NOAA Technical Memorandum NMFS-AFSC-2

Fur Seal Investigations, 1990

by
Hiroshi Kajimura and
Elizabeth Sinclair

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

June 1992

NOAA Technical Memorandum NMFS

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This document should be cited as follows:

Kajimura, H., and E. Sinclair. (editors). 1992. Fur Seal Investigations, 1990. U.S. Dep. Commer. NOAA Tech. Memo. NMFS-AFSC-2, 192 p.

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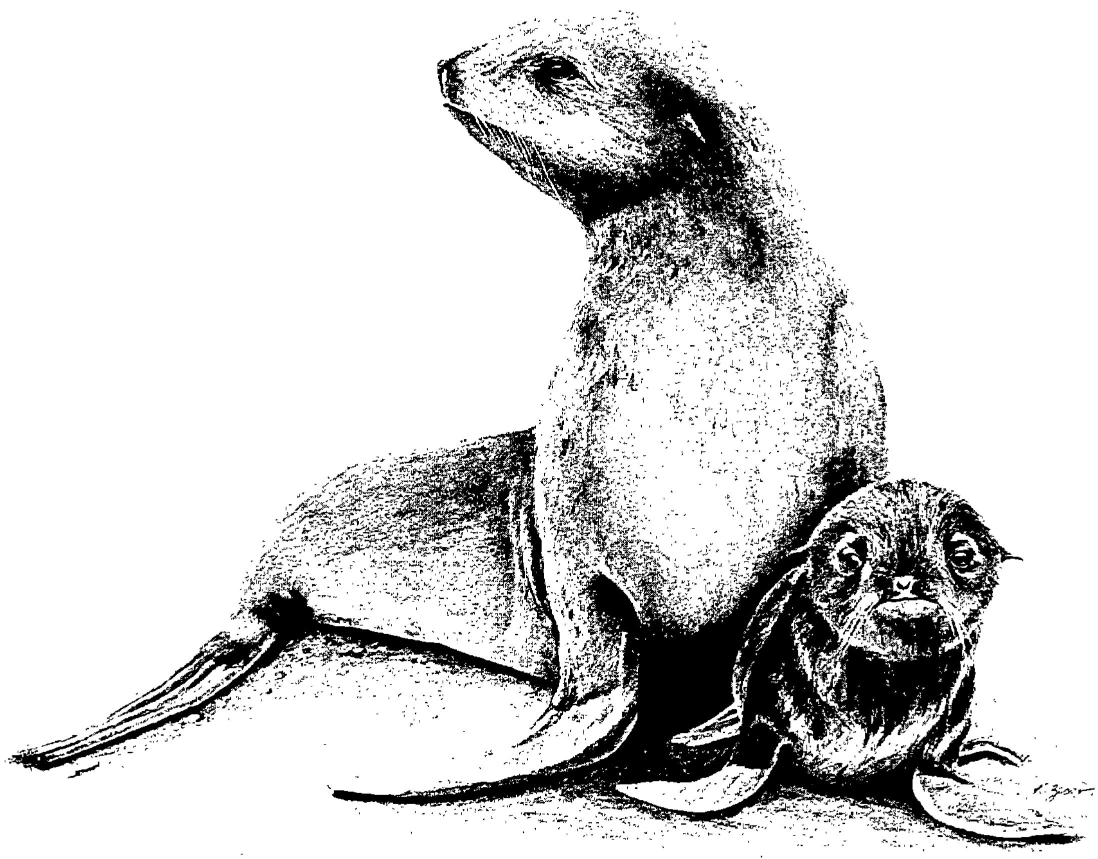

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ABSTRACT

During 1990, the National Marine Mammal Laboratory's program on the northern fur seal (Callorhinus ursinus) included investigations on the Pribilof Islands, Bogoslof Island, San Miguel Island and nearby Castle Rock off the southern California coast, and Medny Island (U.S.S.R.). This report is a collection of papers resulting from 1990 fur seal research.

Northern fur seal research on the Pribilof Islands was conducted from 1 July through 1 September 1990. Censuses of adult males were conducted on all rookeries of St. Paul and St. George Islands and Sea Lion Rock in mid-July of 1990. Harem bull counts on St. Paul Island were 3.1% higher in 1990 than in 1989. On St. George Island, harem bull counts decreased 3.6% between 1989 and 1990. The number of animals on St. George Island comprise approximately 10% of the Pribilof Island population. Pup abundance was estimated by the shearing-sampling method during August and dead pups were counted on all rookeries (except Little Polovina) on St. Paul and St. George Islands and for the first time on Sea Lion Rock.

Approximately 201,305 (SD = 3,724) pups were born on St. Paul Island in 1990, a number not significantly different from the estimates of the 1988 and 1989 year classes. The estimate of the number of pups born on St. George Island in 1990 is 23,397 (SD = 2,054); this estimate is not significantly different from the number of pups born on St. George Island in 1988 (24,820),

nor is it significantly different from the predicted number of pups to be born based on the 1973-88 data, which indicated a 5.9% decline. On Sea Lion Rock, we estimated that 10,217 (SD = 568) pups were born.

A preliminary assessment of potential noise impacts on northern fur seals was conducted. Of primary concern were direct noise sources, such as airplanes, off-road vehicles, ship traffic, and construction activities.

Information on tag resights and weights of 2- and 3-year-old male northern fur seals was collected on St. Paul Island during roundups in July and August 1990. A total of 56 and 319 tag resights were obtained for males 2 and 3 years of age, respectively. Males tended to return to their rookeries of birth. Within a cohort, weights of tagged males had no influence on haul-out patterns of individuals. Although 2- and 3-year-old males lost weight during their time on land, intermittent foraging trips throughout the summer probably resulted in a net increase in growth. Individual male weight data also indicated that weight as pups was correlated to weight at 2 and 3 years of age.

Primary enteric pathogens do not appear to infect significant numbers of pups on the Pribilof (St. Paul and St. George) Islands or Medny Island. Opportunistic pathogens were found in all pups tested from each island, and the most frequently isolated organisms were nonhemolytic *Escherichia coli*, and *Citrobacter*, *Proteus*, and *Enterobacter* spp.

Beach surveys were conducted on two sites on St. Paul Island during 1990 to determine the accumulation of beach debris. The accumulation of beach debris on the Pribilof Islands has decreased among most categories of debris found since 1983. However, plastic banding material increased at Northeast Point during 1990.

A census conducted on Bogoslof Island on 24 July 1990 counted a total of 1,473 northern fur seals including 44 territorial males, 951 nonterritorial males, 295 females, 181 live pups, and 2 dead pups.

Research was carried out on San Miguel Island and nearby Castle Rock off the southern California coast intermittently from June through December 1990. At Adams Cove, San Miguel Island, there were 68 adult northern fur seal males defending territories that contained females and pups and an additional 8 solitary adult males defending territories. This is the largest number of territorial males recorded during a breeding season. PUP abundance at Adams Cove on 27 July was 1,137 live and 12 dead and counts on Castle Rock on 29 July yielded 634 live and 14 dead PUPS- Two hundred northern fur seal pups were tagged on 23 September in Adams Cove. California sea lion (Zalophus californianus) X northern fur seal hybrid pups were again observed on San Miguel Island.

Three U.S. biologists conducted northern fur seal research on Medny Island (U.S.S.R.) from 19 July through 28 August 1990 to examine the possible relationship between the continental shelf and the 1956-81 decline in population abundance in the Pribilof Islands. Data collected included frequency and duration of trips by female fur seals to sea, depth and location of diving, milk fat content, quantity of milk delivered to the pup, attendance patterns of females, pup growth rates, diet, and bacterial pathogens of fur seal pups.

Juvenile fur seals from 122 roundups were sources of data for estimates of entanglement-caused mortality and entanglement rates. The proportion of juvenile males observed entangled in 1990 was 0.33%. This rate reflects the continued reduction in the numbers of animals entangled in fragments of trawl webbing. The frequency of occurrence of trawl webbing among the entangling debris remains about one-half that of the former levels, whereas the proportion of seals entangled in other types of debris did not change. The observed proportion of fur seals entangled in 1990 was similar to that observed during 1988 and 1989, continuing at a rate that is lower than the rate recorded for the last few years of the commercial harvest and roundups through 1986.

These entanglement studies confirm earlier estimates indicating that after 1 year, seals entangled in small debris (light enough to permit the animals to return to land) are reduced in numbers to about one-half the comparable numbers for unentangled seals. Rates at which entangled animals are resighted indicate that mortality of entangled seals increases with the size (weight) of debris. Data collected on the extent of wounds caused by entangling debris show that wounds tend to grow, some encompassing the entire neck within 1 year's time, and contribute to the sources of mortality for seals entangled in small debris.

The 1990 studies suggest the rate of return of tagged seals from which debris is removed is significantly higher than for tagged seals on which entangling debris was left.

