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# Fur Seal Investigations, 1998

by
B. W. Robson (editor)

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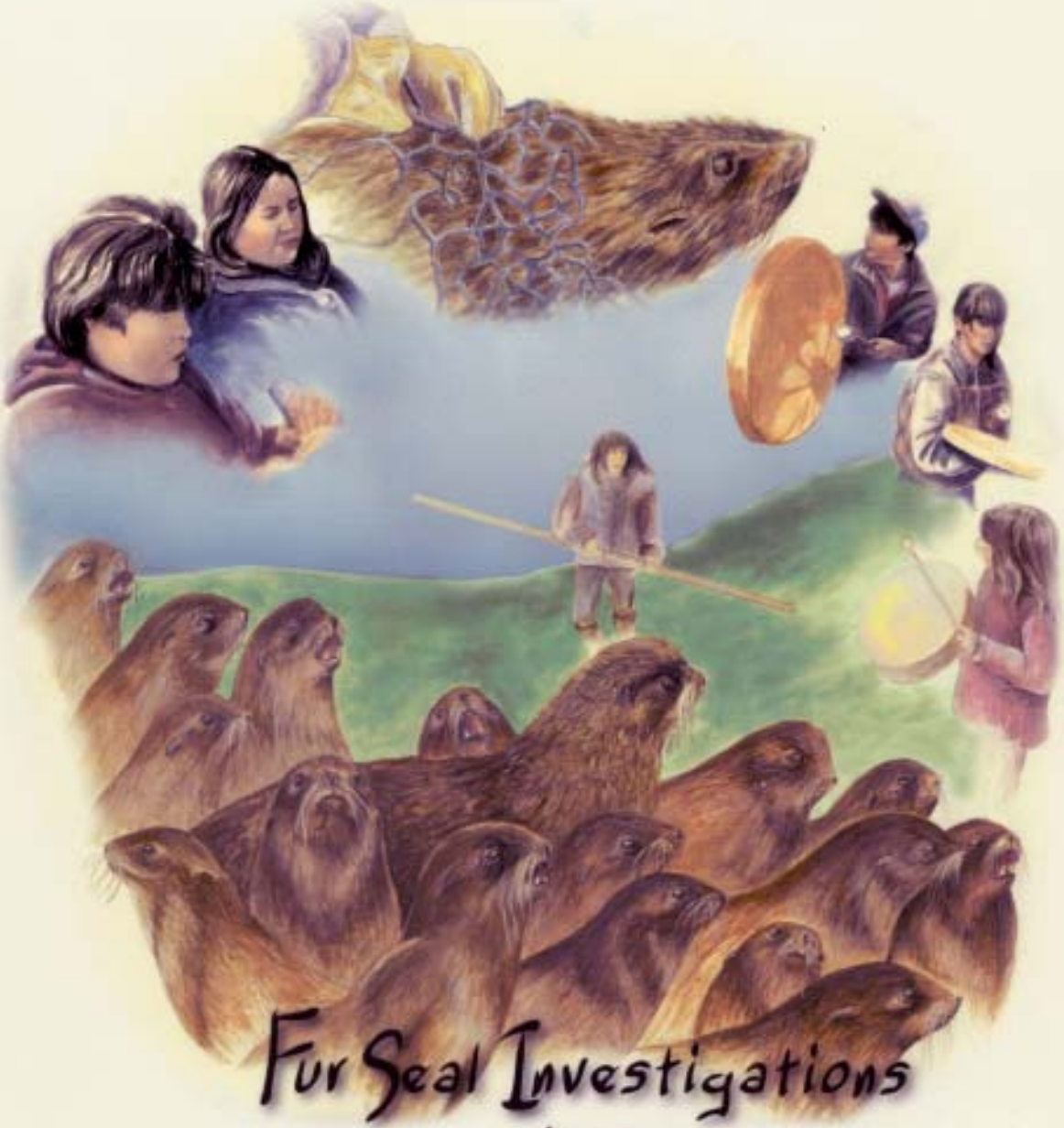

# Fur Seal Investigations '98

## ABSTRACT

Researchers from the National Marine Mammal Laboratory conduct field investigations on the population status of northern fur seals (*Callorhinus ursinus*) annually on the Pribilof Islands and on Bogoslof Island in the eastern Bering Sea and on San Miguel Island located off the coast of California. The size of the Pribilof stock of northern fur seals in 1998 was estimated to be 973,000 individuals and the total population of fur seals in U. S. rookeries was estimated to be 1,004,000 individuals.

Population parameters monitored in 1998 on the Pribilof Islands included the size of the subsistence harvest, the number of adult males, the number of pups born and the mortality rates of fur seals on both islands. A total of 4,762 harem and 8,396 idle adult male seals were counted on St. Paul Island and 1,116 harem and 1,084 idle adult males were counted on St. George Island. From 1997 to 1998, counts of harem males decreased by 6.0% on St. Paul Island, and increased by 22.6% on St. George Island. During this same period, the total number of adult males on the Pribilof Islands decreased by 1.6%.

The estimate for the total number of pups born in 1998 was 179,149 (SE = 6,193) on St. Paul Island and 21,638 (SE = 222) on St. George Island. The mortality rate of pups in 1998 was estimated to be 2.8% on St. Paul Island and 2.1% on St. George Island. The estimated number of pups born in 1998 was not significantly different ($P = 0.82$) from 1996, but was significantly less than in 1994 ($P < 0.01$). The 1998 estimate of pups born on St. George Island was significantly less ($P < 0.01$) than the number of pups born in 1996, but the estimate was not significantly different ($P = 0.22$) from the estimate of the number of pups born in 1994.

Trends in the mass and length of fur seal pups are used as indicators of population health and have been monitored semi-annually since 1989. Consistent with earlier evaluations of pup mass data, the strongest pattern was that the size of pups varied by sex: male pups were heavier and longer than female pups. The mass of male pups on St. George Island was significantly greater than male pups on St. Paul Island in 1998. Both male and female pups were significantly longer ($P < 0.001$) on St. Paul Island than on St. George Island in 1998. The proportion of females was significantly different ($P < 0.05$) than 50%, (46.0% on St. Paul Island and 46.2% on St. George Island, Table 21) for both islands in 1998.

The 1997-98 El Niño had a significant impact on several population parameters of northern fur seals on San Miguel Island. The number of territorial males with females in Adams Cove decreased from 142 bulls in 1996 to 74 in 1997. The total observed pup production during 1998 was 424 in Adams Cove and 194 on Castle Rock, a decline of 79.6% and 79.5%, respectively, from 1997 to 1998. The 79.6% decline in the number of northern fur seal pup births at San Miguel Island in 1998 represents the greatest decline in population growth since studies began in 1968.

The Tribal Government of St. Paul Island continued to monitor the rate of entanglement of northern fur seal males in marine debris in conjunction with the subsistence harvest. The rate of entanglement for male seals was 0.2% (13/6,603) on St. Paul Island. Female entanglement surveys were also conducted on St. Paul Island by researchers from the National Research Institute of Far Seas Fisheries, Japan. The rate of entanglement among females was calculated at 0.0105% for entangled females, 0.0281% for scarred females and 0.0386% for the two categories combined.

Researchers observed large numbers of northern fur seals with fungal infections of the pelage during the 1998 breeding season on both the Pribilof Islands and at San Miguel Island. The average incidence of fungal infections was 2.1% (332/16,116) among females on St. Paul Island rookeries and may have reached as high as 7.0% depending on the date and location of the survey. A lower incidence of fungal infections, 0.5% (17/3,292) was observed among adult male fur seals at seven rookeries on St. Paul Island . On San Miguel Island the incidence of fungal infections was dramatically higher than that observed on the Pribilof Islands. Sixty-five percent of the tagged females (n = 20) and 60% of the tagged males (n = 20) had fungal infections.

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# INTRODUCTION

by

Bruce W. Robson

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

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

Russian names given to rookeries on the Pribilof Islands are translated in Table 1 of the 1997 *Fur Seal Investigations* (Sinclair and Robson 1999). Terms specific to fur seal research are defined in Appendix A. National Marine Mammal Laboratory research on northern fur seals in 1998 was conducted under Marine Mammal Permit No. 782-1455.

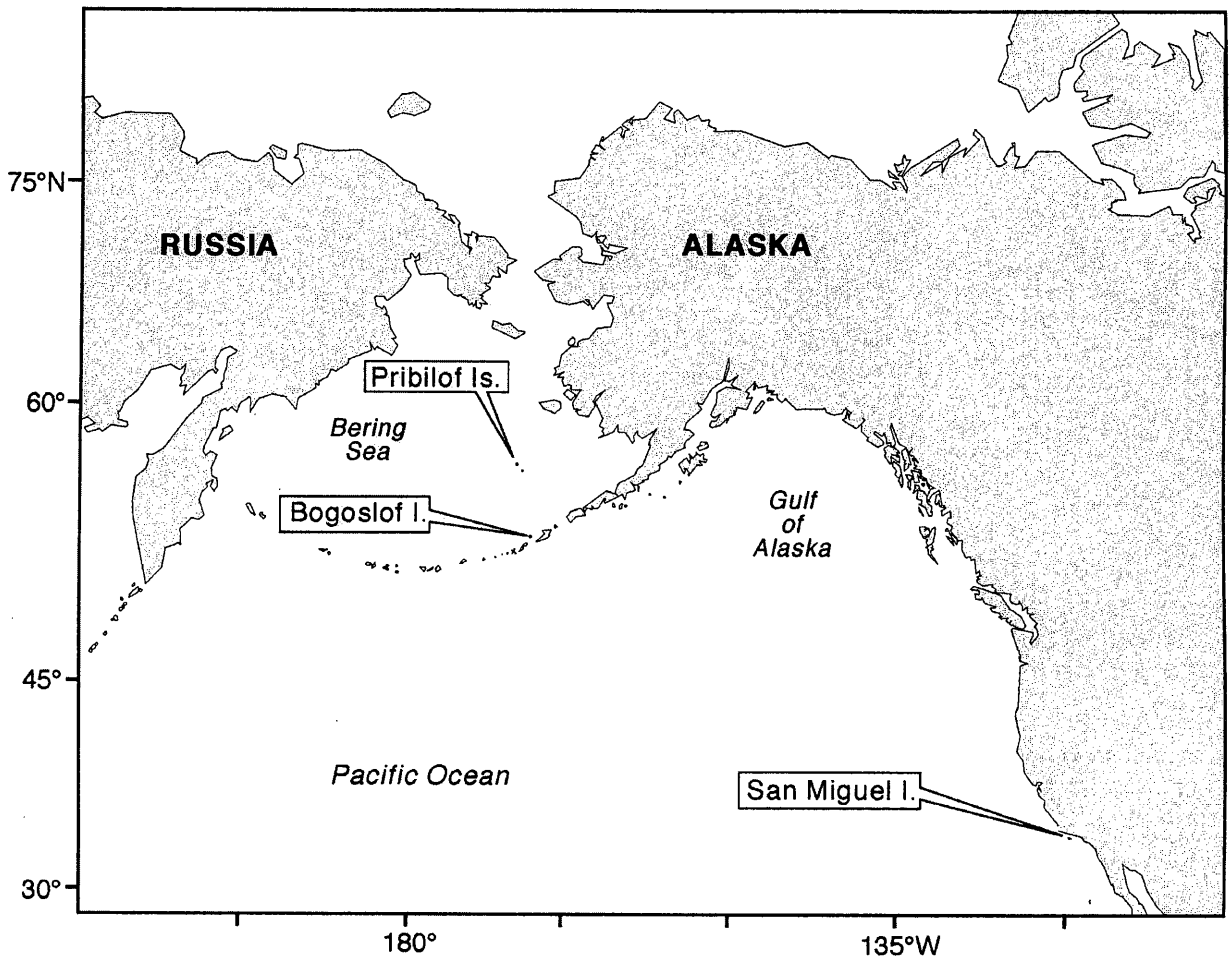


Figure 1.--Location of the three northern fur seal breeding areas within U.S. waters.

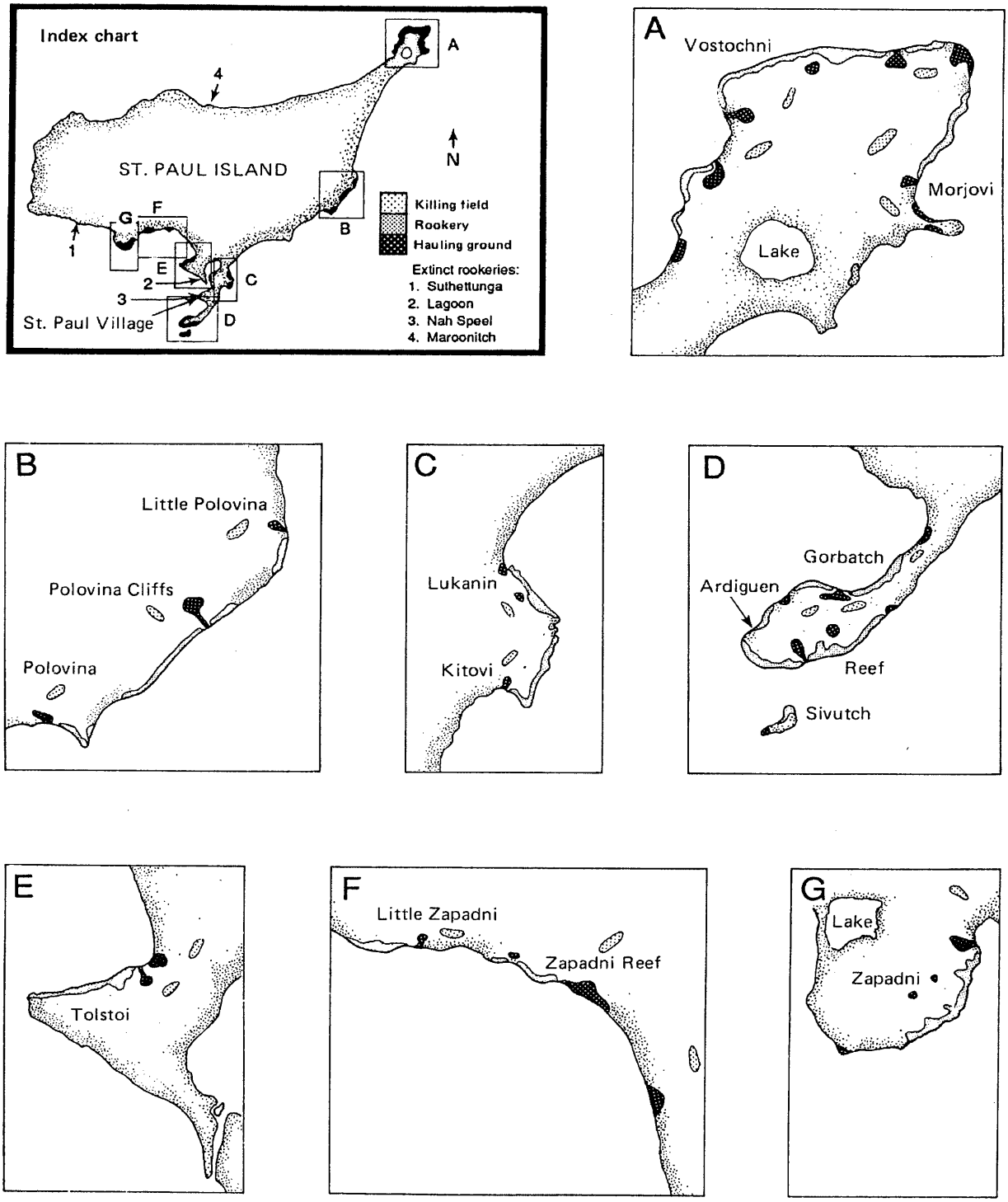


Figure 2.--Location of northern fur seal rookeries (present and extinct), hauling grounds, and harvesting areas, St. Paul Island, Alaska.

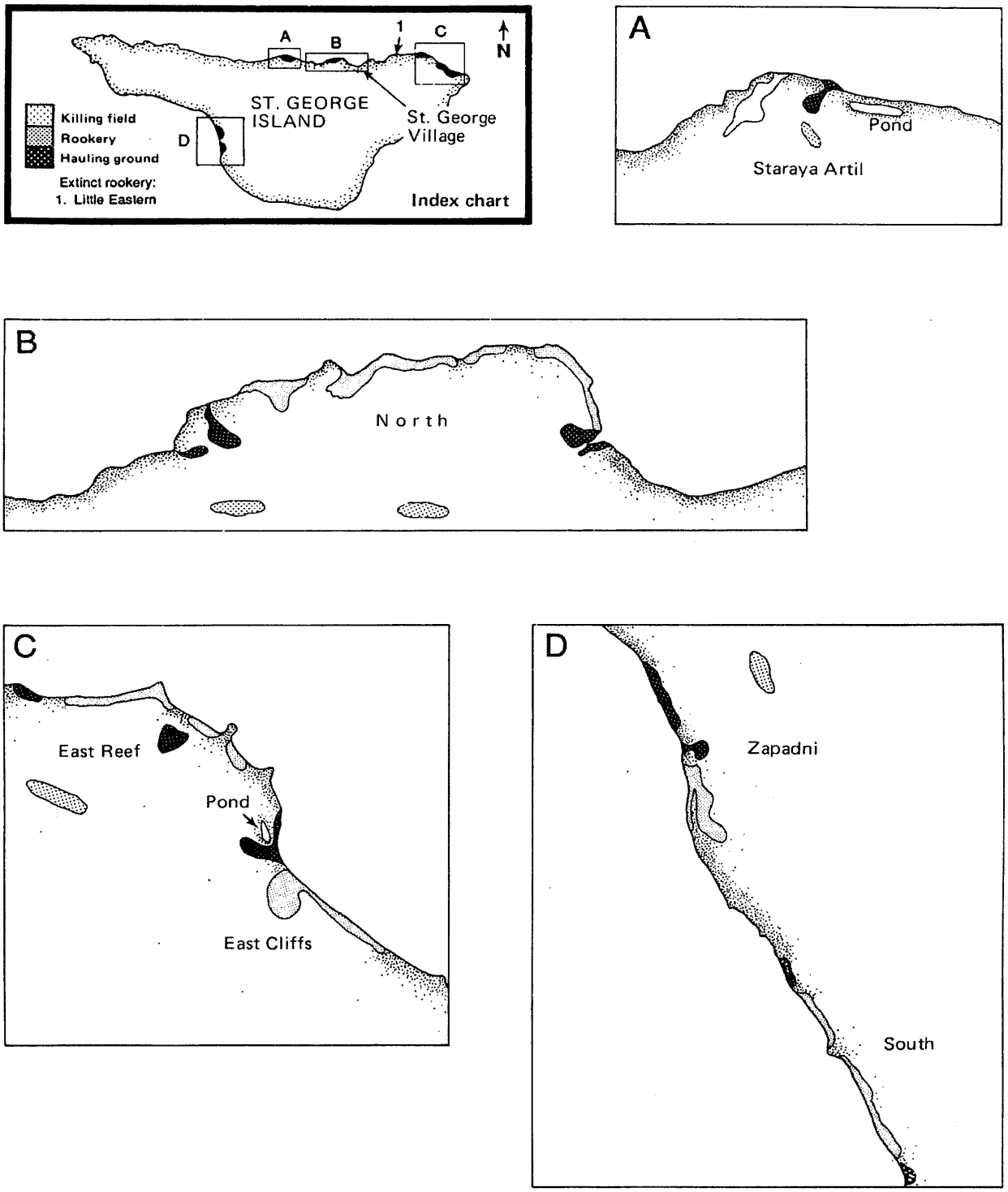


Figure 3.--Location of northern fur seal rookeries (present and extinct), hauling grounds, and harvesting areas, St. George Island, Alaska.

