williams	UAF	Population Assessment
Nicolai Zacharof	CSP	Population Assessment

Affiliation Code
COR - College of the Redwoods, California
CSG - City of St. George, St. George Island, Alaska
CSP - City of St. Paul, St. Paul Island, Alaska
IND - Independent
NBS - National Biological Survey, Anchorage, Alaska
NMFSJ - National Marine Fisheries Service Regional Office, Juneau, Alaska
NRIFS - National Research Institute of Far Seas Fisheries, Shimizu, Japan
NSF - National Science Foundation, post-doctoral position
UAF - University of Alaska, Fairbanks, Alaska
UCSC - University California at Santa Cruz
WPI - Wildlife Pathology International

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