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CONTENTS

INTRODUCTION

by

Hiroshi Kajimura

This report summarizes the research carried out by scientists from the National Marine Mammal Laboratory (NMML) at four northern fur seal (*Callorhinus ursinus*) breeding sites during 1990. Two of the sites are major fur seal breeding colonies consisting of about 800,000 animals and are located on the Pribilof Islands in the eastern Bering Sea (Figs. 1 and 2). The third site is a small colony of about 1,400 fur seals on Bogoslof Island in the southeastern Bering Sea (Fig. 3). The fourth site is on San Miguel Island, California, and nearby Castle Rock (Fig. 4) where the breeding population of northern fur seals averages approximately 4,000 animals.

The NMML scientists have conducted annual surveys and studies of northern fur seals on these islands under terms of the Interim Convention on the Conservation of North Pacific Fur Seals since 1958. Although this Interim Convention lapsed in October 1984, studies have been continued annually by the former member nations.

In 1990, the United States and Japan cooperatively carried out research on the northern fur seal. Two Japanese scientists from the National Research Institute of Far Seas Fisheries Research assisted in conducting entanglement-related studies on St. Paul Island and in conducting a census of northern fur seals on Bogoslof Island.

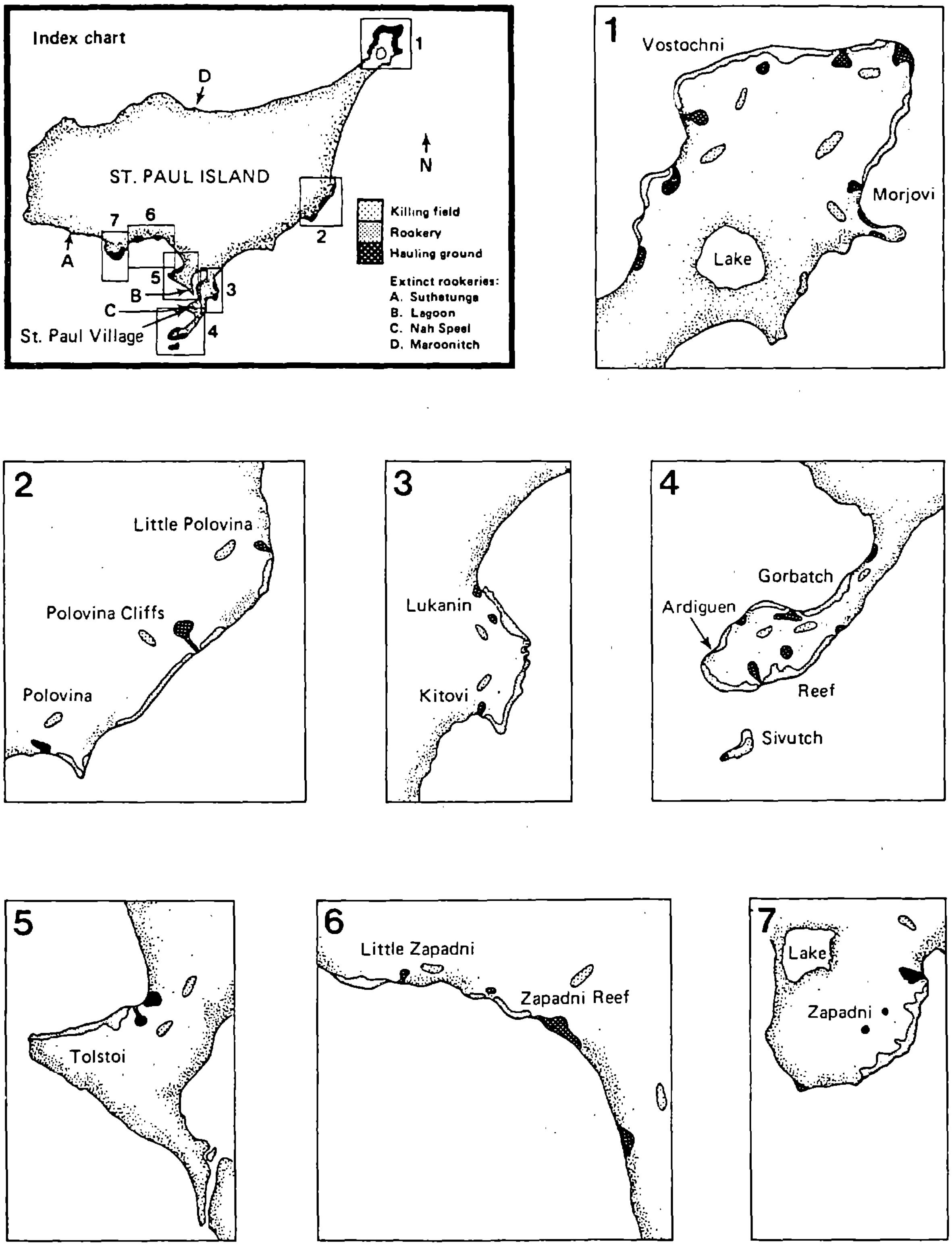

Figure 1.--Location of northern fur seal rookeries (present and extinct), hauling grounds, and harvesting areas, St. Paul Island, Alaska.

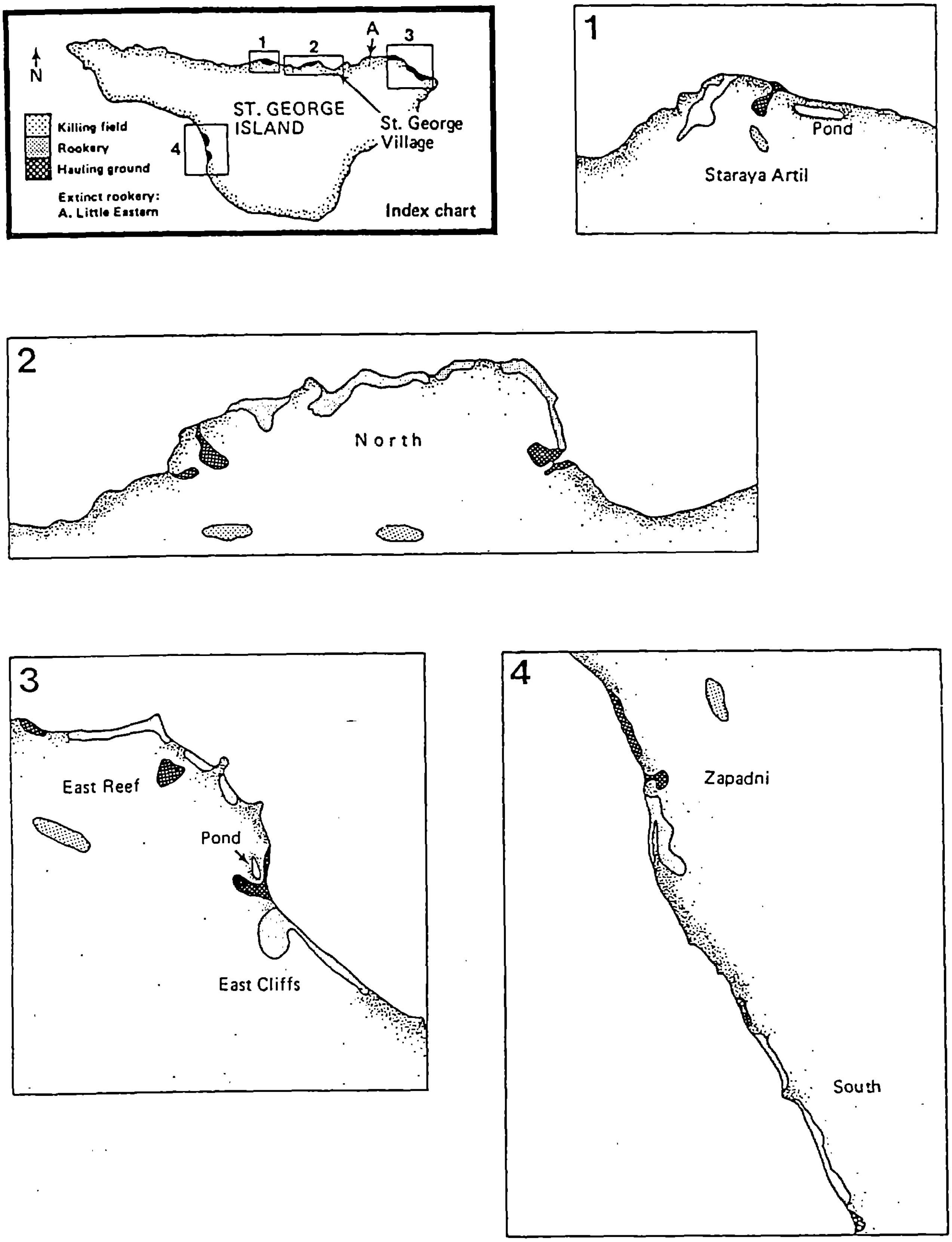

Figure 2.--Location of northern fur seal rookeries (present and extinct), hauling grounds, and harvesting areas, St. George Island, Alaska.