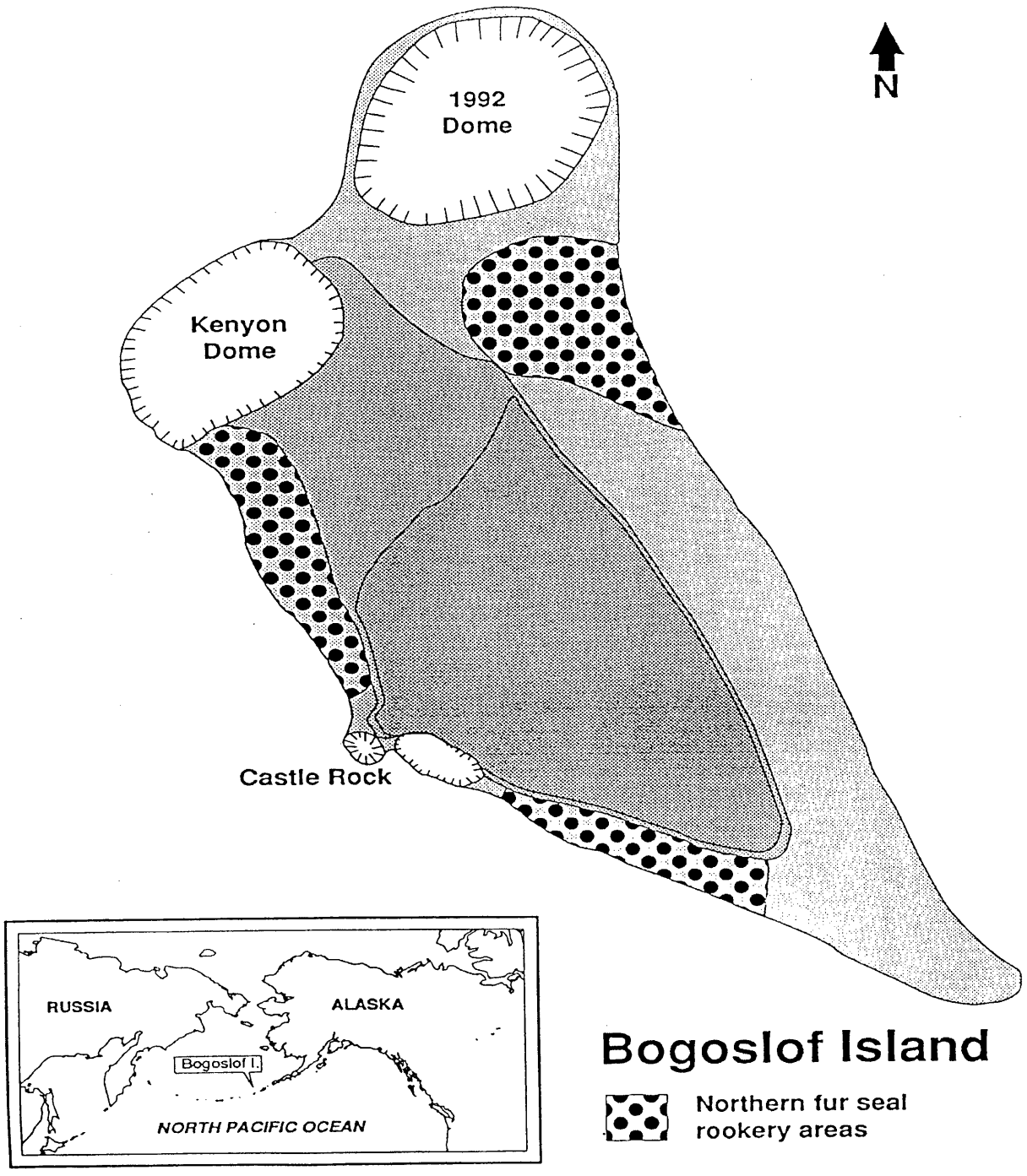


Figure 4.--Fur seal rookeries on Bogoslof Island, Alaska.

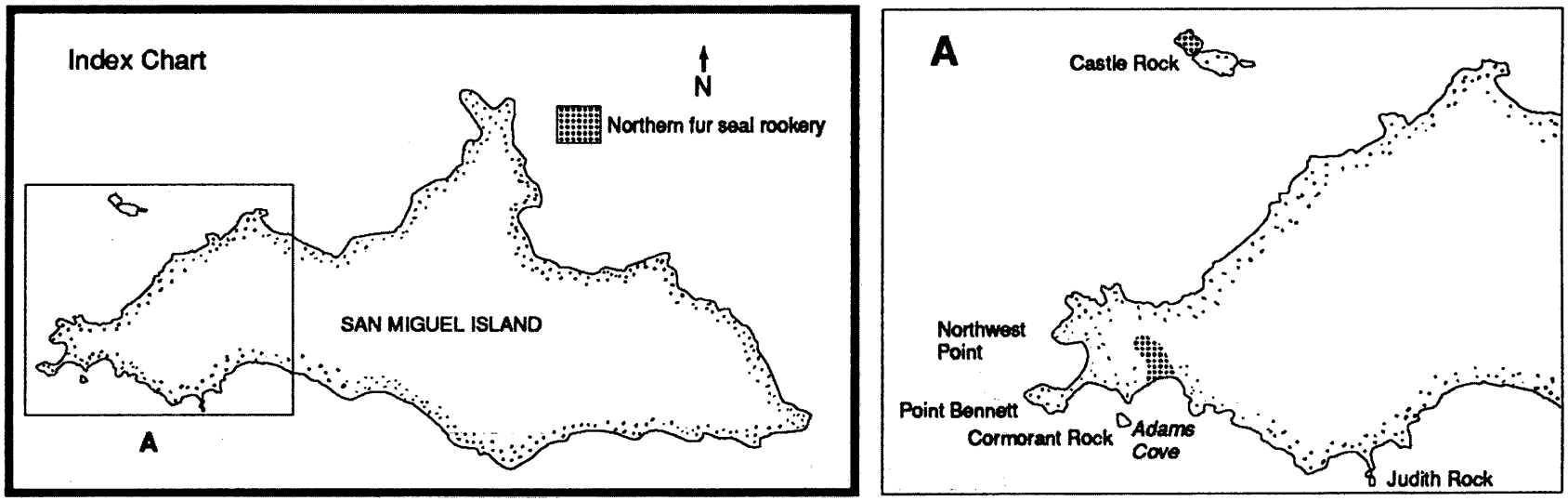


Figure 5.--Location of northern fur seal breeding colonies, San Miguel Island, California.

# POPULATION ASSESSMENT, PRIBILOF ISLANDS, ALASKA

by

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

and Bruce W. Robson

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 characteristics monitored in 1998 include the size of the subsistence harvest, the counts of adult males, estimates of numbers of pups born, and mortality rates of fur seal pups on St. Paul and St. George Islands.

## RESULTS AND DISCUSSION

### Sex Composition of Seals Harvested

A total of 1,291 sub-adult male seals were harvested and 5 females and one adult male fur seal were killed accidentally during the 1998 subsistence harvest on St. Paul Island (Table 1). On St. George Island, 256 sub-adult male seals were taken in the subsistence harvest in 1998 (Table 2).

### Living Adult Male Seals Counted

Adult male seals were counted by section for each rookery (see Appendix A glossary for definitions of terms) on St. Paul Island from July 15 to 20 (Appendix Table B-1). A total

Table 1.-- Date, location, and number of subadult male seals killed in subsistence harvest drives on St. Paul Island, Alaska, in 1998.

| Date | Rookery | Number killed |
|---|---|---|
| June 26 | Reef | 34 |
| June 26 | Polovina | 17 |
| July 7 | Reef | 33 |
| July 8 | Lukanin | 24 |
| July 10 | Zapadni | 33 |
| July 10 | Zapadni | 7 |
| July 14 | Zapadni Reef | 46 |
| July 15 | Polovina | 48 |
| July 16 | Lukanin | 33 |
| July 16 | Kitovi | 14 |
| July 18 | Reef | 66 |
| July 21 | Zapadni [a] | 44 |
| July 22 | Polovina | 84 |
| July 23 | Lukanin | 59 |
| July 24 | Reef | 72 |
| July 25 | Morjovi | 34 |
| July 27 | Zapadni Reef | 50 |
| July 29 | Polovina [b] | 24 |
| July 29 | Kitovi | 39 |
| July 30 | Zapadni | 42 |
| July 31 | Reef | 56 |
| August 1 | Vostochni | 37 |
| August 3 | Zapadni Reef | 43 |
| August 3 | Lukanin | 49 |
| August 4 | Polovina | 47 |
| August 4 | Little Polovina | 28 |
| August 5 | Zapadni | 48 |
| August 6 | Morjovi [c] | 83 |
| August 7 | Reef [d] | 103 |

[a] Includes 1 female accidentally struck.
[b] Includes 3 females accidentally struck.
[c] Includes 1 seal that died of heatstroke and 1 female killed.
[d] Includes 1 bull accidentally struck.

Table 2.-- Date, location, and number of subadult male seals killed in subsistence harvest drives on St. George Island, Alaska, in 1998.

| Date | Rookery | Number killed |
|---|---|---|
| July 8 | North | 23 |
| July 10 | Zapadni | 18 |
| July 15 | North | 20 |
| July 17 | Zapadni | 21 |
| July 19 | North | 23 |
| July 22 | Zapadni | 25 |
| July 25 | North | 17 |
| July 30 | Zapadni | 28 |
| August 1 | Zapadni | 19 |
| August 3 | North | 18 |
| August 5 | North | 15 |
| August 8 | Zapadni | 29 |

of 4,762 harem (Class 3) and 8,396 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 1,116 harem (Class 3) and 1,084 idle (Classes 2 and 5) adult male seals were counted from 10 to 13 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 3.

There was a decrease in the count of territorial males with females (Class 3) on St. Paul Island between 1997 and 1998 (-6.0%), and the count of these males on St. George Island was higher in 1998 than in 1997 (+22.6 %). Owing to the larger size of the population on St. Paul Island, the Pribilof Island total for these males decreased by about 1.6% between 1997 and 1998.

Number of Pups Born on St. Paul Island in 1998

The number of fur seal pups was estimated on seven sample rookeries in August 1998 using the shearing-sampling method. Sample rookeries were chosen from the rookeries not selected in 1996, the first year we returned to sub-sampling rookeries (following the protocol described in York and Towell 1997). Counts of dead pups were made only on these seven sample rookeries. The formulae used to calculate the production estimate and their standard errors are in York and Towell (1996). Two researchers determined the fraction of marked pups on each sample rookery on two occasions. The total number of pups alive at the time of sampling was determined for each of the sampled rookeries using a Peterson

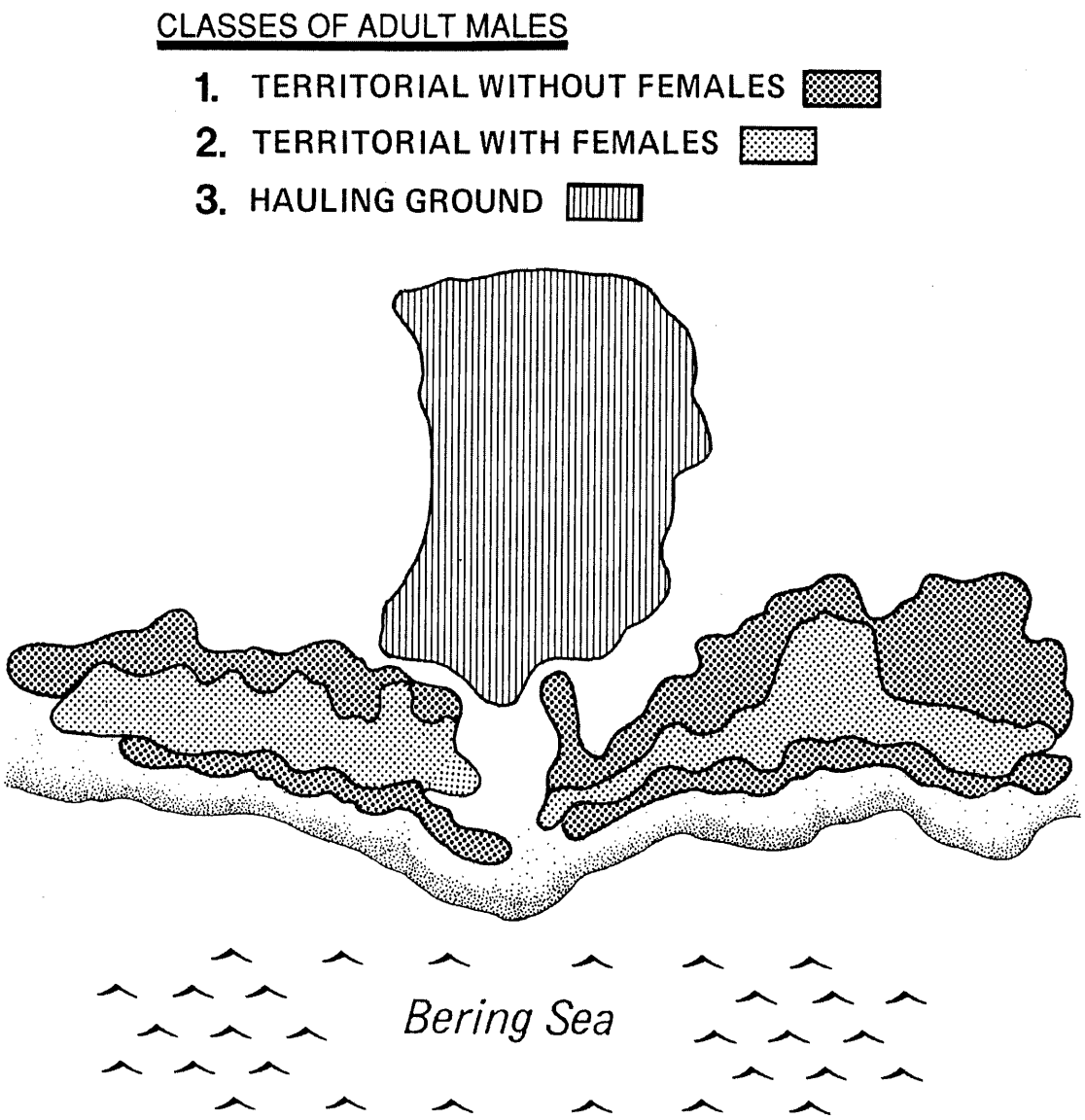


Figure 6.--The relative location of the different classes of adult males for a typical fur seal rookery.

Table 3.--Number of adult male northern fur seals counted, by rookery, Pribilof Islands, Alaska, July 1998.

| Rookery | Date (July) | Class of adult male * 2 | 3 | 5 | Total |
|---|---|---|---|---|---|
| St. Paul Island | | | | | |
| Lukanin | 17 | 50 | 153 | 119 | 322 |
| Kitovi | 17 | 120 | 248 | 244 | 612 |
| Reef | 20 | 247 | 549 | 523 | 1,319 |
| Gorbatch | 20 | 158 | 405 | 788 | 1,351 |
| Ardiguen | 20 | 16 | 72 | 33 | 121 |
| Morjovi | 14 | 223 | 327 | 536 | 1,086 |
| Vostochni | 14 | 363 | 815 | 945 | 2,123 |
| Little Polovina | 16 | 5 | 5 | 350 | 360 |
| Polovina | 16 | 51 | 76 | 226 | 353 |
| Polovina Cliffs | 16 | 153 | 474 | 261 | 888 |
| Tolstoi | 17 | 269 | 549 | 903 | 1,721 |
| Zapadni Reef | 19 | 76 | 170 | 253 | 499 |
| Little Zapadni | 19 | 124 | 359 | 369 | 852 |
| Zapadni | 19 | 294 | 560 | 697 | 1,551 |
| Island total | | 2,149 | 4,762 | 6,247 | 13,158 |
| St. George Island | | | | | |
| South | 11 | 85 | 220 | 70 | 375 |
| North | 13 | 162 | 431 | 205 | 798 |
| East Reef | 11 | 39 | 78 | 51 | 168 |
| East Cliffs | 11 | 96 | 225 | 158 | 479 |
| Staraya Artil | 10 | 54 | 51 | 48 | 153 |
| Zapadni | 10 | 57 | 111 | 59 | 227 |
| Island total | | 493 | 1,116 | 591 | 2,200 |

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

estimate (York and Towell 1996). The total number of pups alive at the time of sampling on all rookeries was estimated by multiplying the total number of breeding males from all rookeries by a jackknife ratio of pups to breeding males on the seven sample rookeries (York and Kozloff 1987, York and Towell 1997). The total number of dead pups was estimated from the mortality rate on the sampled rookeries. The total number of pups born was estimated by summing the estimates of live and dead pups. Variances of numbers of pups and mortality rates were estimated following York and Kozloff (1987) and York and Towell (1997); in addition, bootstrap variances of the parameters based on 2,000 replicates were also obtained.

From August 8 to 13, 8,890 pups were marked by shearing. The number of pups sheared on each rookery was 10% of the mean of the 1994 pup production estimates and the estimated number of pups alive at the time of marking in 1996 for each sample rookery. Shear marks were allocated proportionally on each rookery by section (Appendix Table B-3) according to the fraction of the rookery total for harem males counted in each section of the sampled rookery. The ratio of marked to unmarked pups was determined by two researchers on two occasions for each rookery from August 14 to 21 . Each researcher obtained counts of marked and unmarked pups independently to ensure that the entire rookery was well sampled. Each sampling day was considered an independent replicate from which the variance was computed for each rookery.

Dead pups were counted on all sampled rookeries from August 18 to 21 . Numbers of dead pups counted by section are given in Appendix Table B-4. A summary of the number

Table 4.-- 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 (SE), on sample rookeries of St. Paul Island, Alaska, 1998.

| Rookery | Sheared | E1 | E2 | Mean | SE |
|---|---|---|---|---|---|
| Lukanin | 492 | 3,887 | 4,329 | 4,108 | 221.0 |
| Reef | 2,324 | 21,233 | 19,466 | 20,350 | 883.5 |
| Gorbatch | 1,549 | 15,358 | 14,369 | 14,864 | 494.5 |
| Ardiquen | 270 | 1,957 | 1,749 | 1,853 | 104.0 |
| Morjovi | 1,405 | 12,649 | 11,684 | 12,167 | 482.5 |
| Polovina | 294 | 2,504 | 2,346 | 2,425 | 79.0 |
| Zapadni | 2,556 | 22,493 | 21,441 | 21,967 | 526.0 |

Table 5.-- Number of pups alive at the time of marking, standard deviation (SD), numbers of dead pups, total pups born, mortality rate, idle males, harem males and the ratio of pups alive at marking to harem males, on sample rookeries of St. Paul Island, Alaska, 1998.

| Sample Rookery | Pups alive at marking | SD | Dead pups* | Total pups born | Mortality rate (%) | Idle males | Harem males | Ratio pups/males |
|---|---|---|---|---|---|---|---|---|
| Lukanin | 4,108 | 221.0 | 175 | 4,283 | 4.09 | 169 | 153 | 26.85 |
| Reef | 20,350 | 883.5 | 557 | 20,907 | 2.66 | 770 | 549 | 37.07 |
| Gorbatch | 14,864 | 494.5 | 420 | 15,284 | 2.75 | 946 | 405 | 36.70 |
| Ardiguen | 1,853 | 104.0 | 38 | 1,891 | 2.01 | 49 | 72 | 25.74 |
| Morjovi | 12,167 | 482.5 | 219 | 12,386 | 1.77 | 759 | 327 | 37.21 |
| Polovina | 2,425 | 79.0 | 56 | 2,481 | 2.26 | 277 | 76 | 31.91 |
| Zapadni | 21,967 | 526.0 | 793 | 22,760 | 3.48 | 991 | 560 | 39.23 |
| Sample total | 77,734 | 1,265.1 | 2,258 | 79,992 | 2.82 | 3,961 | 2,142 | 36.29 |

* Includes dead pups taken for necropsies from Reef (61).

of pups sheared, the estimated mean number of pups alive at the time of marking, and the standard error of the estimate for each sampled rookery is given in Table 4. The estimated number of pups born, the standard error (SE) of the estimate, number of dead pups, counts of harem bulls, and ratios of pups to adult males for each sampled rookery on St. Paul Island are summarized in Table 5. For each sampled rookery, the standard deviation (SD) of the pup estimate is computed from the standard error of the two estimates; in addition, we calculated bootstrapped estimates of the standard error of the estimate for each rookery based on 2,000 replicates of the estimation process (York and Towell 1996).

The estimate for the total number of pups alive on St. Paul Island at the time of marking in 1998 was 174,091. The empirical standard error was 6,017; the bootstrapped standard error was slightly larger (6,267). The number of dead pups was estimated to be 5,058 (2,258 counted on sample rookeries and 2,800 estimated on the other rookeries; the estimated mortality rate for late August was 2.82% (SE = 0.06%). The estimate of the total number of pups born on St. Paul Island in 1998 is 179,149 (SE = 6,193); the standard error accounts for variance in the estimation of both live and dead pups (York and Towell, 1996). The approximate 95% confidence interval of pups born in 1998 was computed by multiplying the standard deviation of the jackknife ratio of pups to breeding males (e.g.York and Kozloff 1987) by 2.365 (the 97.5 percentile of Student's t-distribution with 7 degrees of freedom) and was 179,149 $\pm$ (2.365 X 6,193), or 179,149 $\pm$ 14,646, or (164,503 - 193,795). The bootstrapped median estimate of the total number of pups born (179,232) is similar to the above, as is the standard error (6,550), and 95% confidence interval (164,542- 188,462) based on 2,000 replications of the estimation process.

The above total does not include the pups on Sea Lion Rock. The last direct census of fur seals pups on Sea Lion Rock (1994) estimated 12,891 pups born (12,589 = live, 302 = dead). If we add this number to the St. Paul estimate calculated above, total pup production on St. Paul Island was 192,040; this value is comparable to years when a census was done on Sea Lion Rock.

The estimated number of pups born and their 95% confidence intervals for St. Paul Island, 1970-98, are shown in Figure 7. The total estimated number of pups born in 1998 was not significantly different ($P = 0.82$) from 1996, but was significantly less than the estimate in 1994 ($P < 0.01$). Appendix Table B-2 summarizes pup production and mortality excluding Sea Lion Rock since 1972.

The number of pups born and the number of harem bulls at different rookeries on St. Paul Island are significantly correlated (correlation = 0.998, Fig. 8). The slope of the regression line with a zero intercept is 37.40 (SE = 0.924), representing an estimate of the ratio of pups to breeding males.

Number of Pups Born on St. George Island in 1998

The number of pups born on St. George Island was estimated from a shearing-sampling study conducted on all rookeries. The most recent estimate of pup production prior to this study was obtained in 1996. From August 8 to 10 , a total of 3,144 pups were shear-marked on St. George Island; the total number sheared on each rookery was a random number between 10 and 15% of the total number estimated on the rookery in 1996. These marks were allocated proportionally within each rookery according to the fraction of harem bulls counted in 1998 (Appendix Table B-5). The ratio of marked to unmarked pups on each rookery was

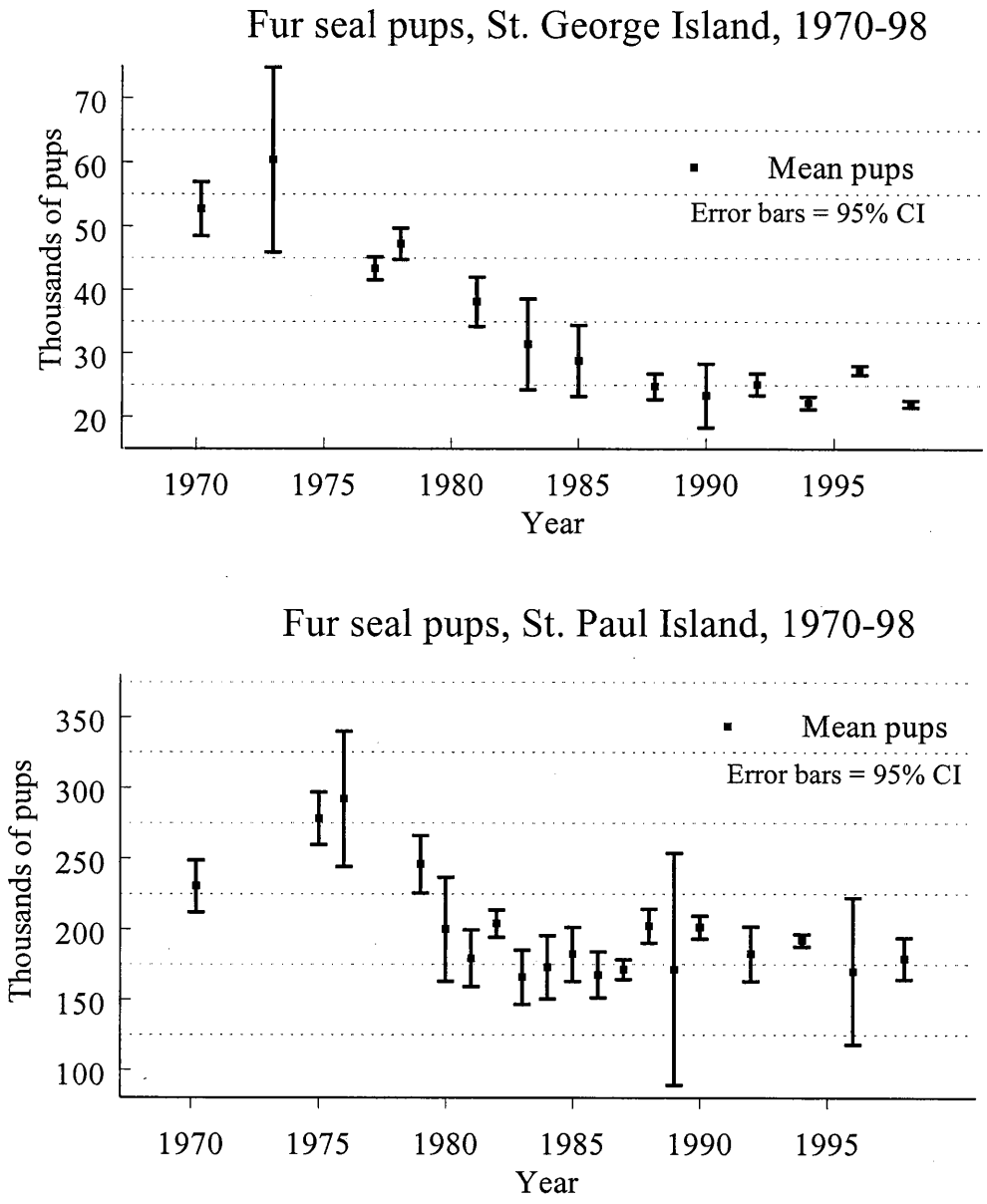


Figure 7.-- Numbers of pups born on St. Paul and St. George Islands, Alaska 1970-98.

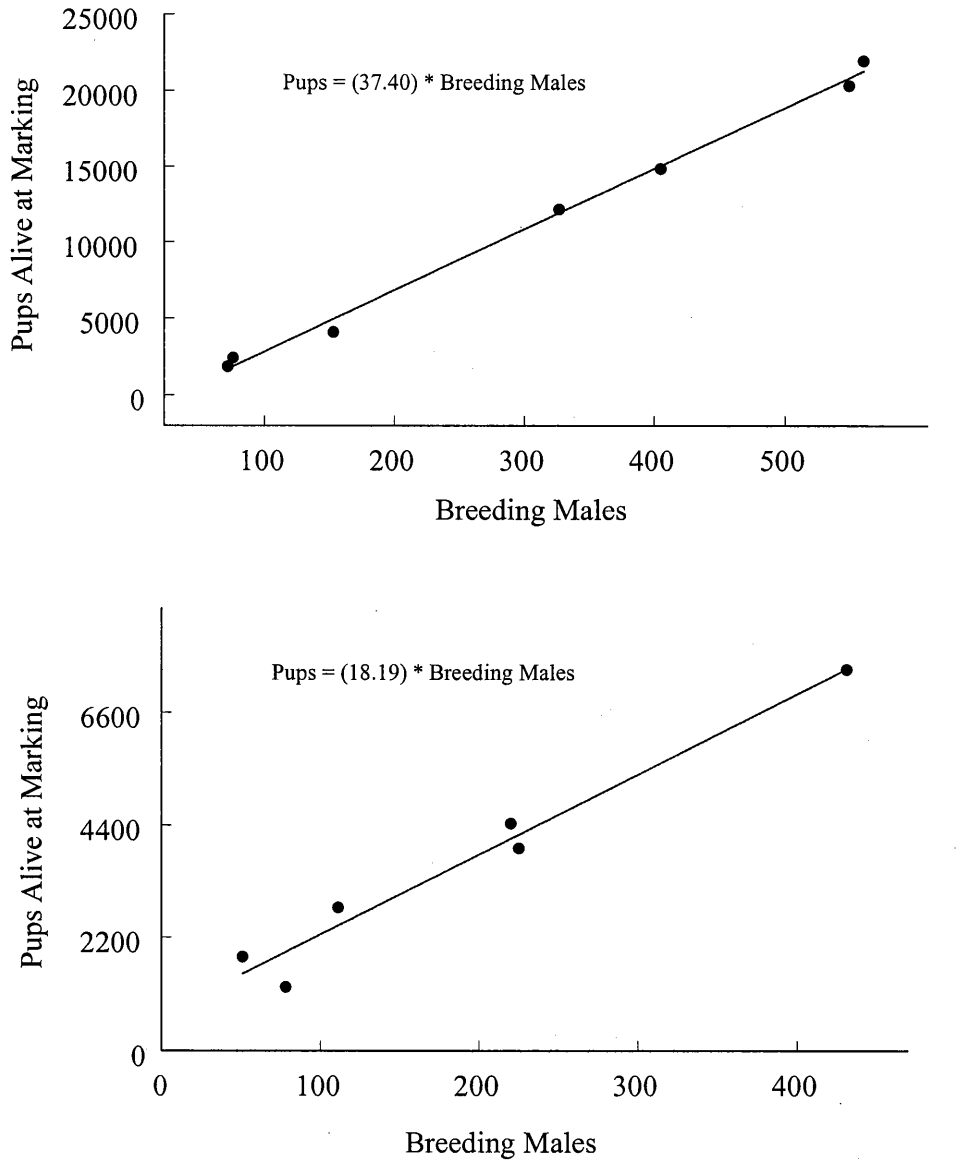


Figure 8.-- Pups born versus number of breeding males on St. Paul Island (top) and St. George Island (bottom), Alaska, 1998.

determined by two researchers on two occasions: once from 13 to 14 August and again from 17 to 23 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 6. Two researchers independently obtained counts of marked and unmarked pups over the entire area of the rookeries. Each sampling day was considered an independent replicate from which the variance was computed for each rookery. Counts of dead pups were made from 18 to 21 August 1998. The estimate of the number alive was calculated similarly to the method described for St. George Island for 1994 (York and Towell 1996) with the ratio of marked to unmarked pups determined by two researchers only. The estimated total number of pups alive on St. George Island at the time of marking was 21,638 (SE = 222, Table 7). The total number of dead pups was 452 (Appendix Table B-6) and the estimated mortality rate was 2.05%. The total number of pups born on St. George Island and the approximate 95% confidence interval was 22,090 $\pm$ (2.447 X 222), or 22,090 $\pm$ 543, or 21,547 - 22,633. The bootstrapped median estimate was similar (22,135); the standard error (388) and 95% confidence interval was somewhat larger (21,426 - 22,894).

The 1998 estimate of pups born on St. George Island is significantly less ($P < 0.01$) than the number of pups born in 1996, but the estimate is not significantly different ($P = 0.22$) than the estimate of the number of pups born in 1994. The 1996 estimate of the number of pups born on St. George Island was the highest since 1985, when over 28,000 pups were born (Fig. 7).

The number of pups born and the number of harem males on St. George Island rookeries are highly correlated (Fig. 8). When the number of pups born are regressed on the

Table 6.-- Number of pups sheared, number of pups estimated to be alive at the time of marking (E1 and E2), mean number alive (Mean) and the standard error of the mean (SE), for St. George Island, Alaska, 1998.

| Rookery | Sheared | E1 | E2 | Mean | SE |
|---|---|---|---|---|---|
| South | 584 | 4,408 | 4,460 | 4,434 | 26.0 |
| North | 1,097 | 7,611 | 7,250 | 7,431 | 180.5 |
| East Reef | 176 | 1,280 | 1,182 | 1,231 | 49.0 |
| East Cliffs | 508 | 4,043 | 3,850 | 3,947 | 96.5 |
| Staraya Artil | 301 | 1,815 | 1,818 | 1,817 | 1.5 |
| Zapadni | 478 | 2,712 | 2,844 | 2,778 | 66.0 |

Table 7.-- Number of pups alive at the time of marking, standard deviation (SD), number of dead dead pups, total pups born, mortality rate, idle males, harem males and the ratio of pups alive at marking to harem males for St. George Island, Alaska, 1998.

| Rookery | Pups alive at marking | SD | Dead pups | Total pups born | Mortality rate (%) | Idle males | Harem males | Ratio pups/males |
|---|---|---|---|---|---|---|---|---|
| South | 4,434 | 26.0 | 56 | 4,490 | 1.25 | 155 | 220 | 20.15 |
| North | 7,431 | 180.5 | 142 | 7,573 | 1.88 | 367 | 431 | 17.24 |
| East Reef | 1,231 | 49.0 | 15 | 1,246 | 1.20 | 90 | 78 | 15.78 |
| East Cliffs | 3,947 | 96.5 | 124 | 4,071 | 3.05 | 254 | 225 | 17.54 |
| Staraya Artil | 1,817 | 1.5 | 46 | 1,863 | 2.47 | 102 | 51 | 35.63 |
| Zapadni | 2,778 | 66.0 | 69 | 2,847 | 2.42 | 116 | 111 | 25.03 |
| Island total | 21,638 | 222.1 | 452 | 22,090 | 2.05 | 1,084 | 1,116 | 19.39 |

number of males, the value of $R^2$ is about 0.97. The intercept of the regression line is not significantly different from zero (P = 0.11) and was not included in the regression equation; the slope of the regression line is 18.19 (SE = 1.08), representing the ratio of pups to breeding males.

## Trends in Numbers of Pups

Since 1975, the number of pups born on both islands has decreased. We fit the following negative exponential model to the numbers of pups born on each island to describe this decrease over time:

$$P(y) = \alpha_0 + \alpha_1 2^{-(y-1975)/\gamma} + e \qquad \text{where,}$$

$P(y)$ is the number of pups born in year y,

y is the year, from 1972 to 1998,

$\alpha_0$ is the asymptotic or eventual size of the population,

$\alpha_1$ is the total decrease in the size of the population between 1975 and the time the population approaches $\alpha_0$,

$\gamma$ is the half-life; that is, the time required for the population to lose half of the difference between the current and asymptotic population, and

e is an error term, assumed to be normally distributed with mean 0.

The models for each island appear to track both data sets fairly well (Fig. 9). There are important differences between the St. George and St. Paul Islands models: 1) the decrease occurred more rapidly on St. Paul Island (note that the half life parameter for St. George Island is about twice

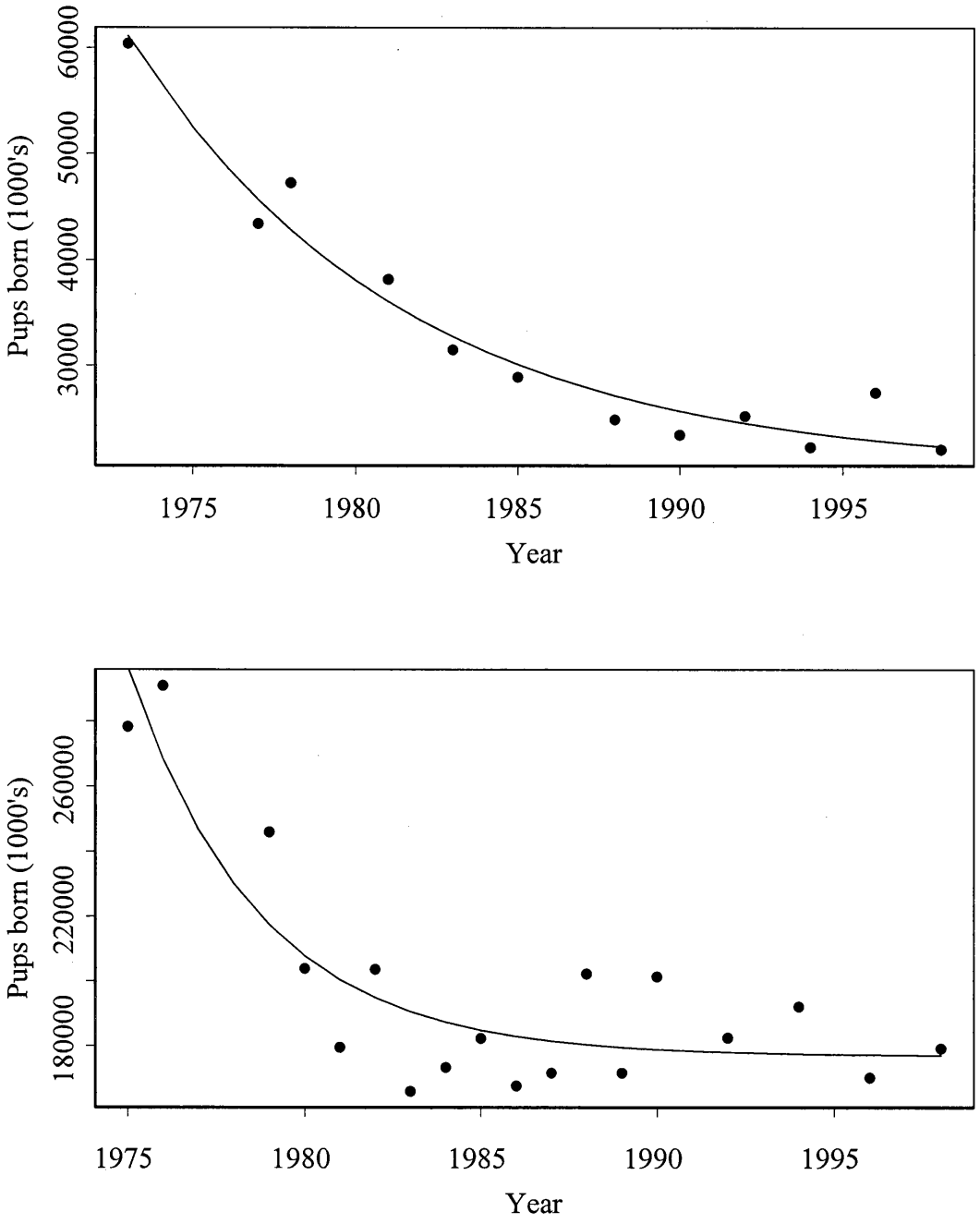


Figure 9.-- Points on the figures above represent the numbers of pups born on St. George Island (top) and St. Paul Island (bottom), Alaska. The line represents the fitted negative exponential model.

Table 8.-- Parameter estimates from the negative exponential model fit to the number of pups from 1972 to1998. Models were fit to estimate numbers of pup (1000s) as a function of time. Estimates and standard errors of the estimates (SE) to the parameters of the model are listed below, as well as, the shear-sampling estimate, and the predictive value from the model using the data from 1972 to 1998.

| | St. Paul Island | | St. George Island | |
|---|---|---|---|---|
| Model Parameters | Estimate | SE | Estimate | SE |
| $\alpha_0$ | 176.81 | 7.25 | 20.18 | 2.57 |
| $\alpha_1$ | 120.03 | 15.56 | 40.90 | 2.94 |
| $\gamma$ | 2.56 | 0.76 | 5.86 | 1.14 |
| Estimate Type (1000s) | | | | |
| Asymptotic ($\alpha_0$) | 176.81 | 7.25 | 20.18 | 2.57 |
| Shear-Sampling | 179.15 | 6.19 | 22.09 | 2.22 |
| Predicted (1998) | 176.74 | 7.82 | 22.42 | 1.84 |

Table 9.-- Details of the computation of the estimate of the stock size of fur seals in 1998. Separate columns are given for the Pribilof (St. George, St. Paul, and Sea Lion Rock) and non-Pribilof populations (San Miguel and Bogoslof Islands).

| Formula | Pribilof Islands | San Miguel and Bogoslof Islands | Component |
|---|---|---|---|
| Average for 1994, 1996, 1998 | 217,357 | 7,074 | Pups |
| (Pups) x (0.5) | 108,678 | 3,537 | Yearlings |
| (Yearlings) x (0.8) | 86,942 | 2,830 | Age 2 yr |
| (2-yr old females) x (0.86)/2 | 37,385 | 1,217 | Females age 3 yr |
| (2-yr old males) x (0.8)/2 | 34,777 | 1,132 | Males age 3 yr |
| (Total pups) / (0.6) | 362,261 | 11,791 | Females 3+ years |
| (3-yr old males x (3.6) | 125,197 | 4,075 | Males 4+ years |
| Total | 972,597 | 31,656 | |

that of St. Paul Island (Table 8); 2) the expected proportion of population lost on St. Paul Island was 120/(120+177) = 40% was much less than the loss on St. George Island (67%). The models predict that the eventual sizes of the St. Paul and St. George Island populations ($\alpha_0$) are 176,800 (SE = 7250) and 20,180 (SE =2,570), respectively. An important similarity between the two models is that the present populations are very close to the fitted asymptotic values. These values are not significantly different from the current population sizes (Table 8).