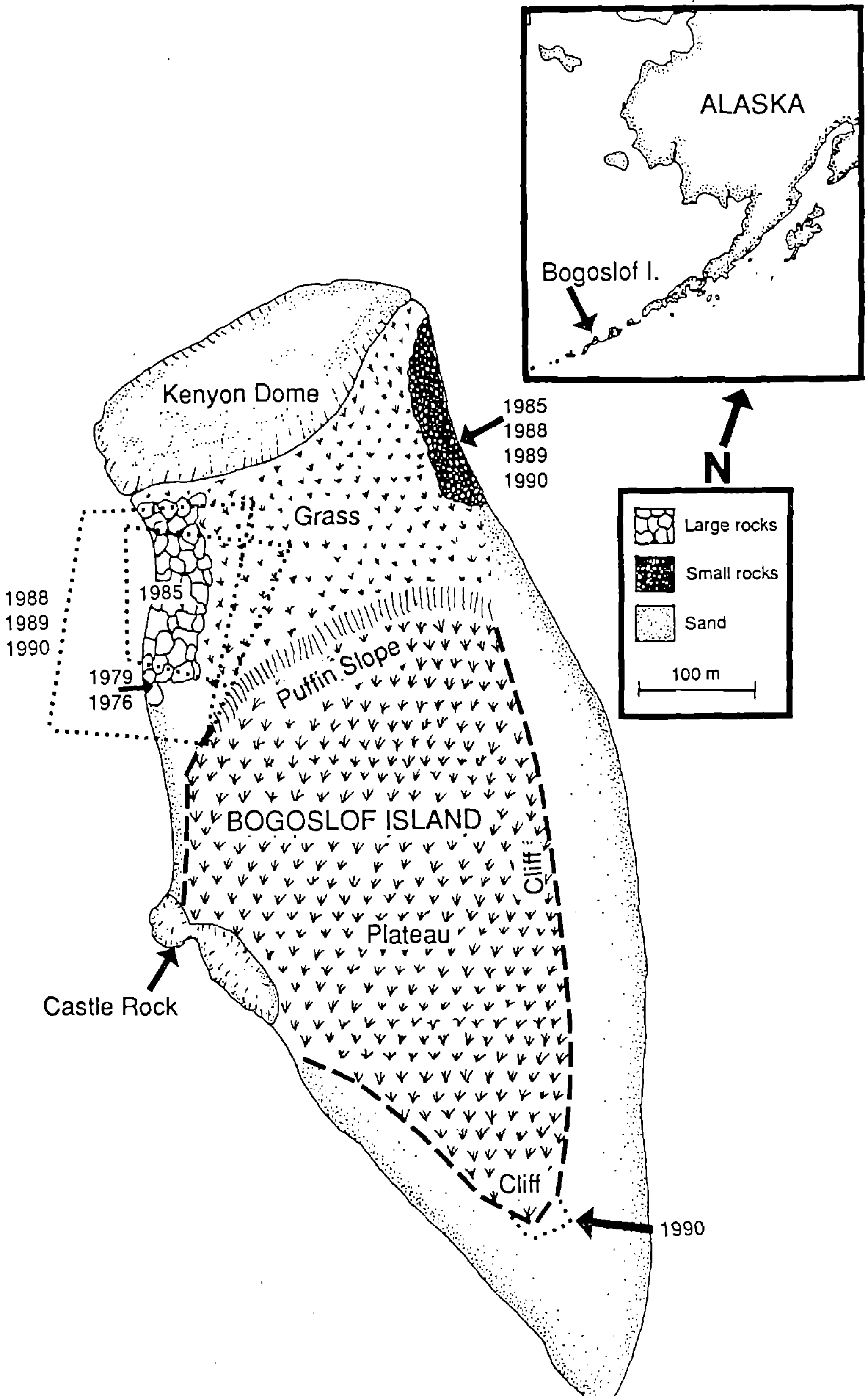

Figure 3.-- Location of fur seals on Bogoslof Island, Alaska indicated by year of observations.

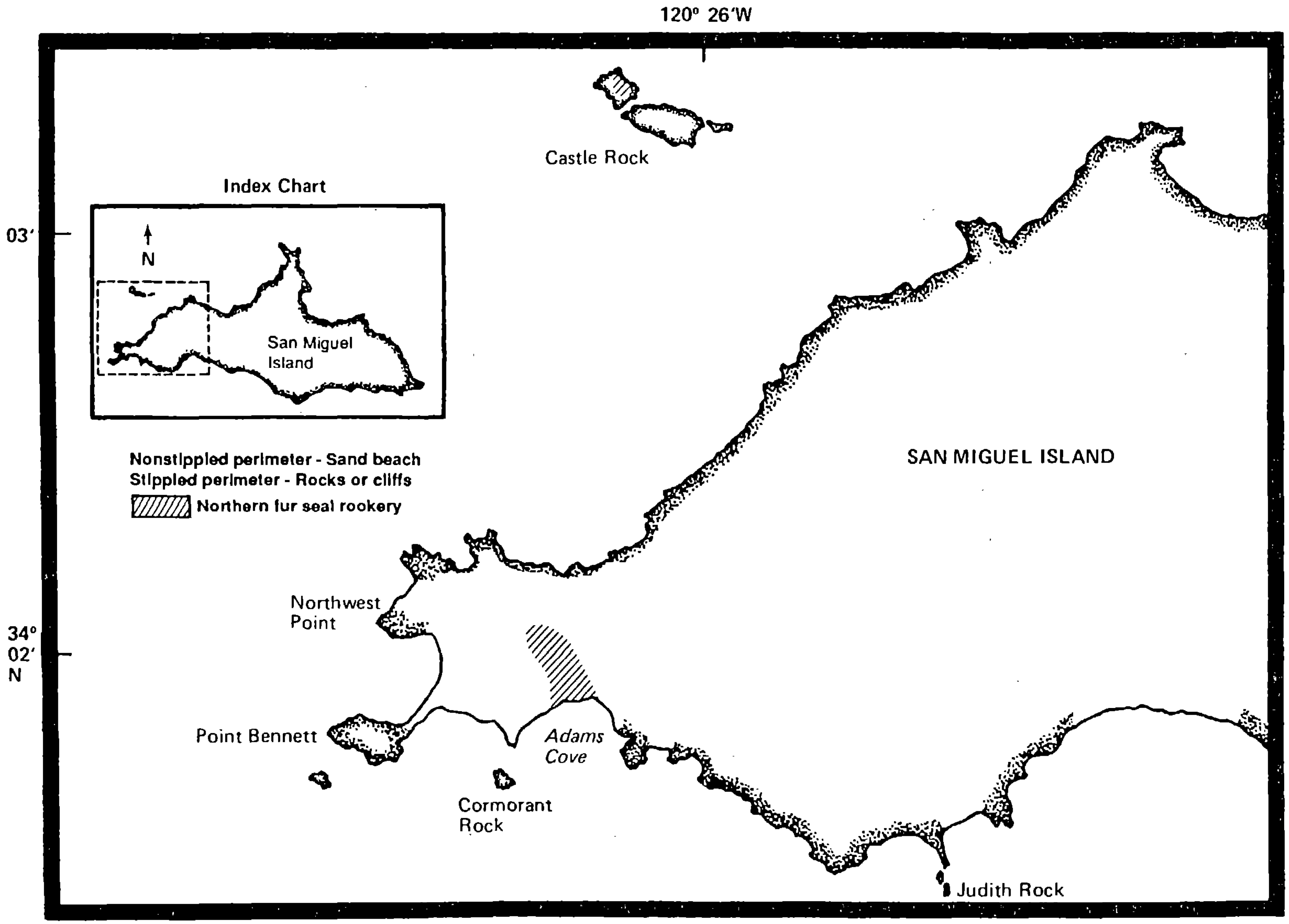

Figure 4. --Location of northern fur seal breeding colonies, San Miguel Island, California.

Three U. S. scientists, two from the NMML and one from the Minerals Management Service, also traveled to Medny Island (U.S.S.R.) with 10 Soviet scientists conducting studies on fur seals typical to those done previously on the Pribilof Islands.

Fur seals were commercially harvested on the Pribilof Islands from the late 1800s to 1984. A moratorium on the commercial harvesting of fur seals, on St. Paul Island was imposed beginning in 1985 because of the depressed northern fur seal population on the island. A moratorium on commercial hanresting of fur seals was imposed earlier on St. George Island (1973) to permit research on the population as it reverted to its natural state. Because of the moratorium on commercial harvesting on both islands, juvenile male fur seals (primarily 2- and 3-year-olds) are now harvested only for subsistence. In 1990, 1,240 juvenile males were taken in the subsistence harvest, 1,076 were taken on St. Paul Island, and 164 animals were taken on St. George Island. No female fur seals were taken on either island.

There is no harvest of fur seals on Sea Lion Rock and Bogoslof Island, Alaska, and Castle Rock and San Miguel Island, California. However, young male seals occasionally haul out at some distance from their rookeries of birth, and thus may be subjected to a harvest mortality.