## Estimate of Total Stock Size

Crude estimates of the total fur seal abundance have been presented in the past (Loughlin et al. 1994). These estimates were calculated by multiplying the average number of pups born over the past 3 censuses by a correction factor of 4.47 (See Table 9 for the calculation method). That correction factor was derived from estimates of survival and fecundity (Loughlin et al. 1994 ) from data collected at sea during 1958-74. Therefore, a strong assumption built into the estimate is that these vital rates are still valid. Since we cannot verify these assumptions, the estimate must be viewed only as a rough approximation. The numbers presented in Table 9 do not include the Russian or Japanese rookeries. The estimate of the total stock for the Pribilof Islands population in 1998 is about 973,000 fur seals. The total stock size for the United States, which includes the Pribilof, Bogoslof, and San Miguel Island populations, is about 1,004,000 fur seals.

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

Tooth samples (usually canines) were collected from a subsample of subadult males killed during the subsistence harvest and from all dead fur seals other than pups whenever possible. The sample rookeries and adjacent beaches of St. Paul Island and all rookeries of St.

George Island were surveyed for dead fur seals older than pups during August 1998 (Table 10). In 1998, tooth samples were collected from a total of 142 fur seals, 108 on St. Paul Island and 34 on St. George Island. The sex of individual animals was not determined from the tooth samples in 1998. Appendix Table B-7 summarizes the number of dead male and female fur seals from which teeth were collected from 1965 to 1996.

## SUMMARY

During 1998, 1,291 sub-adult male seals were harvested and 5 females and one adult male fur seal were killed accidentally during the 1998 subsistence harvest on St. Paul Island. On St. George Island, 256 sub-adult male seals were taken in the 1998 subsistence harvest. On St. Paul Island, 4,762 harem (Class 3) and 8,396 idle (Classes 2 and 5) adult male seals, also referred to as bulls, were counted in mid-July. On St. George Island, a total of 1,116 harem (Class 3) and 1,084 idle (Classes 2 and 5) adult male seals were counted. The estimate of the total number of pups born on St. Paul Island in 1998 is 179,149 (SE = 6,193). The estimate of the total number of pups born on St. George Island is 22,090 (SE = 22). An estimate of the total stock size for the United States, which includes the Pribilof, Bogoslof, and San Miguel Island populations, is about 1,004,000 fur seals.

Table 10.-- Number of animals older than pups found dead on the Pribilof Islands from which teeth were collected during August 1998.

| Rookery | Sex unidentified | Total |
|---|---|---|
| St. Paul | | |
| Lukanin | 7 | 7 |
| Reef | 21 | 21 |
| Gorbatch | 15 | 15 |
| Ardiguen | 0 | 0 |
| Morjovi | 8 | 8 |
| Polovina | 3 | 3 |
| Zapadni | 54 | 54 |
| Total St. Paul | 108 | 108 |
| St. George | | |
| South | 0 | 0 |
| North | 12 | 12 |
| East Reef* | 4 | 4 |
| East Cliffs | 11 | 11 |
| Staraya Artil | 2 | 2 |
| Zapadni | 5 | 5 |
| Total St. George | 34 | 34 |
| Total both Islands | 142 | 142 |

* 1 Dead adult found with no teeth available.

# MASS, LENGTH, AND SEX RATIOS OF NORTHERN FUR SEAL PUPS ON ST. PAUL AND ST. GEORGE ISLANDS, 1998

by

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

Mass and length measurements of fur seal pups on St. Paul and St. George Islands have been recorded in late August and serve as an indicator of population health. Here we report average mass, average lengths and sex ratios for male and female pups from Tolstoi, Vostochni, Polovina Cliffs, and Reef rookeries on St. Paul Island and all rookeries on St. George Island in 1998. We also report on comparisons of mass, length and sex ratios between islands.

## METHODS

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

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

Our analysis of the sex ratios examined island and rookery differences using a 2-sided exact binomial test. We used this test to determine if the proportion of female pups was significantly different from 50%.

## RESULTS AND DISCUSSION

### Pup Mass and Length

Pup mass (Fig. 10, Table 11) varied significantly ($P < 0.001$) by sex and rookery for St. Paul Island. Male and female pups were analyzed separately since the variance for males was greater than that for females and again rookery effects were significant ($P < 0.001$ males, $P = 0.042$ females, Table 12). Similarly, pup lengths (Fig. 11, Table 13) were significantly different ($P < 0.001$) by sex and rookery on St. Paul Island in 1998. Male and female pups were again analyzed separately and there was a significant difference in pup lengths between rookeries for each ($P = 0.003$ females, $P < 0.001$ males Table 14).

On St. George Island, pup mass (Fig. 10, Table 15) was also significantly different ($P < 0.001$) by sex and rookery. Again, male and female pups were analyzed separately due to the difference in the variances for each sex. Rookery was a significant factor in the analysis of male mass ($P < 0.001$, Table 16) but was not significant in the analysis of the female mass ($P = 0.090$). The analysis of variance for lengths (Fig. 11, Table 17) also indicated significant differences by sex ($P < 0.001$). Separate analyses for males and females were conducted and there were significant differences between rookeries for males ($P < 0.001$, Table 18) and females ($P < 0.001$, Table 18).

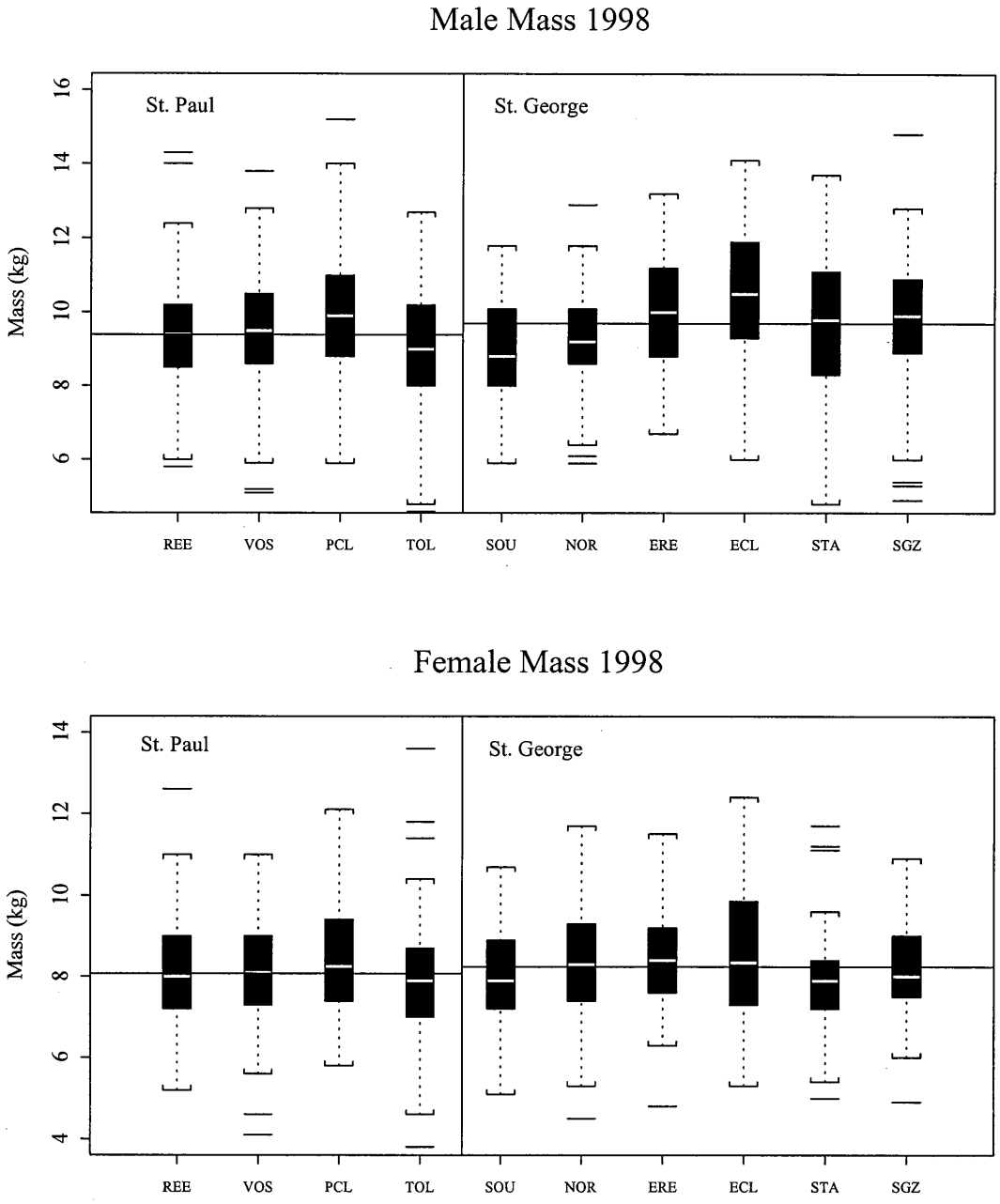


Figure 10.-- Boxplots of the median mass (white line) and 95% confidence intervals of the median mass (dark hatch) of northern fur seal pups on St. Paul and St. George Islands, Alaska, August 1998: Reef (REE), Vostochni (VOS), Polovina Cliffs (PCL), Tolstoi (TOL), South (SOU), North (NOR), East Reef (ERE), East Cliffs (ECL), Staraya Artil (STA) and St. George Zapadni (SGZ).

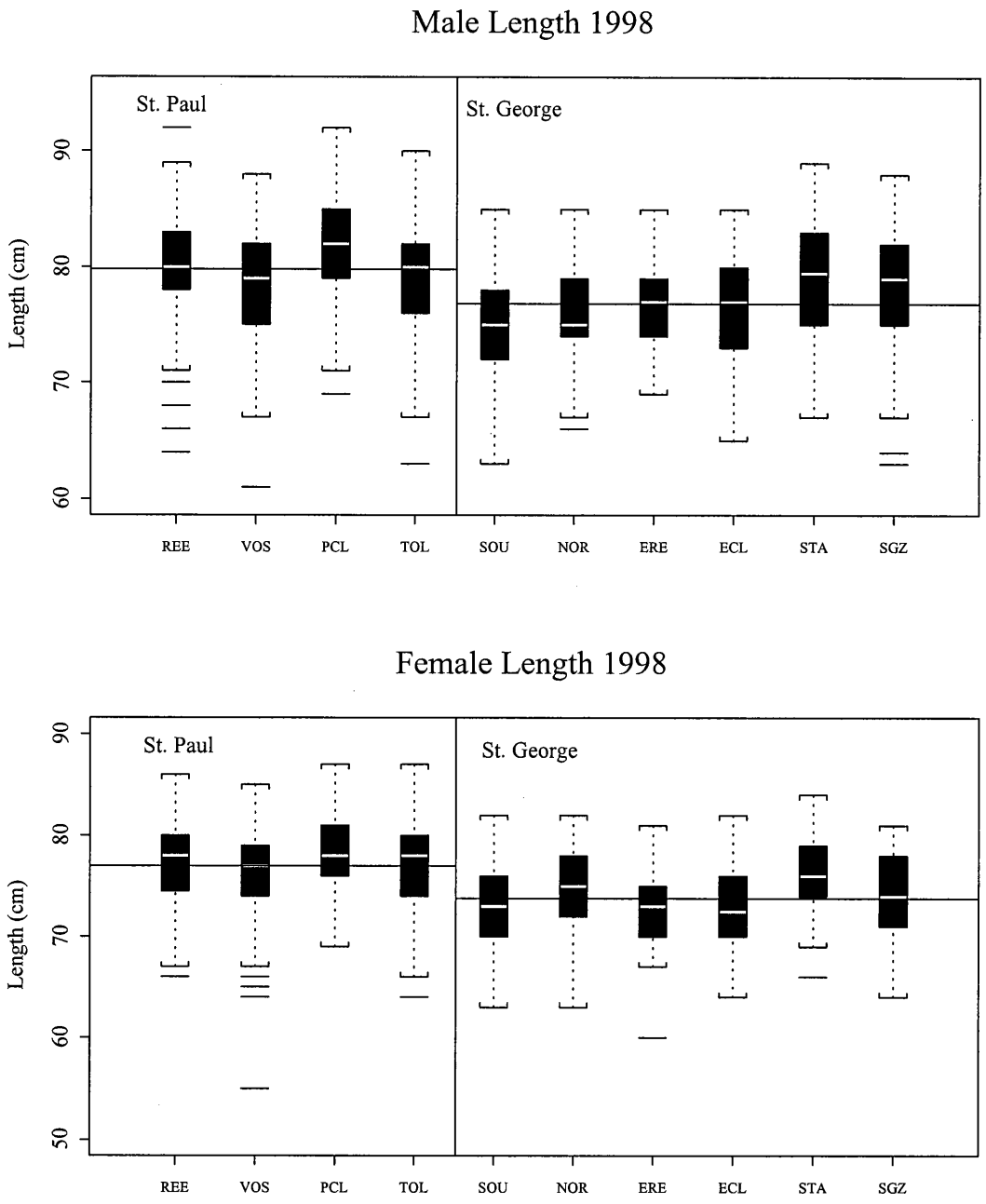


Figure 11.-- Boxplots of the median length (white line) and 95% confidence intervals of the median length (dark hatch) of northern fur seals on St. Paul and St. George Islands, Alaska, August 1998: Reef (REE), Vostochni (VOS), Polovina Cliffs (PCL), Tolstoi(TOL), South (SOU), North (NOR), East Reef (ERE), East Cliffs (ECL), Staraya Artil (STA) and St. George Zapadni (SGZ).

Table 11.-- Mean mass (kg), standard deviation (SD), and sample sizes (n) of male and female northern fur seal pups weighed on St. George Island, Alaska, 24-26 August 1998.

| Rookery | | Females | Males | Combined |
|---|---|---|---|---|
| South | kg | 8.02 | 8.99 | 8.53 |
| 25 August | SD | 1.23 | 1.44 | 1.42 |
| | n | 65 | 71 | 136 |
| North | kg | 8.31 | 9.33 | 8.78 |
| 26 August | SD | 1.34 | 1.41 | 1.46 |
| | n | 73 | 62 | 135 |
| East Reef | kg | 8.46 | 10.00 | 9.25 |
| 24 August | SD | 1.31 | 1.46 | 1.58 |
| | n | 62 | 65 | 127 |
| East Cliffs | kg | 8.56 | 10.37 | 9.60 |
| 24 August | SD | 1.62 | 1.76 | 1.92 |
| | n | 52 | 71 | 123 |
| Staraya Artil | kg | 7.90 | 9.61 | 8.88 |
| 24 August | SD | 1.41 | 1.91 | 1.91 |
| | n | 46 | 62 | 108 |
| Zapadni | kg | 8.14 | 9.83 | 9.16 |
| 25 August | SD | 1.16 | 1.77 | 1.76 |
| | n | 46 | 70 | 116 |
| Combined | kg | 8.24 | 9.70 | 9.02 |
| | SD | 1.36 | 1.69 | 1.70 |
| | n | 344 | 401 | 745 |

Table 12.-- Mean mass (kg), standard deviation (SD), and sample sizes (n) of male and female northern fur seal pups weighed on St. Paul Island, Alaska, 24-26 August 1998 .

| Rookery | | Females | Males | Combined |
|---|---|---|---|---|
| Reef | kg | 8.14 | 9.36 | 8.85 |
| 25 August | SD | 1.32 | 1.59 | 1.60 |
| | n | 112 | 153 | 265 |
| Vostochni | kg | 8.11 | 9.45 | 8.82 |
| 24 August | SD | 1.25 | 1.62 | 1.60 |
| | n | 119 | 133 | 252 |
| Pol. Cliffs | kg | 8.33 | 9.88 | 9.24 |
| 25 August | SD | 1.29 | 1.66 | 1.70 |
| | n | 106 | 149 | 255 |
| Tolstoi | kg | 7.86 | 8.92 | 8.37 |
| 26 August | SD | 1.49 | 1.73 | 1.69 |
| | n | 169 | 159 | 328 |
| Combined | kg | 8.08 | 9.39 | 8.79 |
| | SD | 1.36 | 1.68 | 1.68 |
| | n | 506 | 594 | 1100 |

Table 13.-- Mean length (cm), standard deviation (SD), and sample sizes (n) of male and female northern fur seal pups measured on St. George Island, Alaska, 24-26 August 1998 .

| Rookery | | Females | Males | Combined |
|---|---|---|---|---|
| South | cm | 73.08 | 75.08 | 74.13 |
| 25 August | SD | 4.31 | 4.21 | 4.36 |
| | n | 65 | 71 | 136 |
| North | cm | 74.23 | 76.00 | 75.04 |
| 26 August | SD | 4.48 | 4.30 | 4.47 |
| | n | 73 | 62 | 135 |
| East Reef | cm | 72.89 | 76.77 | 74.87 |
| 24 August | SD | 3.60 | 3.30 | 3.95 |
| | n | 62 | 65 | 127 |
| East Cliffs | cm | 73.02 | 76.34 | 74.93 |
| 24 August | SD | 3.92 | 4.43 | 4.52 |
| | n | 52 | 71 | 123 |
| Staraya Artil | cm | 76.24 | 79.23 | 77.97 |
| 24 August | SD | 3.99 | 5.17 | 4.92 |
| | n | 45 | 62 | 107 |
| Zapadni | cm | 73.80 | 77.87 | 76.26 |
| 25 August | SD | 4.09 | 5.51 | 5.36 |
| | n | 46 | 70 | 116 |
| Combined | cm | 73.79 | 76.85 | 75.44 |
| | SD | 4.21 | 4.71 | 4.73 |
| | n | 343 | 4.01 | 744 |

Table 14.-- Mean length (cm), standard deviation (SD), and sample sizes (n) of male and female northern fur seal pups measured on St. Paul Island, Alaska, 24-26 August 1998 .

| Rookery | | Females | Males | Combined |
|---|---|---|---|---|
| Reef | cm | 77.17 | 80.13 | 78.88 |
| 25 August | SD | 4.28 | 4.43 | 4.60 |
| | n | 112 | 153 | 265 |
| Vostochni | cm | 75.97 | 78.39 | 77.25 |
| 24 August | SD | 4.69 | 4.74 | 4.86 |
| | n | 119 | 133 | 252 |
| Pol. Cliffs | cm | 78.13 | 81.60 | 80.16 |
| 25 August | SD | 3.94 | 4.11 | 4.38 |
| | n | 106 | 149 | 255 |
| Tolstoi | cm | 76.89 | 78.95 | 77.89 |
| 26 August | SD | 4.39 | 4.63 | 4.62 |
| | n | 169 | 159 | 328 |
| Combined | cm | 77.00 | 79.79 | 78.51 |
| | SD | 4.40 | 4.63 | 4.73 |
| | n | 506 | 594 | 1100 |

Table 15.--Analyses of variance of mass of male and female northern fur seal pups on St. Paul Island, Alaska, August 1998, across rookeries.

| Factor | df | SS due to factor | MSS* | Residual | df | F | P |
|---|---|---|---|---|---|---|---|
| Females | | | | | | | |
| Rookery | 3 | 15.3 | 5.1 | 925 | 502 | 2.8 | 0.042 |
| Males | | | | | | | |
| Rookery | 3 | 72.4 | 24.1 | 1611 | 590 | 8.8 | 0.000 |

*MSS = SS divided by df

Table 16.--Analyses of variance of length of male and female northern fur seal pups on St. Paul Island, Alaska, August 1998, across rookeries.

| Factor | df | SS due to factor | MSS* | Residual | df | F | P |
|---|---|---|---|---|---|---|---|
| Females | | | | | | | |
| Rookery | 3 | 266.1 | 88.7 | 9509 | 502 | 4.7 | 0.003 |
| Males | | | | | | | |
| Rookery | 3 | 877.0 | 292.3 | 11820 | 590 | 14.6 | 0.000 |

*MSS = SS divided by df

Table 17.--Analyses of variance of mass of male and female northern fur seal pups on St. George Island, Alaska, August 1998, across rookery.

| Factor | df | SS due to factor | MSS* | Residual | df | F | P |
|---|---|---|---|---|---|---|---|
| Females | | | | | | | |
| Rookery | 5 | 17.5 | 3.5 | 614 | 338 | 1.9 | 0.090 |
| Males | | | | | | | |
| Rookery | 5 | 83.7 | 16.7 | 1054 | 395 | 6.3 | 0.000 |

*MSS = SS divided by df

Table 18.--Analyses of variance of length of male and female northern fur seal pups on St. George Island, Alaska, August 1998, across rookery.

| Factor | df | SS due to factor | MSS* | Residual | df | F | P |
|---|---|---|---|---|---|---|---|
| Females | | | | | | | |
| Rookery | 5 | 399.9 | 80.0 | 5656 | 337 | 4.8 | 0.000 |
| Males | | | | | | | |
| Rookery | 5 | 708.1 | 141.6 | 8166 | 395 | 6.9 | 0.000 |

*MSS = SS divided by df

Mass and length were compared between islands by sex. The variances of the mass for males and females between islands were not significantly different ($P = 0.972$ and $P = 0.915$, respectively) . Male mass was significantly greater on St. George Island than St. Paul Island ($P = 0.006$), but there was no significant difference between the islands for the mass of female pups ($P = 0.088$). The variances of the lengths for each sex by island were not significantly different (males, $P < 0.694$; females, $P = 0.374$). Male (St. Paul 79.79 cm, St. George 76.85 cm) and female (St. Paul 77.00 cm, St. George 73.79 cm) pups were longer on St. Paul Island than St. George Island (males, $P < 0.001$; females, $P < 0.001$).

Sex Ratios

The fractions of females (Table 19) for each rookery and island were tested using an exact binomial test. The fraction of females were significantly different than 50% for Reef (42.3%, $P = 0.014$) and Polovina Cliffs (41.6%, $P = 0.008$) rookeries. Zapadni rookery was the only rookery on St. George Island where the fraction of females was significantly different than 50% (39.7%, $P = 0.032$). The fraction of females were significantly different than 50% for both islands (St. Paul, 46.0%, $P = 0.008$, and St. George, 46.2%, $P = 0.040$). These proportions on the two islands were not significantly different ($P = 0.941$). The overall fraction of females (46.1%) for both islands combined was significantly different than 50% ($P = 0.001$).

## SUMMARY

Consistent with earlier evaluations of pup mass data (York and Antonelis 1990, York and Towell 1993, Towell et al. 1996, and Towell et al. 1997), the strongest pattern was that the size of pups varied by sex: male pups were heavier and longer than female pups. The mass of male pups on St. George Island was significantly greater than male pups on St. Paul Island in 1998.

Table 19.--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 and St. George Islands, Alaska, August 1998. The fraction of females is significantly less than 50% (P = 0.95) for bold items.

| Rookery | Females | Total | Fraction |
|---|---|---|---|
| St. Paul | | | |
| Reef | **112** | **265** | **0.423** |
| Vostochni | 119 | 252 | 0.472 |
| Polovina Cliffs | **106** | **255** | **0.416** |
| Tolstoi | 169 | 328 | 0.515 |
| Total | **506** | **1100** | **0.460** |
| St. George | | | |
| South | 65 | 136 | 0.478 |
| North | 73 | 135 | 0.541 |
| East Reef | 62 | 127 | 0.488 |
| East Cliffs | 52 | 123 | 0.423 |
| Staraya Artil | 46 | 108 | 0.426 |
| Zapadni | **46** | **116** | **0.397** |
| Total | **344** | **745** | **0.462** |

Both male and female pups were significantly longer ($P < 0.001$) on St. Paul Island than on St. George Island in 1998. The proportion of females was significantly different ($P < 0.05$) than 50%, (46.0% on St. Paul Island and 46.2% on St. George Island, Table 20) for both islands in 1998.

These differences in mass and length may reflect the influence of environmental variability on the condition of pups and their mothers. Undetected biases in sampling techniques may also be responsible for the differences detected in this study. The large difference in length measurements between islands may be attributed to measurement technique. On St. George Island, two measurers did about one-half the number of pups on each rookery; St. Paul measurers were rotated more frequently. The protocol for taking length measurements is very subjective and the process must be more closely examined.

Table 20.--Numbers of female pups, total number of pups, and fraction (that are female) of live northern fur seals pups captured during weighing operations on St. Paul and St. George Islands, Alaska for the years 1992-1998.

| | St. Paul | | | St. George | | |
|---|---|---|---|---|---|---|
| Year | Females | Total | Fraction | Females | Total | Fraction |
| 1992 | 494 | 1118 | 0.442 | 291 | 634 | 0.459 |
| 1994 | 926 | 1926 | 0.481 | 430 | 886 | 0.485 |
| 1995 | 939 | 2040 | 0.460 | 294 | 653 | 0.450 |
| 1996 | 520 | 1149 | 0.453 | 331 | 749 | 0.442 |
| 1997 | 495 | 1020 | 0.485 | 311 | 639 | 0.487 |
| 1998 | 506 | 1100 | 0.460 | 344 | 745 | 0.462 |

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

by

Sharon R. Melin and Robert L. DeLong

The northern fur seal population has thrived at San Miguel Island except for one severe decline in 1983 associated with an El Niño event (DeLong and Antonelis 1991). El Niño events cause changes in marine communities by altering the sea level height, the sea surface temperature, thermocline depth, current flow patterns, and upwelling strength of marine ecosystems (Norton et al. 1985, Arntz et al. 1991). In response to these changes in oceanographic conditions, prey species of fur seals at San Miguel Island move farther north and deeper in the water column (Arntz et al. 1991), and thereby become more energetically expensive to obtain. Consequently, animals are in poor condition and the population experiences reduced reproductive success, high pup mortality, and probable adult mortality (DeLong and Antonelis 1991, Melin and DeLong 1994, Melin et al. 1996). Because El Niño events occur periodically along the California coast where they impact population growth of fur seals at San Miguel Island, they play an important role in the dynamics of this population (DeLong and Antonelis 1991, Melin and DeLong 1994, Melin et al. 1996).

From July 1997 through May 1998, a strong El Niño event in recorded history affected the coastal waters of California (Lynn et al. 1998). The most severe conditions occurred between September and November 1997 (Lynn et al. 1998). Although the event began to wane in May 1998, it continued to impact fur seals at San Miguel Island throughout the 1998 breeding season. Based upon oceanographic indices, the 1997-98 El Niño event was similar to the 1982-83 El

Niño event (Norton et al. 1985, Lynn et al. 1998). The sea surface temperatures ranged from 2° to 5° C warmer than normal and the thermocline deepened during the eleven month period (Lynn et al. 1998). Similar changes in the California Current during the 1982-83 El Niño event resulted in a 60.3% decline in the northern fur seal pup production at San Miguel Island (DeLong and Antonelis 1991). Because the oceanographic characteristics of the 1997-98 El Niño were similar to the 1982-83 El Niño event (Norton et al. 1985), we expected a significant decline in pup production, substantial pup mortality, and lower weights of pups at 4-months of age for the northern fur seal population at San Miguel Island in 1998 compared to 1996 and 1997.

Here we report the results of the 1998 population monitoring studies at San Miguel Island including those on the timing of reproductive events during the breeding season and estimates of pup production, pup mortality, and pup condition. The results are compared to 1996, a 'normal' year, and 1997, the year the 1997-98 El Niño began, to provide a context for evaluating the magnitude of the effects of the 1997-98 El Niño event on the fur seals at San Miguel Island. The results indicate that the El Niño conditions in 1997 and 1998 had a significant impact on the population growth of San Miguel northern fur seals.

## METHODS

### Surveys of Adults

The timing of reproductive events was determined from surveys of northern fur seals during the breeding season at the Adams Cove colony from 3 June to 5 August 1996, 24 May to 10 August 1997, 29 May to10 and 1998. Surveys were conducted from two blinds overlooking the Adams Cove colony (approximately 20 m above and 40 to 300 m horizontal distance from

the breeding animals) every 1 to 3 days. Counts of territorial adult males (with and without females), adult females, and pups were conducted using a 15-45× zoom scope and 10 × 50 binoculars. The mean pupping date was determined by weighting the day of the season by the change in the number of pups counted on each survey (day 1 was the day the first pup was born and each survey day thereafter was numbered consecutively even though the surveys were not necessarily conducted on consecutive days). The date on which the number of new pups counted equaled the weighted average was used as the mean pupping date.

## Live Pup Census and Pup Mortality

The live pup census was conducted when pupping was completed. This is subjective but is based upon the frequency of births observed during the daily surveys. When no births occur for several days, pupping is considered completed and the live pup census is conducted. This usually occurs the last week of July. The live pup census was conducted from a mobile blind by two observers using binoculars and counting groups of pups. The mean number of pups was calculated from the total counts of the two observers. The standard error about the mean was calculated using the sum of the standard deviations from the two independent counts for each group of pups. The sum of the standard deviations was divided by the square root of the total number of pup groups to obtain the standard error.

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

stacked by each observer. Observed pup mortality at Castle Rock was obtained from one survey at the time of the live pup count.

### Pup Tagging and Condition Indices

Northern fur seal pups were tagged with pink plastic roto tags in Adams Cove in September of 1996, 1997 and 1998. Tags with the same number were placed on both foreflippers of each pup. The sex and weight of each pup was recorded and the pup was released.

## RESULTS

### Surveys of Adults

The first territorial males arrived on 29 May in 1998. The date of arrival of the first territorial males in 1996 and 1997 is uncertain, but 27 males were ashore on 3 June 1996 and 7 males were ashore on 24 May 1997 when the field seasons began. The maximum number of territorial bulls in Adams Cove increased 22.5% between 1996 (n = 204) and 1997 (n = 250) but declined 55.2% in 1998 (n = 112). The number of males that held territories with females was 162, 142, and 74 in 1996, 1997, and 1998, respectively. The percentage of males holding territories with females in 1996 (79.4%) was higher than 1997 (56.8%) (df=1, $\chi^2$=24.949) and 1998 (66.1%) (df=1, $\chi^2$=6.118). The percentage of males holding territories with females was higher in 1998 than in 1997 but did not differ significantly (df=1, $\chi^2$=2.391).

The first fur seal pup was born 13 June in 1998, 9 days later than 1997 and 4 days later than 1996. The mean pupping date was 20 July in 1998, 19 days later than 1997 and 8 days later than 1996.

## Live Pup Census and Pup Mortality

The total pup production in Adams Cove was 2,009, 2,077 and 424 pups in 1996, 1997 and 1998, respectively (Table 21). The total production in Adams Cove increased 3.4% from 1996 to 1997 but declined 79.6% from 1997 to 1998. The highest observed pup mortality rate occurred in 1998 (27.4%) followed by 1997 (15.3%) and 1996 (10.0%) (Table 21). Post-survey pup mortality was measured in 1997 and 1998, and resulted in a total pup mortality for the season (June through September) of 41.6% in 1997 and 55.0% in 1998. In an additional survey in 1997, only 276 live pups were counted on 8 October indicating the decline, with post-survey mortality, was at least 86.7% from July to October that year.

Live pup counts were not conducted at Castle Rock in 1996. The mean number of live pups counted was 940 in 1997 and 194 in 1998 (Table 21). The number of dead pups counted at the time of the live pup survey was 51 in 1997 and 9 in 1998 (Table 21). The total production at Castle Rock declined 79.5% between 1997 and 1998 (Table 21). No observed mortality rates were calculated for Castle Rock because the dead pups counted at the time of survey were not representative of the total mortality during the season.

The total production for the San Miguel Island fur seal population was 3,068 and 627 pups in 1997 and 1998, respectively. This represents a decline of 79.6% from 1997 to 1998.

## Pup Weights

A total of 300, 154, and 163 pups were tagged and weighed in 1996, 1997, and 1998, respectively (Table 22). The mean weights of both sexes were different for the three years (ANOVA, $P < 0.001$ for both sexes). The mean weight of male pups (6.3 kg) in 1997 was

Table 21.--Summary of live and dead pup counts of northern fur seals at Adams Cove 1996-98 and Castle Rock 1997-98. Mortality rates are based on observed mortality and are underestimates of the total mortality. Standard Error about the mean is in parentheses.

| Colony/Year | Mean number of live pups | Number dead at live pup survey | Total production | Observed mortality rate | Post-live pup survey mortality | Season observed mortality rate |
|---|---|---|---|---|---|---|
| Adams Cove | | | | | | |
| 1996 | 1,808 (3.90) | 201 | 2,009 | 10.0 | - | - |
| 1997 | 1,759 (5.05) | 318 | 2,077 | 15.3 | 546 | 41.6 |
| 1998 | 308 (0.86) | 116 | 424 | 27.4 | 113 | 54.0 |
| Castle Rock | | | | | | |
| 1997 | 940 (3.50) | 51 | 991 | | | |
| 1998 | 194 (0.76) | 9 | 203 | | | |

significantly lower than the mean weight of males in 1996 (11.8 kg; Bonferroni post-hoc, $P < 0.001$) and 1998 (8.6 kg; Bonferroni post-hoc, $P < 0.001$) and the mean weight in 1998 was significantly lower than the mean weight in 1996 (Bonferroni post-hoc, $P < 0.001$). Similarly, the mean weight of female pups in 1997 (5.9 kg) was lower than the mean weight of females in 1996 (10.6 kg, Bonferroni post-hoc, $P < 0.001$) and 1998 (8.0 kg; Bonferroni post-hoc, $P < 0.001$) and the mean weight in 1998 was lower than the mean weight in 1996 (Bonferroni post-hoc, $P < 0.001$).

## Tag Resight Effort

Twenty (20) adult female and 20 male, flipper-tagged adult individuals were identified throughout the season in 1998 (Table 23). The ages of identified females ranged from 4 to 11 years, and 55.0% of the sighted females had pups (Table 23). Tagged males ranged from 4 to 11 years of age, and tagged territorial males were 8 to 11 years old.

## DISCUSSION

The 79.6% decline in the number of northern fur seal pup births at San Miguel Island in 1998 represents the greatest decline in population growth since studies began in 1968. The 1997-98 El Niño had a significant impact on several population parameters. The late arrival of territorial males, the decline in the number of territorial males, and the lower percentage of males holding territories with females, suggest that fewer males returned to breed in 1998. The low number of pups born indicates that fewer females returned to the rookery to pup and the low total counts of females indicate that fewer females returned to breed. Failure to return to the rookery during the breeding season could be due to high winter mortality or emigration of adult males and females. The low number of adult females could also reflect fewer successful pregnancies.

Table 22.--Mean weights of 4-month-old northern fur seal pups at Adams Cove, San Miguel Island, California.

| | Males | | | Females | | |
|---|---|---|---|---|---|---|
| Year | n | Mean (kg) | SE | n | Mean (kg) | SE |
| 1996 | 153 | 11.8 | 0.14 | 147 | 10.6 | 0.13 |
| 1997 | 75 | 6.3 | 0.13 | 79 | 5.9 | 0.12 |
| 1998 | 78 | 8.6 | 0.21 | 85 | 8.0 | 0.21 |

Table 23.--Number of tagged northern fur seals sighted at Adams Cove, San Miguel Island, California, from May through August 1998.

| | Females | | | Males | | |
|---|---|---|---|---|---|---|
| Cohort | Number tagged | Number sighted | Number sighted with pups | Number tagged | Number sighted | Number territorial |
| 1987 | 56 | 1 | 0 | 43 | 0 | 0 |
| 1988 | 192 | 1 | 1 | 195 | 2 | 2 |
| 1989 | 159 | 3 | 1 | 195 | 5 | 5 |
| 1990 | 85 | 1 | 1 | 114 | 2 | 1 |
| 1991 | 158 | 5 | 3 | 143 | 3 | 0 |
| 1992 | 163 | 1 | 0 | 136 | 1 | 0 |
| 1993 | 146 | 7 | 4 | 153 | 5 | 0 |
| 1994 | 144 | 1 | 1 | 156 | 2 | 0 |

The dates of first birth in 1997 and 1998 were not outside the range of dates reported for this population over the years (DeLong 1982, DeLong and Antonelis 1985, Antonelis et al. 1989). However, the mean pupping date of 13 July in 1998 was later than the mean pupping date of 29 June reported by DeLong (1982). The high mortality rates and lower weights of 4-month-old pups in 1997 and 1998 suggest that females were having difficulty finding enough prey to maintain lactation.

The pattern of population growth between 1996 and 1998 indicates that pup production in 1997 was not significantly impacted by the El Niño conditions, but the high post-survey mortality rate and the low pup weights indicate that the primary impact was the increased mortality of pups in their first year. Including the October survey in 1997, it would appear that up to 87.0% of the pups born in 1997 died before weaning. In contrast with 1997, the pup production in 1998 declined significantly, pup mortality was high, and pup weights were lower than 1996, but higher than 1997. Thus, the El Niño conditions impacted pup production and pup survival in 1998, but the increase in pup weights between 1997 and 1998 suggests that the impacts were waning late in the 1998 season.

The differences in impacts of the 1997-98 El Niño on pup production and mortality reflect the importance of the timing of the onset of these events relative to the annual cycle of the northern fur seal population. The 1997-98 El Niño conditions intensified along the California coast in September 1997 (Lynn et al. 1998), after the breeding season. Consequently, the warmer environmental conditions and changes in prey distribution impacted the survival of pups born in 1997 rather than 1997 pup production. However, because the altered environmental conditions persisted until September, both pup production and first-year pup survival were

negatively impacted in 1998. The decline in population growth of 79.6% for both colonies in 1998 reduced the population to a level last observed in 1984 (DeLong and Antonelis 1991), and exemplifies the importance of El Niño events in regulating the fur seal population at San Miguel Island. The population suffered another significant decline, 60.3% in 1983, also related to an El Niño event (DeLong and Antonelis 1991). The population recovered 7 years later, suggesting that adult female mortality occurred in addition to pup mortality (Melin and DeLong 1994). The evidence presented here suggests that adult mortality occurred in addition to pup mortality during 1997 and 1998, thus we anticipate a slow recovery from the 1998 decline.

# NORTHERN FUR SEAL ENTANGLEMENT STUDIES: ST. PAUL ISLAND, 1998

by

Candace M. Stepetin, Samantha M. Zacharof, Masashi Kiyota, and Bruce W. Robson

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

In 1998, the Tribal Government of St. Paul Island and the Pribilof Islands Stewardship Program continued a study of juvenile male fur seal entanglement using surveys conducted in conjunction with the subsistence harvest. This program was initiated in 1995 in collaboration with the National Marine Fisheries Service to reduce the frequency with which seals are disturbed by eliminating research roundups during July and early August.

The objective of this study was to continue to monitor trends in the entanglement rate of northern fur seals in marine debris on St. Paul Island. This information is used to provide:

1) a continuing index of entanglement rates, 2) a means of indirectly assessing the relative amount of entangling debris within the habitat of the fur seal, and 3) an assessment of the debris types associated with different fisheries that may have an impact upon fur seals. In addition to the juvenile male entanglement studies, researchers collected information on annual (1991-98) rates of entanglement among adult female fur seals. As in previous years, researchers captured and removed debris from entangled seals encountered during other research projects.