Terms having special meanings in northern fur seal research are defined in the glossary (Appendix A), and Russian names given to some of the rookeries of the Pribilof Islands following their discovery by Russian fur hunters in 1786 are translated in Table 1.

Much of the tabular data for this report are presented as appendices. Appendix B contains the data customarily presented concerning general studies, Appendix C provides entanglement related data, Appendix D gives the methodology used in estimating entanglement related survival, and Appendix E is a list of personnel involved in fur seal research in 1990.

This report summarizes the research carried out in 1990 under authority of the Marine Mammal Permit No. 598, as well as cooperative research in international waters.

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

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

POPULATION ASSESSMENT, PRIBILOF ISLANDS, ALASKA

by

Anne E. York and Charles W. Fowler

In accordance with original provisions 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. Data on population size, age and sex composition, and natural mortality are collected annually to meet this objective.

Population Parameters

Herd characteristics monitored in 1990 include the number of live adult males and pups born on St. Paul Island, St. George Island, and Sea Lion Rock.

Sex Composition of Seals Harvested

A total of 1,077 subadult male seals were killed in the subsistence harvest by St. Paul Island residents in 1990. On St. George Island, 164 subadult male seals were taken in the subsistence harvest in 1990. No female fur seals were taken on either island (Table 2).

Living Adult Male Seals Counted

A total of 4,430 harem (see glossary for definition) and 7,629 idle (classes 1, 2, 4, and 5 as defined in glossary) adult male seals (bulls) were counted on St. Paul Island from 9 to 14

Table 2.--Date, location, and number of subadult male seals killed in subsistence harvest drives on St. Paul Island, Alaska, in 1990.

Date	Rookery	Number killed
July 5	Reef	41
July 6	Zapadni	42
July 9	Halfway Point	35
July 11	Reef	71
July 13	Zapadni	60
July 16	Lukanin	41
July 18	Zapadni	64
July 20	Reef	72
July 23	Zapadni	58
July 24	Reef	77
July 26	Polovina	65
July 28	Northeast Point*	65
July 31	Reef	57
August 2	Zapadni	69
August 7	Zapadni	80
August 8	Reef	180

* Includes Vostochni and Morjovi rookeries

July (Appendix Table B-l). Total numbers of harem and idle bulls counted since 1980 are given in Appendix Table B-2. Classification and number of male seals counted by rookery are given in Table 3. 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 5.

Harem bull counts on St. Paul Island were 3.1% higher in 1990 than in 1989. On St. George Island, harem bull counts decreased 3.6% between 1989 and 1990. The effects of the 1984 cessation of commercial harvesting on St. Paul Island are apparent in the 22% increase in the harem male count and a 403% increase in the idle male count between 1987 and 1990. On St. George Island, where the commercial harvest ceased in 1972, the idle male count has increased by 29% since 1987.

Number of Pups Born on St. Paul Island in 1990

Shearing sampling was used to estimate numbers of live pups (York and Kozloff 1987). Dead and live pups were counted on all rookeries (except Little Polovina rookery on St. Paul Island) and on Sea Lion Rock in August 1990. A census was not conducted on Little Polovina because the number of pups born there has declined precipitously since 1980, and any disturbance to the rookery was considered inadvisable. The confidence interval for total number of pups born in 1989 (Fig. 6) was very large (Antonelis et al. 1990); thus, it was considered necessary to census all rookeries in 1990 to verify that the ratio of pups to numbers of breeding bulls was approximately constant across the

Table 3.--Number of adult male northern fur seals counted by rookery and class on Pribilof Islands, Alaska, July 1990.

Rookery	Date (July)	Class of adult male * 2	3	5	Total
St. Paul Island					
Lukanin	10	41	129	174	344
Kitovi	10	103	230	374	707
Reef	13	153	484	408	1045
Gorbatch	13	97	361	605	1063
Ardiguen	13	20	78	13	111
Morjovi	14	74	341	809	1,224
Vostochni	14	187	785	783	1,755
Little Polovina	11	6	15	85	106
Polovina	11	14	60	317	391
Polovina Cliffs	11	119	407	321	847
Tolstoi	9	187	552	982	1,721
Zapadni Reef	12	59	142	140	341
Little Zapadni	12	88	323	365	776
Zapadni	12	242	523	863	1,628
Island total		1,390	4,430	6,239	12,059
St. George Island					
Zapadni	12	38	122	412	572
South	12	76	179	68	323
North	11	151	337	298	786
East Reef	11	28	54	202	284
East Cliffs	11	75	150	157	382
Staraya Artil	12	47	68	114	229
Island Total		415	910	1,251	2,575

*See glossary of annual reports on fur seal investigations for a description of the classes of adult male seals.

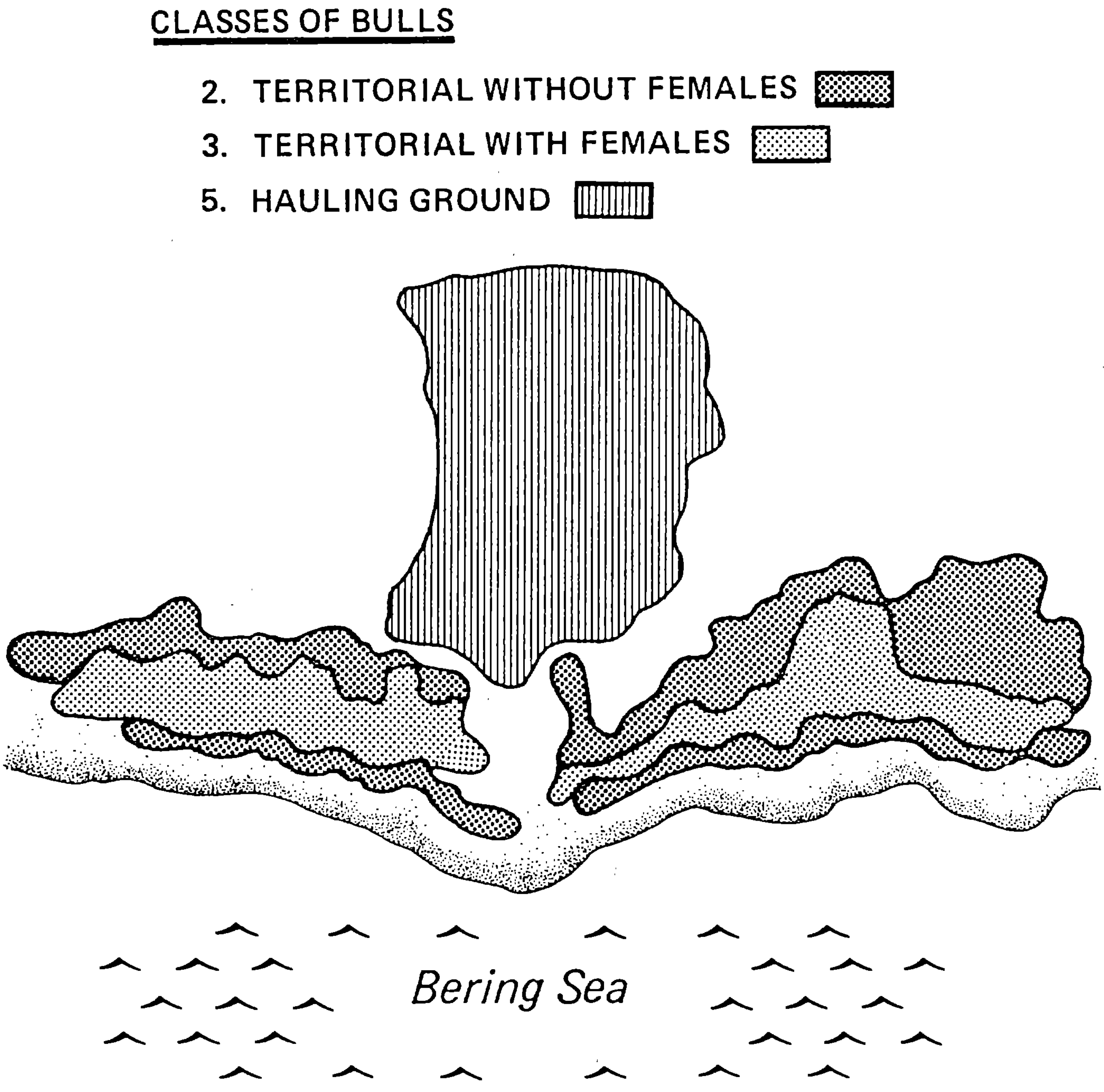

Figure 5. --General composition of a typical fur seal rookery. Class 2 as depicted here corresponds to classes 1 and 2 of Appendix A and class 5 corresponds to classes 4 and 5 of Appendix A.