## METHODS

### Harvest Surveys of Males

Male fur seals on hauling grounds located on St. Paul Island were surveyed for entanglement in July and August 1998. Harvest surveys were conducted in conjunction with the Aleut subsistence harvest following the methods described in Robson et al. (1997). During each survey, counts were made of the total number of seals released from the killing field during the subsistence harvest (Robson et al.1997b). Separate counts of juvenile (age 2 - 4) male seals were not conducted during 1998 harvest surveys, which represents a shift in the index of entanglement from previous years. Harvested seals were examined for evidence of entanglement and added to the final count.

When an entangled seal was sighted, the release of seals was stopped and the entangled seal was captured and the entangling debris removed. Information on the type of entangling debris, the extent of the wound, and the estimated age of the seal was recorded. Debris removed from entangled seals was examined to determine the type, color, weight and size

(stretched mesh and twine size for net fragments; length and width of the entangling loop for other materials such as packing bands or ropes).

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

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

### Entanglement Surveys of Adult Females

In 1998, island-wide surveys of entangled adult female fur seals were conducted on St. Paul Island using the techniques described by Kiyota and Fowler (1994). All rookeries were

surveyed in conjunction with the counts of adult males from 14 to 20 July. Locations of entangled females were recorded and attempts were made to locate and disentangle these seals when possible, with minimal disturbance to the rookeries.

## RESULTS AND DISCUSSION

### Harvest Surveys of Juvenile Males

Twenty-four subsistence harvest surveys were conducted on St. Paul Island during July and early August of 1998 (Table 24). Observers sampled 5,489 seals released from the killing field and 1,114 killed in the subsistence harvest. Twelve entangled male seals were observed during harvest surveys and included in the calculation of the entanglement rate below. Ten seals with scars indicating evidence of previous entanglement were also observed; however, they were not used in calculations of the incidence of entanglement (Table 24). One juvenile male on St. Paul Island was observed during a survey with shear marks indicating prior removal of entangling debris during 1997 and was included in the calculation of the entanglement rate. Thirty-eight seals captured and disentangled during other research activities on both islands from late June through early August 1998 are not included in the calculations of the entanglement rate.

The rate of entanglement for male seals surveyed on the killing field was 0.2% (13/6,603) on St. Paul Island. As in previous years, entangling debris consisted primarily of pieces of trawl net, plastic packing bands, and loops of synthetic or natural twine. Of the 12 entangled seals observed during surveys, 10 were captured and their debris was identified. Six (60%) males were entangled in packing bands, 3 in trawl net (30%) and one seal was entangled in twine (10%). These data are presented in Table 25 expressed as the incidence of entanglement (observed percent ) among males entangled by debris category.

Table 24.--Summary of harvest surveys of northern fur seal males conducted on St. Paul Island during July and August, 1998 including the number of observations of seals entangled, resighted, and observed with scars.

| Date | Location | Release count | Harvest count | Total count | Entangled | Sheared | Total entangled | Scarred |
|---|---|---|---|---|---|---|---|---|
| 07-Jul-98 | Reef | 124 | 33 | 157 | 0 | 0 | 0 | 0 |
| 08-Jul-98 | Lukanin | 62 | 24 | 86 | 0 | 0 | 0 | 0 |
| 10-Jul-98 | Zapadni | 454 | 40 | 494 | 0 | 0 | 0 | 0 |
| 14-Jul-98 | Zapadni Reef Sands | 155 | 46 | 201 | 0 | 0 | 0 | 0 |
| 16-Jul-98 | Lukanin | 119 | 33 | 152 | 0 | 0 | 0 | 0 |
| 16-Jul-98 | Kitovi | 182 | 14 | 196 | 0 | 0 | 0 | 2 |
| 18-Jul-98 | Reef | 308 | 66 | 374 | 1 | 0 | 1 | 0 |
| 21-Jul-98 | Zapadni | 275 | 44 | 319 | 3 | 0 | 3 | 1 |
| 23-Jul-98 | Lukanin | 146 | 59 | 205 | 0 | 0 | 0 | 0 |
| 24-Jul-98 | Reef | 275 | 72 | 347 | 1 | 0 | 1 | 0 |
| 25-Jul-98 | Morjovi | 164 | 34 | 198 | 0 | 0 | 0 | 0 |
| 27-Jul-98 | Zapadni Reef Sands | 300 | 50 | 350 | 0 | 0 | 0 | 2 |
| 29-Jul-98 | Polovina | 207 | 24 | 231 | 1 | 1 | 2 | 1 |
| 29-Jul-98 | Kitovi | 121 | 39 | 160 | 0 | 0 | 0 | 1 |
| 30-Jul-98 | Zapadni | 279 | 42 | 321 | 0 | 0 | 0 | 0 |
| 31-Jul-98 | Reef | 212 | 56 | 268 | 0 | 0 | 0 | 0 |
| 01-Aug-98 | Vostochni Sands | 250 | 37 | 287 | 0 | 0 | 0 | 0 |
| 03-Aug-98 | Zapadni Reef Sands | 169 | 43 | 212 | 0 | 0 | 0 | 0 |
| 03-Aug-98 | Lukanin | 290 | 49 | 339 | 0 | 0 | 0 | 0 |
| 04-Aug-98 | Polovina | 210 | 47 | 257 | 1 | 0 | 1 | 2 |
| 04-Aug-98 | Little Polovina | 237 | 28 | 265 | 0 | 0 | 0 | 0 |
| 05-Aug-98 | Zapadni | 320 | 48 | 368 | 3 | 0 | 3 | 0 |

Table 24.--Summary of harvest surveys of northern fur seal males conducted on St. Paul Island during July and August, 1998 including the number of observations of seals entangled, resighted, and observed with scars.

| Date | Location | Release count | Harvest count | Total count | Entangled | Sheared | Total entangled | Scarred |
|---|---|---|---|---|---|---|---|---|
| 06-Aug-98 | Morjovi | 273 | 83 | 356 | 1 | 0 | 1 | 0 |
| 07-Aug-98 | Zolotoi Sands | 357 | 103 | 460 | 1 | 0 | 1 | 1 |
| St. Paul Totals | | 5,489 | 1,114 | 6,603 | 12 | 1 | 13 | 10 |

Table 25.--Debris found on juvenile male northern fur seals from St. Paul Island, Alaska, 1981-98, expressed as the incidence of entanglement (observed percent) among juvenile males entangled by debris category (data for 1981-91 from Fowler and Ragen 1990, Fowler and Baba 1991, and Fowler et al. 1992). Sample sizes shown are the number of entangled juveniles for which debris type could be determined, and do not include sheared resights or seals which were not captured or examined closely. Observed percent values are calculated as the overall entanglement rate for juveniles on each island multiplied by the proportion of seals in a debris category.

| Year | Trawl net fragments | Packing bands | Cord, rope, and string | Monofilament net fragments | Misc. items | Entanglement rate | Sample size |
|---|---|---|---|---|---|---|---|
| 1981 | 0.29 | 0.08 | 0.04 | 0.00 | 0.03 | 0.43 | 102 |
| 1982 | 0.24 | 0.10 | 0.04 | 0.01 | 0.01 | 0.41 | 102 |
| 1983 | 0.30 | 0.07 | 0.02 | 0.01 | 0.03 | 0.43 | 112 |
| 1984 | 0.22 | 0.09 | 0.05 | 0.02 | 0.01 | 0.39 | 87 |
| 1985 | 0.31 | 0.05 | 0.07 | 0.01 | 0.01 | 0.45 | 76 |
| 1986 | 0.27 | 0.06 | 0.07 | 0.01 | 0.01 | 0.42 | 70 |
| 1988 | 0.15 | 0.07 | 0.05 | 0.00 | 0.01 | 0.28 | 53 |
| 1989 | 0.12 | 0.10 | 0.06 | 0.02 | 0.01 | 0.29 | 47 |
| 1990 | 0.11 | 0.11 | 0.07 | 0.01 | 0.03 | 0.32 | 71 |
| 1991 | 0.06 | 0.08 | 0.06 | 0.01 | 0.00 | 0.21 | 38 |
| 1992 | 0.14 | 0.07 | 0.05 | 0.01 | 0.03 | 0.29 | 40 |
| 1995 | 0.11 | 0.08 | 0.02 | 0.00 | 0.01 | 0.22 | 22 |
| 1996 | 0.10 | 0.07 | 0.03 | 0.00 | 0.02 | 0.23 | 37 |
| 1997 | 0.06 | 0.09 | 0.01 | 0.00 | 0.03 | 0.19 | 32 |
| 1998 | 0.06 | 0.12 | 0.02 | 0.00 | 0.00 | 0.20 | 10 |

The incidence of entanglement among male seals on St. Paul Island is within the range of entanglement rates observed among juvenile males from 1988 to 1992 and 1995-97 (Table 26) (Robson et al. 1997a, Robson et al. 1997b). It is also comparable to the entanglement rate calculated for the total count of adult and juvenile males during harvest and research roundups during 1995-97 (Table 26) (Robson et al. 1997a, Robson et al. 1997b). However, a recalculation of the entanglement rate for all males released from the killing field during the 1996 and 1997 harvest surveys (NMFS unpublished data), shows that the incidence of entanglement was 0.11% in 1996 and 0.11% in 1998 when the killing field survey method was used. This difference may indicate a slight bias due to selection by harvesters for younger seals during harvest roundups, and subsequent drives to the killing field, or a higher number of captures of entangled seals during the initial drive during 1996 and 1997.

## Adult Female Entanglement

Three entangled and 8 scarred (evidence of previous entanglement) adult female fur seals were observed during female entanglement surveys on St. Paul Island (Table 27) in 1998. The rate of entanglement among females was calculated at 0.0105% for entangled females, 0.0281% for scarred females, and 0.0386% for the two categories combined. The 1997 data are comparable to the observed rate of entangled, and entangled and scarred females combined in 1995-97, and to that observed in 1992 and 1993 (Table 28) (Kiyota and Fowler 1992, Kiyota unpublished data).

Table 26.--The percentage of juvenile and total male northern fur seals from St. Paul Island, Alaska, entangled in marine debris as recorded from 1967 to 1984 during the commercial harvest (data from Kozloff et al. 1986); from 1985 to 1992 during roundups (data updated from Fowler et al. 1993) and from 1995 to 1997 (Robson et al. 1999).

| Year | Percent Entangled | |
|---|---|---|
| | Juvenile males | Total males |
| 1967 | 0.15 | -- |
| 1968 | 0.16 | -- |
| 1969 | 0.20 | -- |
| 1970 | 0.28 | -- |
| 1971 | 0.41 | -- |
| 1972 | 0.43 | -- |
| 1973 | 0.48 | -- |
| 1974 | 0.58 | -- |
| 1975 | 0.71 | -- |
| 1976 | 0.42 | -- |
| 1977 | 0.35 | -- |
| 1978 | 0.46 | -- |
| 1979 | 0.40 | -- |
| 1980 | 0.49 | -- |
| 1981 | 0.43 | -- |
| 1982 | 0.41 | -- |
| 1983 | 0.43 | -- |
| 1984 | 0.39 | -- |
| 1985 | 0.45 | -- |
| 1986 | 0.42 | -- |
| 1987 | -- | -- |
| 1988 | 0.28 | -- |
| 1989 | 0.29 | -- |
| 1990 | 0.32 | -- |
| 1991 | 0.21 | -- |
| 1992 | 0.29 | -- |
| 1993 | -- | -- |
| 1994 | -- | -- |
| 1995 | 0.22 | 0.18 |
| 1996 | 0.23 | 0.19 |
| 1997 | 0.19 | 0.15 |
| 1998 | -- | 0.20 |

Table 27.--Summary of surveys of northern fur seal female entanglement conducted on St. Paul Island during July 1998.

| Date | Rookery | No. counted | Females entangled | Females scarred | Females entangled and scarred |
|---|---|---|---|---|---|
| 7/14/98 | Morjovi | 2,048 | 1 | 0 | 1 |
| 7/14/98 | Vostochni | 4,434 | 0 | 0 | 0 |
| 7/16/98 | Polovina | 360 | 0 | 0 | 0 |
| 7/16/98 | Polovina Cliffs | 3,671 | 0 | 1 | 1 |
| 7/16/98 | Little Polovina | 46 | 0 | 0 | 0 |
| 7/17/98 | Tolstoi | 3,736 | 0 | 0 | 0 |
| 7/17/98 | Kitovi | 1,542 | 0 | 0 | 0 |
| 7/17/98 | Lukanin | 1,036 | 0 | 0 | 0 |
| 7/19/98 | Big Zapadni | 3,433 | 0 | 4 | 4 |
| 7/19/98 | Little Zapadni | 2,012 | 0 | 0 | 0 |
| 7/19/98 | Zapadni Reef | 626 | 0 | 0 | 0 |
| 7/20/98 | Gorbatch | 2,173 | 0 | 2 | 2 |
| 7/20/98 | Ardiguen | 436 | 0 | 0 | 0 |
| 7/20/98 | Reef | 2,908 | 2 | 1 | 3 |
| Total | | 28,461 | 3 | 8 | 11 |
| Rate (%) | | | 0.0105 | 0.0281 | 0.0386 |

Table 28.-- Observed incidence and rate of female entanglement on St. Paul Island from 1991-98 based on surveys of all major rookeries.

| Year | Number | | | Rate (%) | | |
|---|---|---|---|---|---|---|
| | Counted | Entangled | Scarred | Entangled | Scarred | Ent+Scar |
| 1991 | 16,009 | 3 | 7 | 0.019 | 0.044 | 0.062 |
| 1992 | 25,089 | 3 | 6 | 0.012 | 0.024 | 0.036 |
| 1993 | 31,638 | 3 | 11 | 0.009 | 0.035 | 0.044 |
| 1994 | 30,269 | 7 | 10 | 0.023 | 0.033 | 0.056 |
| 1995 | 29,109 | 3 | 8 | 0.010 | 0.028 | 0.038 |
| 1996 | 30,426 | 4 | 7 | 0.013 | 0.023 | 0.036 |
| 1997 | 30,406 | 2 | 9 | 0.007 | 0.029 | 0.036 |
| 1998 | 28,461 | 3 | 8 | 0.011 | 0.028 | 0.039 |

# INCIDENCE OF FUNGAL INFECTIONS OF THE PELAGE IN NORTHERN FUR SEALS DURING 1998

by

Staff Scientists of the National Marine Mammal Laboratory and the
National Research Institute of Far Seas Fisheries, Japan

## INTRODUCTION

Scheffer (1962) described a pelage condition observed in northern fur seals on the Pribilof Islands characterized by areas of sparse or patchy hair fibers sometimes termed "rubbed" or "mangy" fur. This condition is commonly observed among northern fur seals on San Miguel Island, with higher levels of incidence occurring during periods of warm ocean conditions. Dermatophytic fungi of the genus *Trichophyton* have been cultured from infected areas of skin and pelage on affected seals at San Miguel Island (R.L. DeLong, unpublished data). *Trichophyton* sp. are also among the genera of fungi isolated from the hair and skin of northern fur seals from both St. Paul and San Miguel Islands by Vedros et al. (1982). Researchers from the National Marine Mammal Laboratory and the National Research Institute of Far Seas Fisheries observed large numbers of northern fur seals with pelage conditions attributable to fungal infections during the 1998 breeding season on both of the Pribilof Islands and at San Miguel Island. This report documents the incidence of fungal infections observed at both breeding colonies during the 1998 breeding season.

# METHODS

## Pribilof Islands

During the 1998 female entanglement census (15 to 20 July) on St. Paul Island, adult females at breeding rookeries whose chests or backs were visible were scanned either by naked eye or using binoculars, and the number of females with fungal infections recorded. Pelage conditions were classified into three categories; 1) black spots or ashen areas, 2) light colored areas of hair loss and 3) instances where both conditions were present (Fig. 12). Adult male fur seals were surveyed for evidence of pelage anomalies on a sub-sample of St. Paul Island rookeries during the same time period.

Surveys of adult females were conducted on St. George Island during the pup production estimate on 23-26 August, however pelage conditions were not differentiated, and therefore, the two types of pelage conditions were combined into one category. For each island, the percent of observed animals with fungal infections was calculated from the total number of observed seals sighted during each survey effort.

## San Miguel Island

Pelage condition was recorded during tag resight efforts at San Miguel Island in 1998. For each tagged animal, the percent of damaged pelage on the body was estimated. In addition to the tag resight surveys, the number of adult females with pelage anomalies in five territories was recorded during live pup surveys in 1998. The percentage of females with fungal infections was calculated from the total number of females in the five territories.

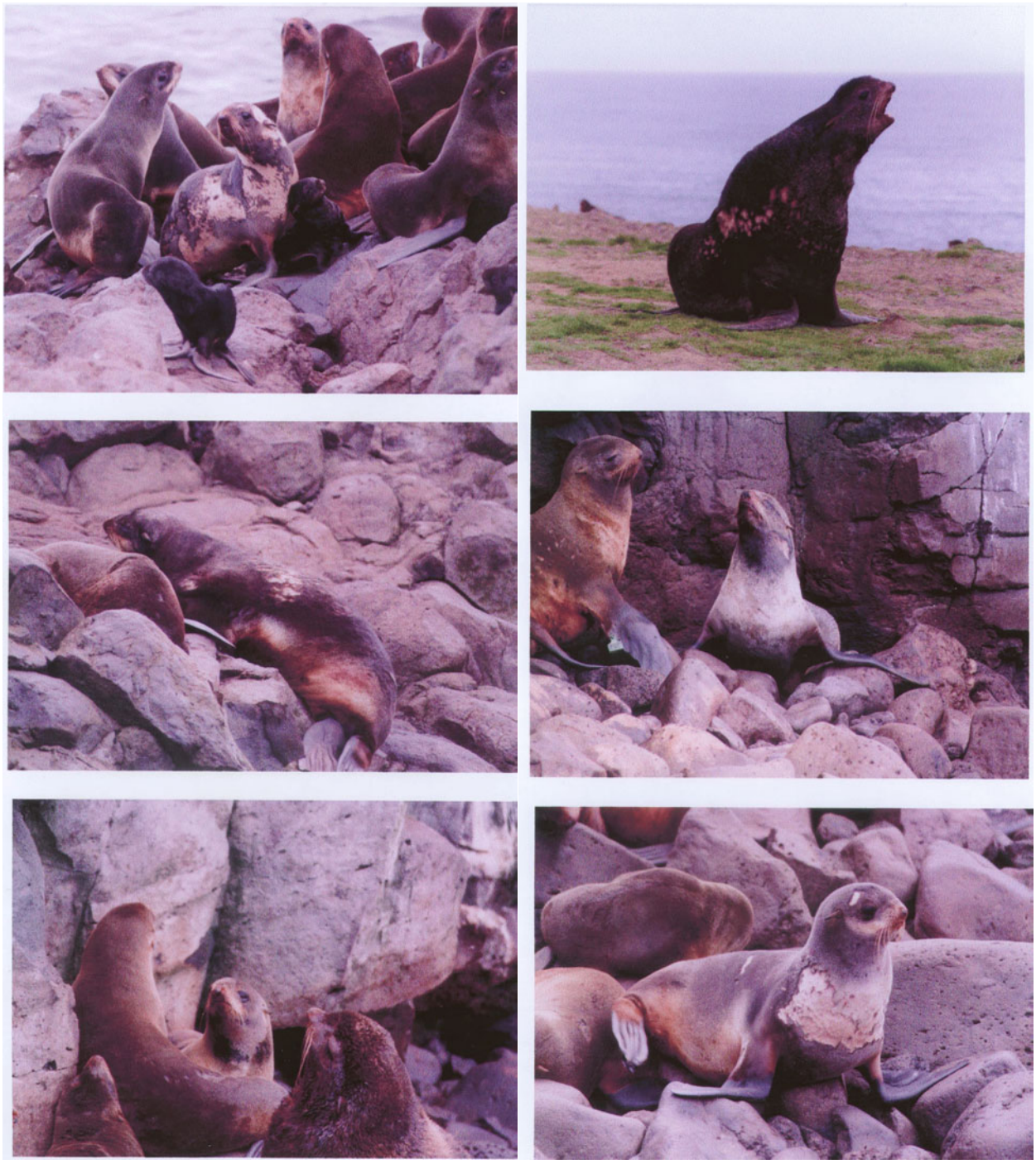

Figure 12.--Photographs showing northern fur seals with fungal infections of the pelage on St. Paul Is. during July 1998.

# RESULTS AND DISCUSSION

Both patchy hair loss and black spots were observed among females in all rookeries investigated on the Pribilof Islands. The average incidence of fungal infections was 2.1% (332/16,116) among females on St. Paul Island rookeries (Table 30). A lower overall incidence of fungal infections, 0.5% (17/3,292) was observed among adult male fur seals at seven rookeries on St. Paul Island (Table 31). On St. George Island, two independent observers estimated the incidence of fungal infections among females at 7.4% (134/1803) and 5.5% (104/1880) at three rookeries (Table 32).

Although some variation was observed between rookeries at any particular breeding colony, it is likely that these differences reflect conditions under which observations were made (e.g., distance, light conditions, and animal density) rather than a geographical pattern of occurrence. Detailed observations over a 2-day period conducted in conjunction with behavioral observations at Polovina Cliffs rookery on St. Paul Island showed levels of incidence of 13.6% (9/66 on 24 July) and 14.3% (6/42 on 25 July). Observations from a similar distance and in comparable viewing conditions at Little Polovina rookery showed a similar high incidence (8.7%), as did sections of other rookeries where animals were sparsely distributed and were observed from a close distance.

St. George Island observations were made over a month later than those on St. Paul Island, so the higher incidence of fungal infections on St. George Island may be due to an increasing number of affected individuals as the season progresses, or alternatively, to variation between observers in assessing the condition of seals. The counts conducted by two independent

Table 30.--Incidence of pelage anomalies in adult female northern fur seals, St. Paul Island, 15-20 July 1998.

| Rookery | Polovina Cliffs | Little Polovina | Tolstoi | Zapadni | Little Zapadni | Zapadni Reef | Gorbatch | Ardiguen | Reef | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| Missing guard hair | 13 | 0 | 22 | 10 | 5 | 4 | 13 | 0 | 17 | 84 |
| Black fur | 24 | 0 | 31 | 12 | 7 | 1 | 25 | 5 | 19 | 124 |
| Both anomalies | 37 | 4 | 16 | 14 | 8 | 4 | 17 | 4 | 20 | 124 |
| Total females obs. | 74 | 4 | 69 | 36 | 20 | 9 | 55 | 9 | 56 | 332 |
| Total counted | 2,900 | 46 | 3,452 | 2,853 | 1,462 | 639 | 2,286 | 436 | 2,042 | 16,116 |
| Incidence | 2.6% | 8.7% | 2.0% | 1.3% | 1.4% | 1.4% | 2.4% | 2.1% | 2.7% | 2.1% |

Table 31.--Incidence of pelage anomalies in adult male northern fur seals, St. Paul Island, 15-20 July 1998.

| Rookery | Tolstoi | Zapadni | Little Zapadni | Zapadni Reef | Gorbatch | Ardiguen | Reef | Total |
|---|---|---|---|---|---|---|---|---|
| Pelage anomalies | 2 | 10 | 1 | 0 | 4 | 0 | 0 | 17 |
| Total counted | 844 | 937 | 311 | 139 | 581 | 73 | 407 | 3,292 |
| Incidence | 0.2% | 1.1% | 0.3% | 0.0% | 0.7% | 0.0% | 0.0% | 0.5% |

Table 32.--Incidence of pelage anomalies in adult female northern fur seals, St. George Island, 23- 26 August 1998.

| Rookery | East Cliffs | | Zapadni | | South | | Total | |
|---|---|---|---|---|---|---|---|---|
| Observer | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 |
| Total females observed with pelage anomalies | 52 | 49 | 12 | 6 | 70 | 49 | 134 | 104 |
| Total females counted | 699 | 919 | 151 | 137 | 953 | 824 | 1803 | 1880 |
| Incidence | 7.4% | 5.2% | 7.9% | 4.4% | 7.3% | 5.9% | 7.4% | 5.5% |

observers during August on three St. George Island rookeries were significantly different ($\chi^2 = 5.50$, $p < 0.05$, $df = 1$) with an average difference of 2.4% between observers.

The incidence of fungal infections on San Miguel Island was dramatically higher than that observed on the Pribilof Islands. Of 42 females ashore during a single survey on San Miguel Island in 1998, 40 (95%) had fungal infections (Table 33). Sixty-five percent of the tagged females (n = 20) and 60% of the tagged males (n = 20) had fungal infections.

The high incidence of fungal infections among northern fur seals on both the Pribilof Islands and San Miguel Island relative to previous years may be related to higher than normal ocean temperatures in the North Pacific Ocean and Bering Sea during 1998. From July 1997 through May 1998, the most severe El Niño conditions in recorded history occurred along the California coast (Lynn et al. 1998). Fungal infections are present in the San Miguel Island population every year but the percentage of animals with pelage anomalies in the population fluctuates annually, and in 1998 a greater percentage of fur seals arrived at San Miguel Island with fungal infections (Melin, personal observation). Similarly, while researchers on the Pribilof Islands have documented the occurrence of fungal infections in the past (Scheffer 1962), the level of incidence observed during the 1998 breeding season has not been seen in recent years.

Table 33.–Tagged northern fur seals observed with fungal infections at San Miguel Island from June-August 1998.

| Sex | Age | Tag | % Fungal Infection | Sex | Age | Tag | % Fungal Infection |
|---|---|---|---|---|---|---|---|
| Male | 3 | A2759 | -- | Male | 7 | C959 | 0 |
| Male | 3 | A2763 | -- | Male | 8 | A1229 | 0 |
| Male | 3 | A3106 | -- | Male | 8 | A1314 | 0 |
| Male | 3 | A3170 | -- | Male | 9 | A1026 | 50 |
| Male | 3 | A3174 | -- | Male | 9 | A1106 | 50 |
| Male | 4 | A2107 | 80 | Male | 9 | A1184 | 10 |
| Male | 4 | A2371 | 0 | Male | 9 | A1263 | -- |
| Male | 4 | A2398 | -- | Male | 9 | A1278 | -- |
| Male | 4 | A2406 | -- | Male | 9 | A957 | 80 |
| Male | 4 | A2465 | -- | Male | 9 | C813 | 0 |
| Male | 4 | A2563 | -- | Male | 10 | A1144 | -- |
| Male | 4 | A2564 | -- | Male | 10 | A1158 | -- |
| Male | 4 | A2575 | -- | Male | 10 | A1178 | -- |
| Male | 4 | A2601 | -- | Male | 10 | A815 | 40 |
| Male | 4 | A2607 | -- | Male | 10 | A888 | 10 |
| Male | 4 | A2631 | -- | Male | 12 | A605 | -- |
| Male | 4 | A2654 | -- | Female | 3 | A2828 | -- |
| Male | 4 | A2683 | -- | Female | 3 | A3129 | -- |
| Male | 5 | A1844 | 90 | Female | 4 | A2220 | 0 |
| Male | 5 | A1950 | 0 | Female | 4 | A2460 | -- |
| Male | 5 | A1977 | 80 | Female | 4 | A2467 | -- |
| Male | 5 | A1999 | 20 | Female | 4 | A2487 | -- |
| Male | 5 | A2012 | 70 | Female | 4 | A2544 | -- |
| Male | 5 | A2114 | -- | Female | 4 | A2592 | -- |
| Male | 5 | A2136 | -- | Female | 4 | A2658 | -- |
| Male | 5 | A2168 | -- | Female | 4 | A2668 | -- |
| Male | 5 | A2205 | -- | Female | 5 | A1836 | 0 |
| Male | 5 | A2227 | -- | Female | 5 | A1841 | 50 |
| Male | 5 | A2252 | -- | Female | 5 | A1973 | 0 |
| Male | 5 | A2264 | -- | Female | 5 | A1992 | 0 |
| Male | 5 | A2360 | -- | Female | 5 | A2011 | 90 |
| Male | 6 | A1706 | 0 | Female | 5 | A2029 | 0 |
| Male | 6 | A1804 | -- | Female | 5 | A2044 | 30 |
| Male | 6 | A1947 | -- | Female | 5 | A2094 | -- |
| Male | 6 | A2062 | -- | Female | 5 | A2098 | -- |
| Male | 7 | A1757 | -- | Female | 5 | A2111 | -- |
| Male | 7 | A1767 | -- | Female | 5 | A2119 | -- |

| Sex | Age | Tag | % Fungal Infection | Sex | Age | Tag | % Fungal Infection |
|---|---|---|---|---|---|---|---|
| Male | 7 | C862 | 0 | Female | 5 | A2149 | -- |
| Male | 7 | C878 | 70 | Female | 5 | A2172 | -- |
| Female | 5 | A2176 | -- | Female | 9 | A1032 | 40 |
| Female | 5 | A2177 | -- | Female | 9 | A1066 | 90 |
| Female | 5 | A2185 | -- | Female | 9 | A1207 | -- |
| Female | 5 | A2204 | -- | Female | 9 | A1226 | -- |
| Female | 5 | A2210 | -- | Female | 9 | A1230 | -- |
| Female | 5 | A2219 | -- | Female | 9 | A1256 | -- |
| Female | 5 | A2323 | -- | Female | 9 | A1390 | -- |
| Female | 5 | A2366 | -- | Female | 9 | A948 | 30 |
| Female | 6 | A1595 | 10 | Female | 10 | A1154 | -- |
| Female | 6 | A1826 | -- | Female | 10 | A804 | 60 |
| Female | 6 | A1849 | -- | Female | 10 | A901 | -- |
| Female | 6 | A1854 | -- | Female | 10 | A939 | -- |
| Female | 6 | A1859 | -- | Female | 10 | C841 | -- |
| Female | 6 | A1869 | -- | Female | 11 | A620 | 80 |
| Female | 6 | A1934 | -- | Female | 11 | A843 | -- |
| Female | 6 | A1976 | -- | Female | 13 | C240 | -- |
| Female | 6 | A1995 | -- | Female | 14 | A507 | – |
| Female | 6 | A2005 | -- | Female | 8 | C869 | -- |
| Female | 6 | A2006 | -- | Female | 8 | C870 | -- |
| Female | 6 | A2034 | -- | Female | 8 | C918 | -- |
| Female | 6 | A2079 | -- | Female | 8 | C960 | -- |
| Female | 6 | A2081 | -- | | | | |
| Female | 7 | A1453 | 0 | | | | |
| Female | 7 | A1542 | -- | | | | |
| Female | 7 | A1648 | -- | | | | |
| Female | 7 | A1691 | -- | | | | |
| Female | 7 | C1026 | 5 | | | | |
| Female | 7 | C1056 | 20 | | | | |
| Female | 7 | C876 | 70 | | | | |
| Female | 7 | C912 | 0 | | | | |
| Female | 8 | A1289 | 30 | | | | |
| Female | 8 | A1419 | -- | | | | |
| Female | 8 | A1474 | -- | | | | |
| Female | 8 | A1496 | -- | | | | |
| Female | 8 | C1024 | -- | | | | |
| Female | 8 | C1029 | -- | | | | |
| Female | 8 | C1035 | -- | | | | |
| Female | 8 | C1079 | -- | | | | |
| Female | 8 | C858 | -- | | | | |

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# CITATIONS

Antonelis, G. A. 1992. Northern fur seal research techniques manual. U.S. Dep. Commer., NOAA Tech. Memo. NMFS F/NWC-214, 47 p.

Antonelis, G. A., R. L. DeLong, and P. J. Gearin. 1989. Population and behavioral studies, San Miguel Island, California (Adams Cove and Castle Rock), P. 35-40. *In* Kajimura, H. (editor). Fur Seal Investigations, 1986. U.S. Dep. Commer., NOAA Tech. Memo. NMFS F/NWC-174.

Arntz, W., W.G. Pearcy, and F. Trillmich. 1991. Biological consequences of the 1982-83 El Niño in the Eastern Pacific, p. 22-44. *In* F. Trillmich and K. Ono (editors). Pinnipeds and El Niño: Responses to environmental stress. Springer-Verlag,New York.

Baker, J. D., G. A. Antonelis, C. W. Fowler, and A. E. York. 1995. Natal site fidelity in northern fur seals, *Callorhinus ursinus*. Anim. Behav. 50 237-247

Bengtson, J. L., C. W. Fowler, H. Kajimura, R. L. Merrick, K. Yoshida , and S. Nomura. 1988. Fur seal entanglement studies: Juvenile male and newly weaned pups, St. Paul Island, Alaska, p. 34-57. *In* P. Kozloff and H. Kajimura (editors), Fur seal investigations, 1985. U.S. Dep. Commer., NOAA Tech. Memo. NMFS F/NWC-146.

Bigg, M. A. 1979. Incidence of adult northern fur seals entangled in debris on St. Paul Island, 1978. Unpubl. manscr. Available from Pacific Biological Station, Nanaimo, British Columbia V9R SK6, Canada. (Background paper submitted to the 22nd Annual meeting of the Standing Scientific Committee, North Pacific Fur Seal Commission, 9-13 April 1979, Washington, DC)

DeLong, R. L. 1982. Population biology of northern fur seals at San Miguel Island, California. Ph.D. Thesis. Univer. of California, Berkeley, CA. 185 p.

DeLong, R. L., and G. A. Antonelis. 1985. Population growth and behavior, San Miguel Island (Adams Cove and Castle Rock), p. 54-60. *In* Kozlof, P. (editor), Fur seal investigations, 1982. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-F/NWC-71.

DeLong, R. L., and G. A. Antonelis. 1991. Impact of the 1982-83 El Niño on the northern fur seal population at San Miguel Island, California, p. 75-83. *In* F. Trillmich and K. Ono (editors.), Pinnipeds and El Niño: Responses to Environmental Stress. Springer-Verlag; Berlin, Heidelberg, N Y.

Delong, R. L., P. Dawson, and P. J. Gearin. 1988. Incidence and impact of entanglement in netting debris on northern fur seal pups and adult females, St. Paul Island, Alaska, p. 58-68. *In* P. Kozloff and H. Kajimura (editors), Fur seal investigations, 1985, U.S. Dep. Commer., NOAA Tech. Memo. NMFS F/NWC-146.

Fowler, C. W. 1987. Marine debris and northern fur seals: a case study. Mar. Poll. Bull. 18:326-335.

Fowler, C. W., and N. Baba. 1991. Entanglement studies, St. Paul Island, 1990; Juvenile male northern fur seals. AFSC Processed Rep. 91-01, 63 p. Alaska Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE, BIN C15700, Seattle WA 98115-0070.

Fowler, C. W., and T. J. Ragen. 1990. Entanglement studies, St. Paul Island, 1989; Juvenile male roundups. NWAFC Processed Rep. 90-06, 39 p. Alaska Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE, BIN C15700, Seattle WA 98115-0070.

Fowler, C. W., R. R. Ream, B. W. Robson, and M. Kiyota. 1992. Entanglement studies, St. Paul Island, 1991; Juvenile male northern fur seals. AFSC Processed Rep. 92-07, 45 p. Alaska Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE, BIN C15700, Seattle WA 98115-0070.

Fowler, C. W., J. D. Baker, R. R. Ream, B.W. Robson, and M. Kiyota. 1993. Entanglement studies, St. Paul Island, 1992; Juvenile male northern fur seals. AFSC Processed Rep. 93-03, 42 p. Alaska Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE, BIN C15700, Seattle WA 98115-0070.

Kiyota, M., and C. W. Fowler. 1994. Surveys of entanglement among adult female northern fur seals, 1991-1992, p. 90-99. *In* E. H. Sinclair (editor), Fur seal investigations, 1992. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-145.

Kozloff, P., A. E. York, and J. Scordino. 1986. Population assessment, Pribilof Islands, Alaska, p. 6-15. *In* P. Kozloff (editor), Fur seal investigations, 1984. Dep. Commer., NOAA Tech. Memo. NMFS F/NWC-97.

Loughlin, T. R., G. A. Antonelis, J. D. Baker, A. E. York, C. W. Fowler, R. L. DeLong, and H. W. Braham. 1994. Status of the northern fur seal population in the United States during 1992, p. 9-28. *In* E. H. Sinclair (editors), Fur seal investigations, 1992. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-45.

Lynn, R.J., T. Baumgartner, J. Garcia, C.A. collins, T.L. Hayward, K.D. Hyrenbach, A.W. Mantyla, T. Murphree, A. Shankle, F.B. Schwing, K.M. Sakuma, and M.J. Tegner. 1998. The state of the California Current, 1997-1998: Transition to El Niño conditions. Cal. Coop. Oceanic Fish. Invest. Rep. 39: 25-49.

Melin, S. R., and R. L. DeLong. 1994. Population monitoring of northern fur seals on San Miguel Island, California, p. 137-141, *In* E. H Sinclair,. (editor), Fur seal investigations, 1992. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-45.

Melin, S. R., R. L. DeLong, and J. R. Thomason. 1996. Population monitoring studies of northern fur seals at San Miguel Island, California, p. 83-102. *In* E. H. Sinclair, (editor). Fur seal investigations, 1994. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-69.

Norton, J., D. McLain, R. Brainard, and D. Husby. 1985. The 1982-83 El Niño event off Baja and Alta California and its ocean climate context. *In* Wooster, W.S. and D. L. Fluharty (editors), El Niño North: Niño effects in the Eastern Subarctic Pacific Ocean. Washington Sea Grant, Seattle, Washington. 312 p.

Robson, B. W., G. A. Antonelis, and J. L. Laake. 1994. Assessment of measurement error in weights and lengths of northern fur seal pups in 1992, p.34-45. *In* E. H. Sinclair (editor), Fur seal investigations, 1993. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-46.

Robson, B. W., M. T. Williams, M. Kiyota, G. E. Merculief, and C. M. Stepetin. 1997a. Northern fur seal entanglement studies: St. Paul and St. George Islands, 1996, p. 29-56. *In* E. H. Sinclair, (editor), Fur seal investigations, 1996. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-87.

Robson, B. W., M. T. Williams, G. A. Antonelis, M. Kiyota, A L. Hanson Sr., and G. Merculief. 1997b. Northern fur seal entanglement studies: St. Paul and St. George Islands, 1995, p.

15-43. *In* E. H. Sinclair (editor), Fur seal investigations, 1995. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-86.

Robson, B. W., R.G. Towell, M. Kiyota, C. M. Stepetin, and G. E. Merculief. 1999. Northern fur seal entanglement studies: St. Paul and St. George Islands, 1997, p. 33-54. *In* E. H. Sinclair and B.W. Robson, (editors), Fur seal investigations, 1997. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-106.

Scheffer, V. B. 1962. Pelage and surface topography of the northern fur seal. U. S. Fish Wildl. Serv. N. Am. Fauna No. 64. 206 p.

Scordino, J. 1985. Studies on fur seal entanglement, 1981-1984, St. Paul Island, Alaska., p. 278-290. *In* R. S. Shomura and H. O. Yoshida (editors), Proceedings of the workshop on the fate and impact of marine debris, 26-29 November 1984, Honolulu, Hawaii, U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFC-54.

Scordino, J., and R. Fisher. 1983. Investigations on fur seal entanglement in net fragments, plastic bands and other debris in 1981 and 1982, St. Paul Island, Alaska. Unpubl. manuscr., US-8. *In* Background paper submitted to the 26th Annual Meeting of the Standing Scientific Committee of the North Pacific Fur Seal Commission, 28 March-8 April 1983, Washington D.C., 90 p. Available Natl. Mar. Mammal Lab., Alaska Fish.

Sci. Cent., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE, BIN C15700, Seattle WA 98115-0070.

Sinclair, E. H., and B.W. Robson. 1999. Fur seal investigations, 1997. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-106.

Snedecor, G. W., and W. G. Cochran. 1980. Statistical Methods, 7th ed. Ames, Iowa. Iowa State University Press.

Towell, R. G., G. A. Antonelis, A. E. York, and B. W. Robson. 1997. Mass, length, and sex ratios of northern fur seal pups on St. Paul and St. George Islands, 1995, p. 45-64. *In* E. H. Sinclair (editor), Fur seal investigations, 1995. U. S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-86.