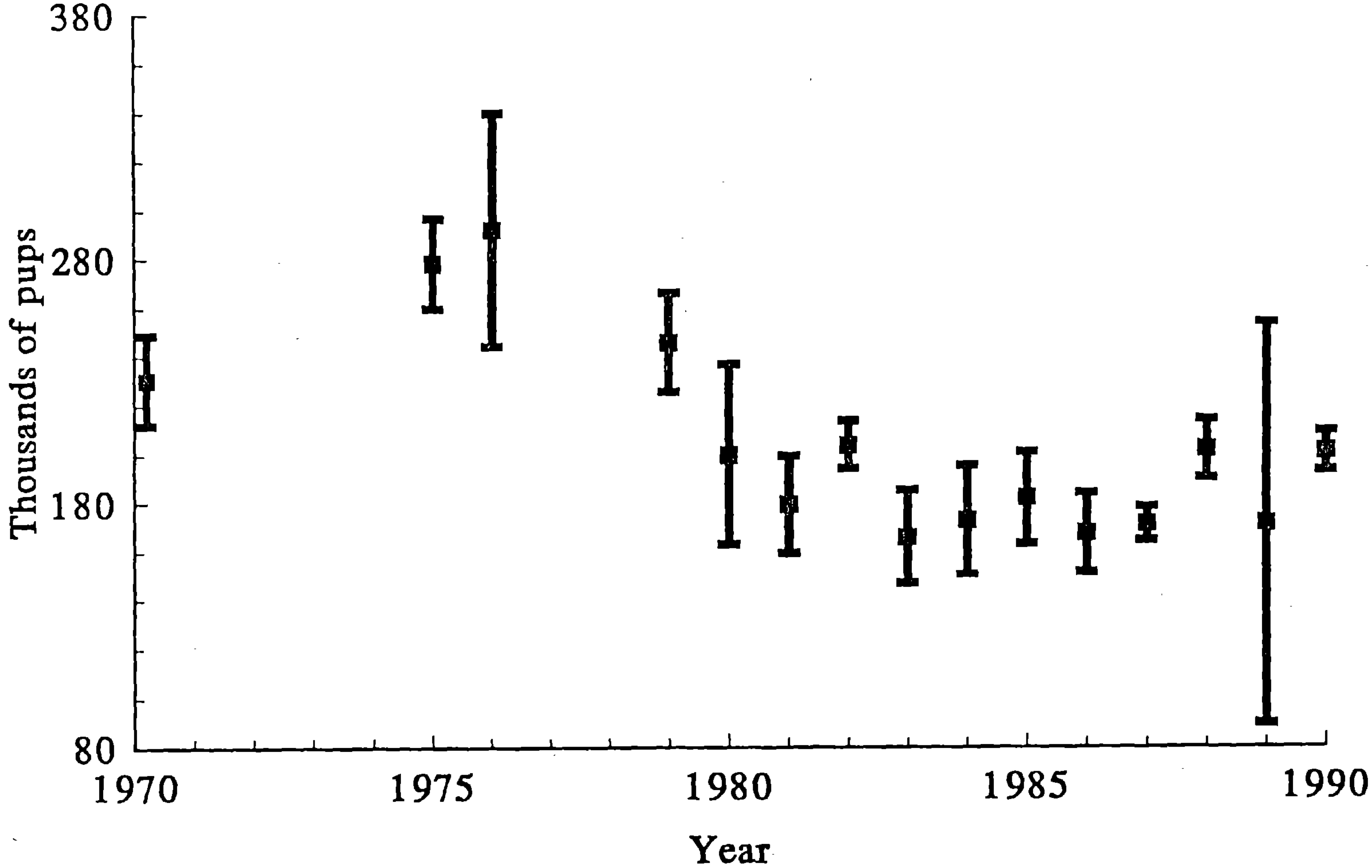

Figure 6.--Numbers of northern fur seal pups born on St. Paul Island, Alaska, 1970-90. Approximate 95% confidence intervals are shown.

rookeries. This assumption is required for computing an unbiased estimate of the numbers of pups from data on sample rookeries (York and Kozloff 1987). Shearing sampling had not been conducted on all rookeries since 1987.

From 5 to 12 August, 17,661 pups were sheared. The number of pups sheared on each rookery was approximately 10% of the last available census. Marks were allocated proportionally throughout the rookery sections according to the fraction of breeding males on the given section (Table B-3, Appendix B). Resighting of pups to determine the ratio of marked to nonmarked pups was done twice on each rookery first from 13 to 18 August and later from 21 to 24 August. The observers worked independently in different areas of the rookery counting different groups of pups and the counts for each day were combined to obtain a total estimate for the rookery. Each sampling day was considered an independent replicate for each rookery.

Dead pups were counted on all rookeries from 18 to 24 August. Numbers of dead pups counted by section are given in Table B-4, Appendix B. A summary of the resampling data and the calculation of the numbers of pups alive at the time of marking is given in Table 4. The estimated number of pups born, dead Pups, counts of breeding males, and ratio of pups to breeding males for all 14 rookeries of St. Paul Island is summarized in Table 5. Rookeries have been divided into sections of relatively equal densities of animals. Section boundaries are maintained from year to year. Counts are conducted by section and reported

Table 4.--Total number of northern fur seal pups sheared, number of sheared pups resighted on two sampling occasions (Rl and R2), total number sampled on two sampling occasions (Tl and T2), number of pups estimated to be alive at the time of marking (El and E2), and the mean number alive (Mean), St. Paul Island, Alaska, 1990. The mean for Sea Lion Rock is the total estimated from one sampling occasion. Separate information is given for Kitovi Amphitheater and 2nd Point South of Sea Lion Neck; these are considered part of section 1 of Kitovi and Morjovi rookeries, respectively.

Rookery	Sheared	R1	R2	T1	T2	E1	E2	Mean
Ardiguen	314	54	39	325	300	1,890	2,415	2,153
Gorbatch	1,416	234	204	2,425	2,300	14,674	15,965	15,320
Kitovi	1,009	156	102	1,300	950	8,408	9,398	8,903
Kitovi Amph.	59	20	9	100	50	295	328	311
Lukanin	519	80	108	725	725	4,703	3,484	4,094
Morjovi	1,009	203	181	2,475	2,075	12,302	11,567	11,935
2nd Point South	158	29	33	200	150	1,090	718	904
Polovina Cliffs	1,659	292	269	3,125	2,750	17,755	16,960	17,357
Polovina	231	46	36	425	350	2,134	2,246	2,190
Reef	2,049	228	298	2,525	3,200	22,692	22,003	22,347
Tolstoi	2,298	218	233	2,525	2,725	26,617	26,876	26,746
Vostochni	3,127	414	448	4,275	4,325	32,290	30,188	31,239
Little Zapadni	1,269	154	200	2,075	2,575	17,099	16,338	16,718
Zapadni	2,074	258	227	3,425	2,575	27,533	23,527	25,530
Zapadni Reef	470	89	80	1,125	900	5,941	5,288	5,614
Sea Lion Rock	1,031	208	--	1,975	---	9,790	---	9,790

Table 5.--Number of pups alive at the time of marking, its standard deviation (SD), number of dead pups, mortality rate, ratio of pups alive at marking to harem males, and total numbers of pups born, St. Paul Island, Alaska, 1990.

Rookery	Harem bulls	Pups alive at marking	SD	Dead pups	Mortality rate (%)	Ratio pups/bulls	Total pups born
Ardiguen	78	2,309[a]	372	121	4.98	29.60	2,430
Gorbatch	361	15,320	912	640	4.01	42.44	15,960
Kitovi	230	9,214	699	424	4.40	40.06	9,638
Lukanin	129	4,094	862	586	12.52	31.73	4,680
Morjovi	341	12,839	582	396	3.00	38.75	13,235
Polovina Cliffs	407	17,357	562	652	3.62	42.65	18,009
Polovina	60	2,190	79	54	2.41	36.50	2,244
Reef	484	22,347	487	1,378	5.81	46.17	23,725
Tolstoi	552	26,746	183	1,145	4.11	48.45	27,891
Vostochni	785	31,239	1,486	981	3.04	39.79	32,220
Little Zapadni	323	16,718	538	918	5.21	51.76	17,636
Zapadni	523	25,530	2,833	1,367	5.08	48.81	26,897
Zapadni Reef	142	5,614	462	443	7.31	39.54	6,057
Little Polovina	15	652[b]	23	31[c]			683[d]
Island Total	4,430	192,169	3,724	9,136	4.54	43.38	201,305
Sea Lion Rock	325	9790	568	427	4.18	30.09	10,217

[a]Includes 156 pups counted in isolated part of rookery between Gorbatch and Ardiguen where pups are not sheard.

[b]Estimate and its standard deviation are calculated from the jackknife ratio estimate of pups to breeding males.

[c]Numbers of dead pups estimated from average mortality of 4.54%.

[d]Total estimated from sum of estimates of live pups and dead pups.

by rookery. For example, in Table 4, estimates for Kitovi Amphitheater and 2nd Point South of Sea Lion Neck (2nd Point South) are presented separately, even though they are part of section 1 of Kitovi and Morjovi rookeries, respectively. In Table 5, the estimates are included with Kitovi and Morjovi rookeries. An estimate of numbers of live pups and its standard deviation (SD) for Little Polovina rookery was computed from a jackknife estimate of the ratio of pups alive at marking to breeding males on the sampled rookeries. An estimate of numbers of dead pups for Little Polovina rookery was computed assuming that the mortality rate there is the same as the average mortality on the other rookeries (Table 4). For each sampled rookery, the SD of the pup estimate is computed from the standard error of the estimates on the two sampling occasions. For Little Polovina, the SD is computed from the standard error of the jackknife ratio of pups to breeding males on the sampled rookeries.

The estimate for the total number of pups born on St. Paul Island was 201,305 (SD = 3,724), the sum of the estimates over all the rookeries. Numbers of dead pups were estimated at 9,128 (9,105 counted on the sampled rookeries and 23 estimated for Little Polovina rookery); the estimated early mortality rate is 4.54%. A 95% confidence interval of the population estimate (201,305 ±(2.18 . 3,724) or 201,305 ± 8,120) was computed by multiplying the SD (calculated as the square root of the sum of the variances for each rookery: assuming the 13 estimates on the censused rookeries were independent by) $t_{13},(0.975)$, the 97.5 percentile of Student's t-distribution with 13 degrees of freedom. The SD of the total is the square root of this variance. Pup estimates and their 95% confidence intervals for St. Paul Island, 1970-90 are shown in Figure 6. The total number of pups born in 1990 was not significantly different from the 1988 and 1989 estimates.

The numbers of pups born and the numbers of breeding males are highly correlated (Fig. 7). When numbers of pups born are regressed on numbers of males, the value of R^2 is about 0.96. The intercept of the regression line, -196 is not significantly different from 0; the slope of the regression line is 42. A detailed analysis of the residuals from the regression and the implications of this for the subsampling method will be discussed in detail in the 1991 annual fur seal report.

Number of pups born on Sea Lion Rock

Shearing-sampling estimation and dead pup counts were conducted for the first time on Sea Lion Rock in August 1990. Both counts were conducted on 18 August and resampling was conducted on 23 August. Because of logistic difficulties of traveling to Sea Lion Rock, resampling was conducted only once. During resampling, the samplers counted distinct groups of pups, with no overlap, so there are no replicate samples. Thus, the variance of the estimated number of animals on the rookery is computed using Seber's unbiased estimate of the variance of the

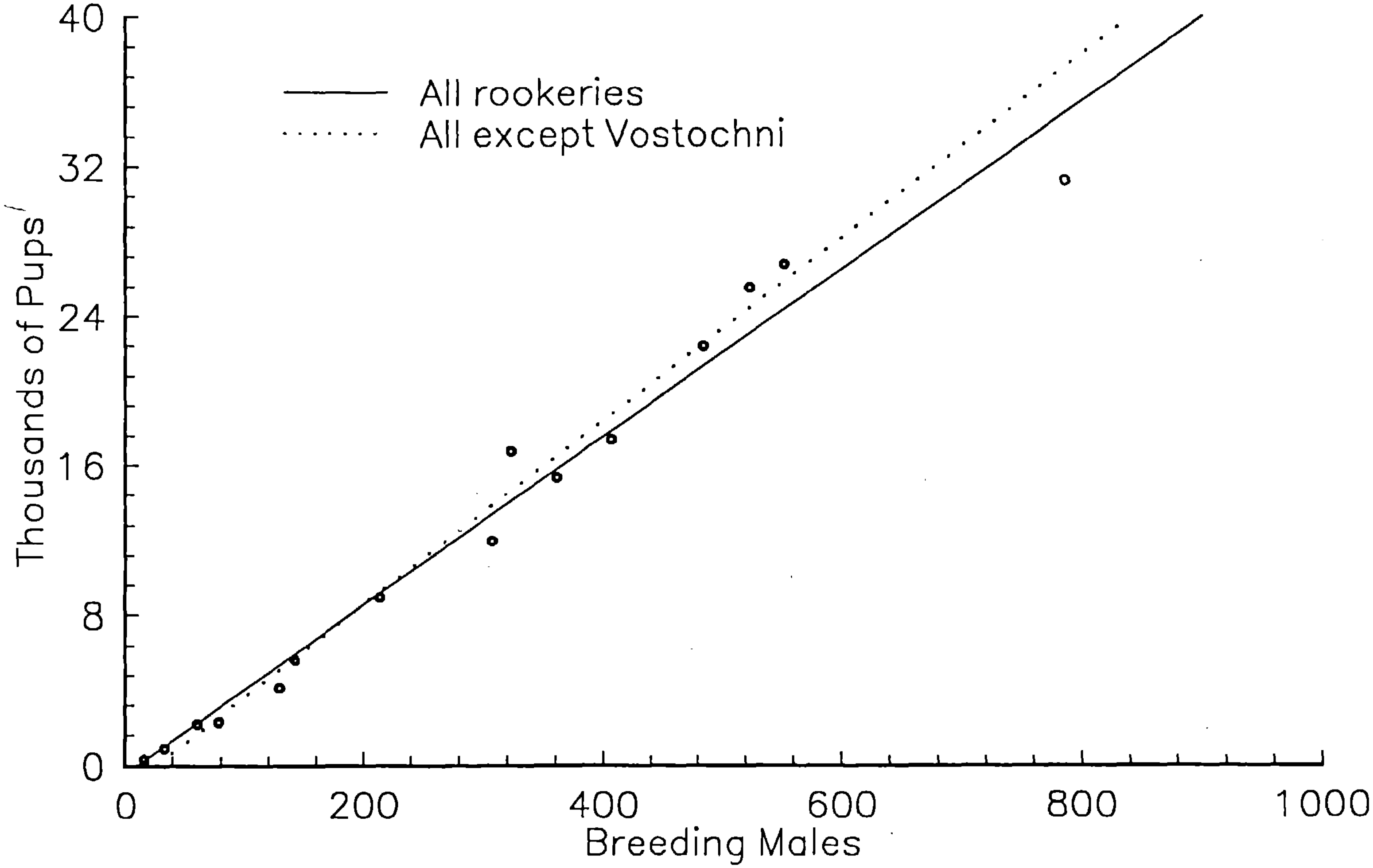

Figure 7. --Numbers of northern fur seal pups alive at the time of sampling versus number of breeding male fur seals for the rookeries on St. Paul Island, Alaska, 1990. Separated regression lines are shown for all rookeries combined and all rookeries combined except Vostochni. rookery.

Petersen estimate, namely:

$$v = \frac{(s+1)(t+1)(s-r)(t-r)}{(r+1)^2 (r+2)},$$

where s is the number of animals sheared, r is the number of animals resighted, and t is the total number of animals resampled.

We attempted to shear approximately 1,500 pups but due to weather that number was decreased to 1,031 (Table 4). The rookery was divided into three sections (Fig. 8); shearing effort and dead pup counts are reported for these sections in Tables B-3 and B-4 of Appendix B, respectively. A summary of the resampling data and the calculation of the numbers of pups alive at the time of marking is given in Table 4. Table 5 summarizes the estimated number of pups born, dead pups, counts of breeding males, and ratio of pups to breeding-males for Sea Lion Rock. The number of pups alive at the time of marking are from Table 4. The total number of pups alive at the time of marking is estimated at 9,790 (SD = 568); an additional 427 dead pups were counted giving an estimated total of 10,217 pups born.

<u>Number of pups born on St. George Island in 1990</u>

The number of pups born on St. George Island during 1990 was estimated from shearing sampling on all rookeries of St. George Island. Pups were sheared from 14 to 15 August 1990 (Table 6). Resighting to determine the ratio of marked to unmarked pups on the sample rookeries was done once by two observers on each rookery from 19 to 20 August 1990; the observers worked in pairs