Towell, R. G., G. A. Antonelis, A. E. York, B. W. Robson, and M. T. Williams. 1996. Mass, length, and sexratios of northern fur seal pups on St. Paul and St. George Islands, 1992-1994, p. 47-70. *In* E. H. Sinclair (editor), Fur seal investigations, 1994. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-69.

Towell, R. G., G. A. Antonelis, A. E. York, and B. W. Robson. 1997. Mass, length, and sex ratios of northern fur seal pups on St. Paul and St. George Islands, 1995, p. 45-64. *In* E.

H. Sinclair (editor), Fur seal investigations, 1995. U. S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-86.

Trites, A. W., and P. A. Larkin. 1989. The decline and fall of the Pribilof fur seal (*Callorhinus ursinus*): A simulation study. Can. J. Fish. Aquat. Sci. 46:1437-1445.

Vedros, N. A., J. Quinlivan, and R. Cranford. 1982. Bacterial and fungal flora of wild northern fur seals (*Callorhinus ursinus*). J. Wildl. Dis. 18:447-456.

York A. E., and G. A. Antonelis, 1990. Weights and sex ratios of northern fur seal pups, 1989, p. 22-32. *In* E. H. Sinclair (editor.), Fur seal investigations, 1991. U.S. Dep. Commer. NOAA Tech. Memo. NMFS F/NWC-190.

York, A. E., and P. Kozloff. 1987. On the estimation of numbers of northern fur seal, *Callorhinus ursinus*, pups born on St. Paul Island, 1980-86. Fish. Bull., U.S. 85:367-375.

York A. E., and R. G. Towell. 1993. Weights and sex ratios of northern fur seal pups, 1990, p. 38-60. *In* E. H. Sinclair (editor), Fur seal investigations, 1991. U.S. Dep. Commer. NOAA Tech. Memo. NMFS-AFSC-24.

York, A. E., and R. G. Towell. 1996. New sampling design for estimating numbers of fur seal pups on the Pribilof Islands, p. 31-46. *In* E. H. Sinclair (editor), Fur seal investigations, 1994. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-69.

York, A. E., and R. Towell. 1997. Can we return to estimating numbers of northern fur seals from subsamples of rookeries?, p. 77-98. *In* E. H. Sinclair (editor), Fur seal investigations 1995. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-86.

# 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. Males included in this count are approximatley 7 years of age and older. |
| Drive | The act of surrounding and moving groups of seals from one location to another. |
| Hauling ground | An area, usually near a rookery, on which nonbreeding seals congregate. See "Rookery." |
| Haul out | The act of seals moving from the sea onto shore at either a rookery or hauling ground. |
| Kleptogyny | The act of an adult male seal (primarily Classes 1,2, or 3) seizing an adult female from another male's territory. |
| Known-age | Refers to a seal whose age is known because the animal bears an inscribed tag or other type of mark. |
| Marked | Describes a seal that has been marked by attaching an inscribed metal or plastic tag to one or more of its flippers, by hair clipping, or by bleaching. |

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

# APPENDIX B

Tabulations of northern fur seal adults and pups counted by rookery, size class, and rookery section during population assessment.

Page

Table B-1.--Number of adult male northern fur seals counted, by class[a] and rookery section, St. Paul Island, Alaska, 15-20 July 1998. A dash indicates no section.

| Rookery | Section | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| class of | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | Total |
| Lukanin | | | | | | | | | | | | | | | |
| 2 | 31 | 19 | - | - | - | - | - | - | - | - | - | - | - | - | 50 |
| 3 | 81 | 72 | - | - | - | - | - | - | - | - | - | - | - | - | 153 |
| 5 | 105 | 14 | - | - | - | - | - | - | - | - | - | - | - | - | 119 |
| Kitovi[b] | | | | | | | | | | | | | | | |
| 2 | 20 (9) | 7 | 29 | 28 | 27 | - | - | - | - | - | - | - | - | - | 120 |
| 3 | 38 (17) | 19 | 50 | 72 | 52 | - | - | - | - | - | - | - | - | - | 248 |
| 5 | 13 (47) | 13 | 28 | 16 | 127 | - | - | - | - | - | - | - | - | - | 244 |
| Reef[c] | | | | | | | | | | | | | | | |
| 2 | 20 | 27 | 61 | | 24 | 40 | 9 | 32 | 16 | 15 | 3 | - | - | - | 247 |
| 3 | 52 | 87 | 122 | | 46 | 63 | 13 | 72 | 57 | 31 | 6 | - | - | - | 549 |
| 5 | 22 | 44 | 75 | | 78 | 27 | 55 | 30 | 15 | 49 | 128 | - | - | - | 523 |
| Gorbatch | | | | | | | | | | | | | | | |
| 2 | 37 | 26 | 34 | 8 | 20 | 33 | - | - | - | - | - | - | - | - | 158 |
| 3 | 91 | 84 | 99 | 10 | 46 | 75 | - | - | - | - | - | - | - | - | 405 |
| 5 | 598 | 36 | 37 | 81 | 17 | 19 | - | - | - | - | - | - | - | - | 788 |
| Ardiguen | | | | | | | | | | | | | | | |
| 2 | 19 | - | - | - | - | - | - | - | - | - | - | - | - | - | 16 |
| 3 | 72 | - | - | - | - | - | - | - | - | - | - | - | - | - | 72 |
| 5 | 33 | - | - | - | - | - | - | - | - | - | - | - | - | - | 33 |
| Morjovi[d] | | | | | | | | | | | | | | | |
| 2 | 39 (27) | 35 | 31 | 25 | 43 | 23 | - | - | - | - | - | - | - | - | 223 |
| 3 | 38 (27) | 52 | 56 | 27 | 81 | 46 | - | - | - | - | - | - | - | - | 327 |
| 5 | 276 (33) | 30 | 43 | 20 | 26 | 108 | - | - | - | - | - | - | - | - | 536 |
| Vostochni | | | | | | | | | | | | | | | |
| 2 | 23 | 15 | 21 | 23 | 18 | 46 | 33 | 34 | 29 | 4 | 15 | 22 | 48 | 32 | 363 |
| 3 | 47 | 22 | 39 | 52 | 40 | 115 | 46 | 75 | 32 | 32 | 36 | 49 | 143 | 87 | 815 |
| 5 | 8 | 46 | 8 | 116 | 237 | 64 | 17 | 15 | 23 | 17 | 8 | 120 | 132 | 134 | 945 |
| Little Polovina | | | | | | | | | | | | | | | |
| 2 | 5 | - | - | - | - | - | - | - | - | - | - | - | - | - | 5 |
| 3 | 5 | - | - | - | - | - | - | - | - | - | - | - | - | - | 5 |
| 5 | 350 | - | - | - | - | - | - | - | - | - | - | - | - | - | 350 |
| Polovina | | | | | | | | | | | | | | | |
| 2 | 35 | 16 | - | - | - | - | - | - | - | - | - | - | - | - | 51 |
| 3 | 51 | 25 | - | - | - | - | - | - | - | - | - | - | - | - | 76 |
| 5 | 197 | 29 | - | - | - | - | - | - | - | - | - | - | - | - | 226 |
| Polovina Cliffs | | | | | | | | | | | | | | | |
| 2 | 27 | 14 | 7 | 20 | 19 | 39 | 27 | - | - | - | - | - | - | - | 153 |
| 3 | 52 | 38 | 36 | 71 | 59 | 90 | 128 | - | - | - | - | - | - | - | 474 |
| 5 | 87 | 26 | 9 | 24 | 32 | 56 | 27 | - | - | - | - | - | - | - | 261 |
| Tolstoi | | | | | | | | | | | | | | | |
| 2 | 33 | 26 | 12 | 34 | 28 | 50 | 43 | 43 | - | - | - | - | - | - | 269 |
| 3 | 49 | 48 | 56 | 78 | 76 | 119 | 65 | 58 | - | - | - | - | - | - | 549 |
| 5 | 12 | 13 | 15 | 22 | 23 | 47 | 42 | 729 | - | - | - | - | - | - | 903 |
| Zapadni Reef | | | | | | | | | | | | | | | |
| 2 | 58 | 18 | - | - | - | - | - | - | - | - | - | - | - | - | 76 |
| 3 | 129 | 41 | - | - | - | - | - | - | - | - | - | - | - | - | 170 |
| 5 | 103 | 150 | - | - | - | - | - | - | - | - | - | - | - | - | 253 |
| Little Zapadni | | | | | | | | | | | | | | | |
| 2 | 5 | 11 | 24 | 36 | 27 | 21 | - | - | - | - | - | - | - | - | 124 |
| 3 | 15 | 54 | 63 | 75 | 84 | 68 | - | - | - | - | - | - | - | - | 359 |
| 5 | 43 | 29 | 25 | 36 | 37 | 199 | - | - | - | - | - | - | - | - | 369 |
| Zapadni | | | | | | | | | | | | | | | |
| 2 | 23 | 38 | 47 | 53 | 34 | 46 | 46 | 7 | - | - | - | - | - | - | 294 |
| 3 | 47 | 57 | 88 | 88 | 72 | 108 | 81 | 19 | - | - | - | - | - | - | 560 |
| 5 | 160 | 37 | 33 | 33 | 51 | 73 | 33 | 277 | - | - | - | - | - | - | 697 |

[a] See Glossary for a description of the classes of adult male seals.
[b] Numbers in parentheses are the adult males counted in Kitovi Amphitheater.
[c] Sections 3 and 4 were combined due to the absence of a section marker.
[d] Numbers in parentheses are the adult males counted on the second point south of Sea Lion Neck.

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 Island, Alaska, 1972-1998. A dash indicates no data.

| | St. Paul | | | | | | St. George | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | Harem Bulls | Idle Bulls | Pups Born | SD | Rookeries Sampled (n) | Dead Pups | Harem Bulls | Idle Bulls | Pups Born | SD | Rookeries Sampled | 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 | 8,620 | 14 | 20,625 | 877 | 1,427 | -- | -- | -- | 3,289 |
| 1976 | 5,324 | 4,041 | 291,000 | 11,108 | 2 | 23,676 | 1,093 | 996 | -- | -- | -- | 2,289 |
| 1977 | 6,457 | 3,845 | -- | -- | -- | 14,083 | 1,610 | 899 | 43,407 | 748 | 6 | 1,208 |
| 1978 | 6,496 | 3,908 | -- | -- | -- | 8,073 | 1,590 | 1,220 | 47,248 | 1,009 | 6 | 2,518 |
| 1979 | 6,242 | 4,457 | 245,932 | 9,464 | 14 | 6,444 | 1,716 | 1,942 | -- | -- | -- | 2,191 |
| 1980 | 5,490 | 4,248 | 203,825 | 11,672 | 4 | 7,859 | 1,563 | 1,795 | -- | -- | -- | 2,385 |
| 1981 | 5,120 | 4,003 | 179,444 | 5,876 | 4 | 6,798 | 1,472 | 1,646 | 38,152 | 1,581 | 6 | 2,025 |
| 1982 | 5,767 | 4,009 | 203,581 | 3,482 | 4 | 7,301 | 1,410 | 1,319 | -- | -- | -- | 1,600 |
| 1983 | 4,827 | 4,242 | 165,941 | 6,034 | 4 | 5,997 | -- | -- | 31,440 | 2,930 | 6 | 903 |
| 1984 | 4,803 | 3,977 | 173,274 | 8,117 | 5 | 6,115 | 1,473 | 1,452 | -- | -- | -- | -- |
| 1985 | 4,372 | 3,363 | 182,258 | 7,997 | 7 | 5,266 | 1,268 | 1,601 | 28,869 | 2,297 | 6 | 806 |
| 1986 | 4,603 | 1,865 | 167,656 | 5,086 | 4 | 7,771 | 1,394 | 1,342 | -- | -- | -- | -- |
| 1987 | 3,636 | 1,892 | 171,610 | 3,218 | 13 | 7,757 | 1,303 | 1,283 | -- | -- | -- | -- |
| 1988 | 3,585 | 3,201 | 202,229 | 3,751 | 4 | 7,272 | 1,259 | 1,258 | 24,820 | 827 | 6 | 1,212 |
| 1989 | 4,297 | 6,400 | 171,534 | 25,867 | 4 | 9,096 | 1,241 | 1,163 | -- | -- | -- | -- |
| 1990 | 4,430 | 7,629 | 201,305 | 3,724 | 13 | 9,128 | 909 | 1,666 | 23,397 | 2,054 | 6 | 928 |
| 1991 | 4,729 | 9,453 | -- | -- | -- | -- | 736 | 1,271 | -- | -- | -- | -- |
| 1992 | 5,460 | 10,940 | 182,437 | 8,918 | 13 | 8,525 | 1,029 | 1,834 | 25,160 | 707 | 6 | 806 |
| 1993 | 6,405 | 9,301 | -- | -- | -- | -- | 1,123 | 1,422 | -- | -- | -- | -- |
| 1994 | 5,715 | 10,014 | 192,104 | 2,029 | 13 | 8,180 | 1,179 | 1,481 | 22,244 | 410 | 6 | 788 |
| 1995 | 5,154 | 8,459 | -- | -- | -- | -- | 1,242 | 1,054 | -- | -- | -- | -- |
| 1996 | 5,643 | 9,239 | 170,125 | 21,244 | 6 | 6,837* | 1,248 | 790 | 27,385 | 294 | 6 | 719 |
| 1997 | 5,064 | 8,560 | -- | -- | -- | -- | 910 | 1,474 | -- | -- | -- | -- |
| 1998 | 4,762 | 8,396 | 179,149 | 6,193 | 7 | 5,058* | 1,116 | 1,084 | 22,090 | 222 | 6 | 452 |

* Dead pups for the entire Island are estimated from the mortality rate on sampled rookeries.

Table B-3.-- Number of northern fur seal pups sheared on each sampled rookery of St. Paul Island, Alaska, 1998.

| | Section | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rookery | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | Total |
| Lukanin | 242 | 250 | | | | | | | | | | | | | 492 |
| Reef [a] | 230 | 338 | 535 | | 174 | 277 | 45 | 312 | 240 | 154 | 19 | | | | 2,324 |
| Gorbatch | 351 | 322 | 379 | 32 | 173 | 292 | | | | | | | | | 1,549 |
| Ardiguen | 270 | | | | | | | | | | | | | | 270 |
| Morjovi [b] | 289 | 214 | 235 | 109 | 367 | 191 | | | | | | | | | 1,405 |
| Polovina | 175 | 119 | | | | | | | | | | | | | 294 |
| Zapadni | 204 | 255 | 390 | 400 | 346 | 499 | 352 | 110 | | | | | | | 2,556 |
| Total | | | | | | | | | | | | | | | 8,890 |

[a] Sections 4 and 5 were combined due to loss of the section break marker.
[b] Section 1 of Morjovi includes pups sheared at Sea Lion Neck.

Table B-4.-- Number of dead northern fur seal pups counted by section on the sampled rookeries of St. Paul Island, Alaska, 1998

| Rookery | Date | Section | | | | | | | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 necropsies | |
| Lukanin | 8/18 | 82 | 93 | | | | | | | | | | | | | 175 |
| Reef [a] | 8/21 | 38 | 105 | 133 | | 32 | 72 | 2 | 57 | 30 | 21 | 6 | | | 61 | 557 |
| Gorbatch | 8/21 | 118 | 101 | 118 | 4 | 37 | 42 | | | | | | | | | 420 |
| Ardiguen | 8/21 | 38 | | | | | | | | | | | | | | 38 |
| Morjovi [b] | 8/19 | 70 | 40 | 21 | 30 | 16 | 42 | | | | | | | | | 219 |
| Polovinai | 8/19 | 41 | 15 | | | | | | | | | | | | | 56 |
| Zapadni | 8/20 | 24 | 101 | 120 | 162 | 78 | 148 | 131 | 29 | | | | | | | 793 |
| Total | | | | | | | | | | | | | | | | 2258 |

[a] Section 4 and 5 were combined.
[b] Section 1 includes dead pups counted at Sea Lion Neck.

Table B-5.-- Number of norther fur seal pups sheared on each rookery of St. George Island, Alaska, 1998.

| Rookery | Section 1 | 2 | 3 | 4 | 5 | Total |
|---|---|---|---|---|---|---|
| South | 244 | 155 | 185 | | | 584 |
| North | 174 | 246 | 376 | 204 | 97 | 1,097 |
| East Reef | 176 | | | | | 176 |
| East Cliffs | 314 | 194 | | | | 508 |
| Staraya Artil * | 301 | | | | | 301 |
| Zapadni* | 326 | | 152 | | | 478 |
| Total | | | | | | 3,144 |

* Sections 1 and 2 were treated as one section for the allocation of shear marks.

Table B-6.-- Number of dead northern fur seal pups counted by section on the rookeries of St. George Island, Alaska, 1998. Numbers in parenthesis are combined counts of dead sheared and individually marked animals. These numbers are included in section totals.

| Rookery | Date | Section | | | | | Total |
|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | |
| South | 8/18 | 29 | 18 | 9 | | | 56 |
| North | 8/20 | 33(1) | 33 | 44(1) | 10 | 22 | 142 |
| East Reef | 8/19 | 15 | | | | | 15 |
| East Cliffs | 8/19 | 95 | 29(3) | | | | 124 |
| Staraya Artil[a] | 8/21 | 46 | | | | | 46 |
| Zapadni[b] | 8/18 | 54 | | 15 | | | 69 |
| Total | | | | | | | 452 |

[a] Dead pups were not counted by section on Staraya Artil.
[b] Sections 1 and 2 were combined.

Table B-7.-- Number of dead northern fur seals counted that were older than pup, Pribilof Islands, Alaska, 1965-98. Teeth (usually canines) were collected from most of these seals. A 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 |
| 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 |
| 1996 | 20[e] | 92[e] | 3 | 20[f] | 23 | 112[f] |
| 1998[g] | - | - | - | - | - | - |

[a] A total of 70 dead adult fur seals of both sexes were counted on the rookeries of St. George Island.
[b] Includes 10 dead adult fur seals of unknown sex.
[c] Includes 16 dead adult fur seals of unknown sex.
[d] Includes 2 dead adult fur seals of unknown sex.
[e] Counts mode only on the 6 sample rookeries where dead pups were counted.
[f] Includes 16 dead adult fur seals of unknown sex.
[g] A total of 108 dead adults were counted on St. Paul Island and 34 dead adults were counted on St. George Island.

# APPENDIX C

Scientific staff engaged in northern fur seal
field research in 1998

National Marine Mammal Laboratory
Douglas P. DeMaster, Director
Thomas R. Loughlin, Leader, Alaska Ecosystem Program
Elizabeth H. Sinclair, Northern Fur Seal Program

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

Appendix C.-- continued.

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

Appendix C.-- continued

Affiliation Code

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

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AFSC-

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110 HILL, P. S., and D. P. DEMASTER. 1999. Alaska marine mammal stock assessments, 1999, 166 p. NTIS PB2000-102844.

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106 SINCLAIR, E.H., and B. W. ROBSON. (editors). 1999. Fur seal investigations, 1997, 111 p. NTIS No. PB2000-100223.

105 MURPHY, J. M., A. L. J. BRASE, and J. A. ORSI. 1999. Survey of juvenile Pacific salmon in the northern region of southeastern Alaska, May-October 1997, 40 p. NTIS No. PB99-175630.

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102 BUCKLEY, T. W., G. E. TYLER, D. M. SMITH, and P. A. LIVINGSTON. 1999. Food habits of some commercially important groundfish off the coasts of California, Oregon, Washington, and British Columbia, 173 p. NTIS No. PB99-166563.

101 MCELDERRY, H., W. A. KARP, J. TWOMEY, M. MERKLEIN, V. CORNISH, and M. SAUNDERS. 1999. Proceedings of the first biennial Canada/U.S. observer program workshop, 113 p. NTIS No. PB99-146482.

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99 SEASE, J. L., J. M. STRICK, R. L. MERRICK, and J. P. LEWIS. 1999. Aerial and land-based surveys of Steller sea lions (Eumetopias jubatus) in Alaska, June and July 1996, 43 p. NTIS No. PB99-134462.

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