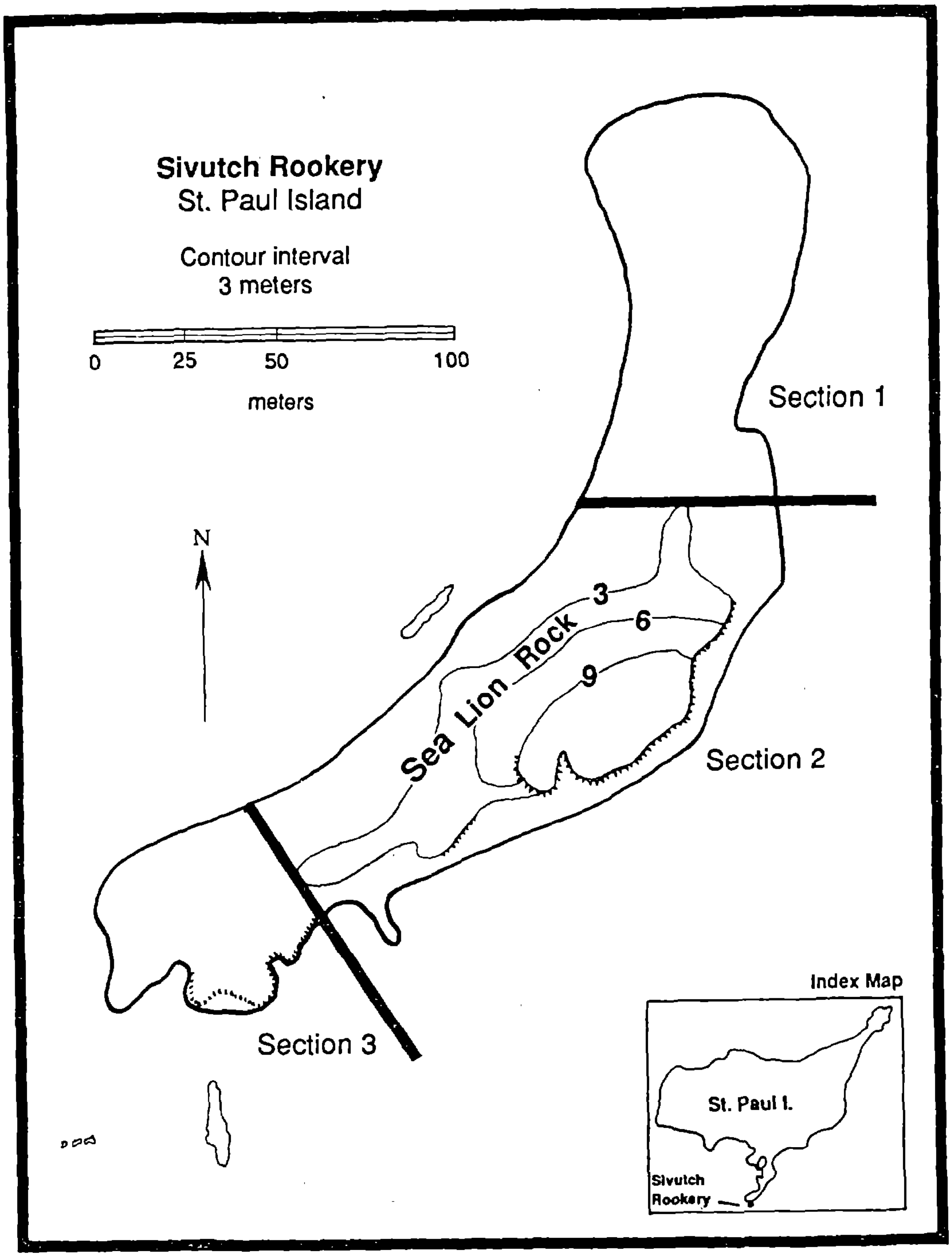

Figure 8.--Sea Lion Rock, Sivutch rookery, St. Paul Island, Alaska.

Table 6.--Number of pups sheared, number of sheared pups resighted by two observers (R1 and R2), number of pups resighted by two observers (T1 and T2), total number of pups estimated by the two observers (E1 and E2), and mean estimate (Mean), for all rookeries, St. George Island, Alaska, 1990.

Rookery	Sheared	R1	R2	T1	T2	E1	E2	Mean
East Reef	147	27	29	150	150	817	760	789
East Cliff	408	21	37	250	250	4,857	2,757	3,807
North	1,058	68	83	600	600	9,335	7,648	8,492
Starya Artil	189	19	28	225	225	2,238	1,519	1,879
Zapadni	322	20	21	225	225	3,623	3,450	3,537
South	476	30	40	275	300	4,363	3,570	3,967
Island Total	2,600	185	238	1,725	1,750	25,233	19,704	22,471

counting the same groups of pups but not communicating their results, so their estimates are considered independent replicates for each rookery. Counts of dead pups were made from 16 to 17 August 1990. The estimate of total number alive at the time of marking is the mean of the Petersen estimates of the two samplers. The variance was computed from the two independent estimates. The total number born on the island is the sum of the numbers alive on each rookery and the count of dead pups. Details of these computations are presented in Table 7: The estimate of the total number of pups born on St. George Island is 23,397; an approximate 95% confidence interval for the total number of pups born on St. George Island is 23,397 ± (2.447 2,054), or 23,397 ± 5,026. This count is not significantly different (P ??0.05) from the 24,820 pups observed on St. George Island in 1988, nor is it significantly different (P ??0.05) from the predicted number of pups born based on a regression fitted to the 1973-88 data, which showed a 5.9% decline (21,604 ± 2,626;cf York 1990). Estimates and 95% confidence intervals of numbers of pups born on St. George Island for 1970-90 are given in Figure 9.

Table 7.- -Number of harem bulls (b) counted, estimated number of pups alive at the time of marking, number of dead pups counted and its standard deviation (SD), number of dead pups counted, estimated number of pups born, estimated mortality rate, and estimated ratio of pups alive (p) at the time of marking to number of harem bulls (b) St. George Island, Alaska 1990.

Rookery	Harem bulls	Live pups	SD	Dead pups	Mortality (%)	Ratio p:b	Total pups
East Reef	54	789	40	7	0.89	14.61	796
East Cliff	150	3,807	1,485	119	3.13	25.38	3,926
North	337	8,492	1,193	435	5.12	25.20	8,927
Starya Artil	68	1,878	508	111	5.91	27.62	1,989
Zapadni	122	3,536	122	121	3.42	28.98	3,657
South	174	3,967	561	135	3.40	22.80	4,102
Island Total	905	22,469	2,054	928	3.97	24.83	23,397

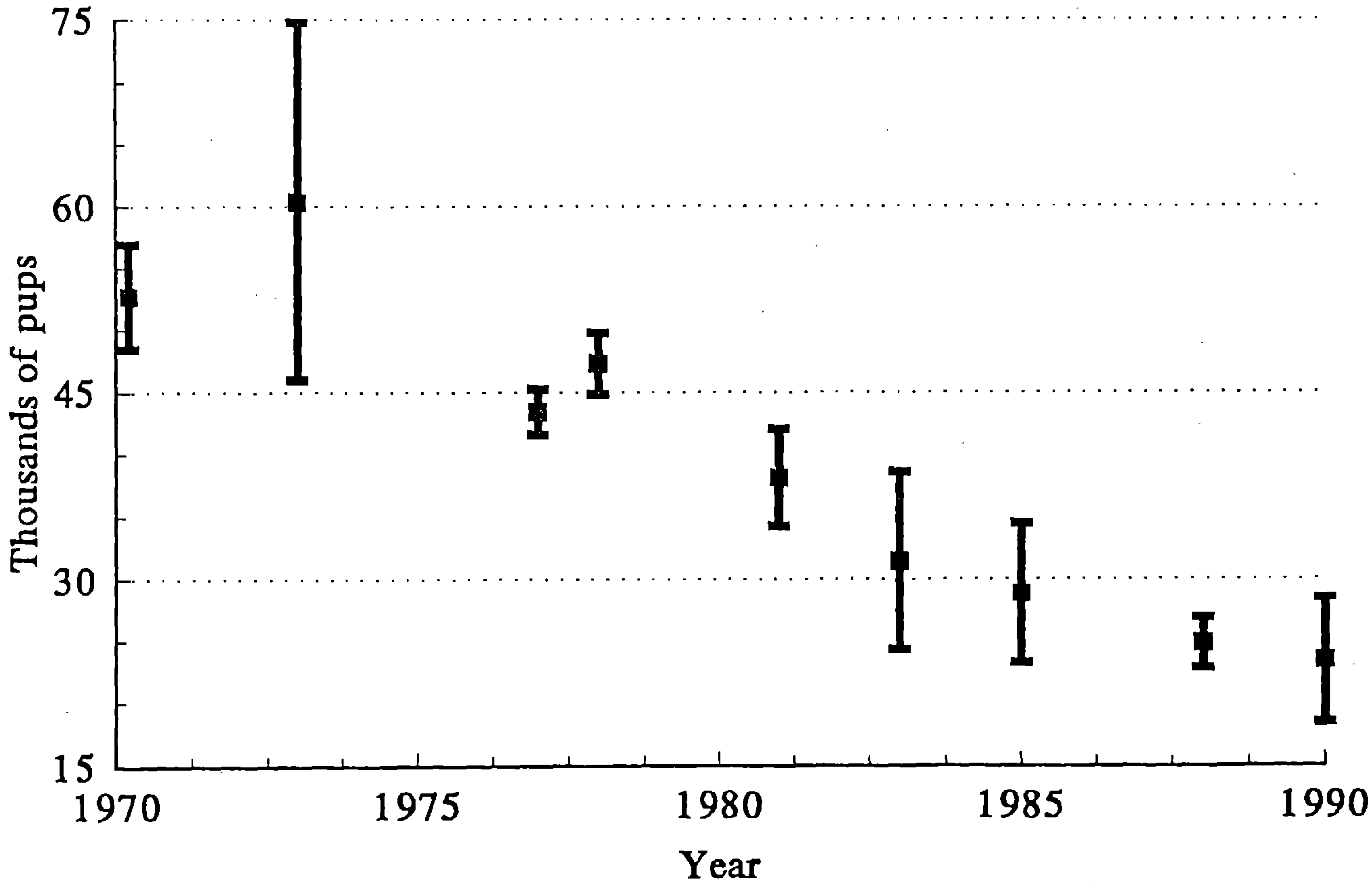

Figure 9.--Numbers of northern fur seal pups born on St. George Island, Alaska, 1970-90. Approximate 95% confidence intervals are shown.

IMPACT OF AIRBORNE NOISE ON NORTHERN FUR SEALS IN THE PRIBILOF ISLANDS, ALASKA: A PRELIMINARY ASSESSMENT

by

Stephen J. Insley

The expected rise in commercial and tourist activities on the Pribilof Islands, Alaska, has increased the potential for northern fur seals (*Callorhinus ursinus*) being disturbed by noise. Several studies have reviewed the problem or have completed investigations of specific source impacts (Climo 1987; Herter and Koski 1988; Johnson et al. 1989; Gentry et al. 1990) but to date, a baseline assessment of noise impact on Pribilof Island fur seals has not been done. Therefore, this study was undertaken to make a preliminary assessment of the impact of sound and to outline the general areas of concern regarding noise.

Two general forms of auditory disturbance were investigated: 1) those from direct noise and 2) those from indirect noise. Direct impacts result from noise sources that can be measured directly (e.g., airplanes, land vehicles, ships, and construction activities). Indirect noise and its effects occur when fur seals respond to human disturbance. Specifically, the presence of humans often causes seals to be more vigilant and to call more frequently. Such calling may escalate enough to increase the ambient noise levels, decreasing the distance from which animals can hear each other. Of primary concern is the potential effect on female-pup recognition calling. The effects of direct noise are reported as follows: 1) noise sources are identified and quantified, 2) background noise levels of fur seal rookeries are measured, and 3) anecdotal accounts of the impacts of noise are given., Indirect impacts of noise are reported as follows: 1) changes in ambient noise levels due to disturbance and 2) the energy levels of fur seal vocalizations.

Methods

This study was conducted on St. Paul and St. George Islands, Alaska, between 27 June and 12 August 1990. It also includes data collected on St. Paul Island during July and August 1988. Locations of the different rookeries referred to are shown in Figures 1 and 2.

Acoustic energy (calls, man-made noise sources, and ambient noise) was measured as sound pressure levels (SPL) and expressed in decibals (dB) (re 20 µPa). Acoustic frequency is reported in hertz (Hz) and kilohertz (kHz). Definitions of the other acoustic measurements used are as follows: 1) L_{eq}, the average energy level, is the steady SPL that is equivalent to the same total acoustic energy as the real fluctuating noise over a given period of time and 2) L_{gO}, the background or ambient noise level is the SPL exceeded 90% of a given time period.

In 1990, SPL measurements were made with a Bruel and Kjaer (B&K) 2231 sound level meter with the 7101 software module and the 1625 one-third octave filter.[1] Data from 1988 were collected in the same manner as 1990 except a B&K 2230 meter was used (Insley, Univ. of California, Davis 95616, unpublished data). The meters were calibrated with a 94 dB, 1 kHz pure-tone (B&K sound level calibrator type 4230) before each session. All SPL measurements were made using a "linear" frequency mode (equal response between 20 Hz and 20 kHz) and a "fast" response time. A Uher 4400 Report L tape recorder operating at 19 cm/s using the 2231 meter for a microphone (constant recording level) was used to document sounds.

In measuring background noise on rookeries, the main factors that could affect. data were considered first. On the Pribilof Islands these include: 1) proximity to animals; 2) the number of animals in which a clear line-of-sight exists (i.e., as influenced by measuring from above or on the same level as the animals); 3) animal activity; 4) proximity of animals to the sea (i.e., narrow or wide rookery); and 5) sea state. The first two factors were controlled by performing measurements from above with a clear line-of-sight to a minimum concentration of 20 animals so that the measurement would reflect the contribution of many animals. The distance to the nearest animal varied according to the study site, and ranged from 3 m at Vostochni and Zapadni rookeries to 5 m at Ardiguen and Polovina rookeries.

The calculations of sound propagation (calls and noise

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

sources) were made using measurements from two sampling locations and the geometric spreading relationship

$$L_{p2} = L_{p1} - 20\log r_2/r_1 - A_e ,$$

where L_{p2} is the SPL at location 2, L_{p1} is the SPL at location 1, r_1 and r_2 are the respective distances from the source along the same line to locations 1 and 2, and A_e is the excess attenuation due to obstacles or atmospheric attenuation (Beranek 1971). The excess attenuation from atmospheric absorption can be safely ignored because most of the energy in the noise sources of interest was below 1 kHz where attenuation from atmospheric absorption is negligible for the distances used. Two distances representing a relatively close (30 m) and a distant (300 m) encounter with the various noise sources were chosen so that the SPLs from different sources could be compared. The two distance-standardized values are mainly for the comparison of aircraft noise; 300 m is a standard measurement distance for aircraft (Johnson et al. 1989) and 30 m was the approximate minimum close-range distance for aircraft during the study.

The investigation of indirect noise (increase in conspecific noise triggered by the presence of humans) addressed two specific questions: how much did the background noise level increase and how long did it take to return to the ambient noise level? The disturbance source used was a human walking to the rookery periphery during bull counts at the height of the breeding season (11-14 July). Measurements were made from a location above the animals (i.e., cliff side, tripod, or catwalk).

To demonstrate the effect of increased background noise on seals, the change in audible call distance (the distance from which a call could be heard by a conspecific) as background noise levels changed was estimated. This was accomplished by first obtaining source levels for the calls of different animals and then calculating the distance from which these vocalizations were maintained above the measured background levels. Source levels were taken as close as possible (i.e., <5 m) to the focal animal and were limited to the calls produced by an animal facing within 20-30 degrees of the sound level meter. Call attenuation was estimated using the geometric spreading relationship described previously.

Results and Discussion

Impact from Direct Noise Sources

Background Noise Levels--Background noise levels were measured in several rookeries and covered a variety of conditions (Table 8). The index used to compare background noise levels was the range of L_{90}s taken at 5-minute intervals over several hours. Background noise varied -considerably, ranging from 67.0 to 85.5 dB depending both on sea state and animal activity. Noise that is below the minimum background level (67 dB) at the rookery is likely to have a low disturbance potential unless a particularly negative association exists. Any noise above the maximum ambient levels of 78.5 to 85.5 dB should be considered as a potential disturbance.

Table 8.--Range of background sound pressure levels (SPLs) measured at four rookeries during different weather conditions.

Rookery	L_{90} range[a] (dB)	Wind/Sea state	Main sources[b] (%,seals/sea)
Vostochni	69.0-78.5	calm/<1 m	100/0
Zapadni	67.0-74.0	calm/1 m	75/25
Ardiguen	68.5-72.5	15knots/1.5 m	50/50
Polovina	85.5	>30knots/3-4 m	0/100

[a]The range of L_{90} levels (SPL exceeded 90% of the time) in dB (re 20 μPa) measured using a linear sensitivity mode and a fast response time for 5-minute intervals over 2-5 hour periods.

[b]Estimation of the percent to which seal and ocean noises contribute to background noise levels.

This applies only to sounds of similar quality (e.g., frequency) to that made by the seals themselves. A distinct sound at similar volume might cause disturbance.

Noise Sources

Generalized potential noise sources for the St. Paul and St. George Islands are listed in Table 9. The sources likely to be of concern are addressed in more detail in Table 10 by their maximum measured SPLs and distance-standardized SPL values. The distance standardized SPLs indicate that airplanes tend to produce higher levels of noise than other sources. One exception was the trawler where even at over 300 m the levels exceeded the high end of the rookery's background noise. Given that these sources are often closer than 300 m and that background noise in the rookery is often less than 85 dB, there is a potential for negative impact. Airplanes are often clearly audible by fur seals on rookeries when they were greater than 1 km away.

Most acoustic energy was below 1 kHz for all sources. For example, peak frequencies of the diesel-powered construction equipment, the offshore trawler, and the all-terrain vehicle (ATV), were all between 60 and 300 Hz. Peak frequencies of aircraft vary between 60 and 500 Hz depending mainly on the craft and the engine status (e.g., takeoff, landing, taxiing, or cruising).

Observations of animal reactions to different noise sources are listed in Table 11 to give an indication of response variation. In judging the above reactions it is important to

Table 9.--List of principal direct noise sources and potential impact on St. Paul and St. George Islands, Alaska.

	Potential impact		Rookeries affected	
Source	St. Paul	St. George	St. Paul[a]	St. George[b]
Aircraft	Yes	Yes	P, L, R	E, N, S, Z[c]
Off-road vehicles	Yes	No	V, L	-
On-road vehicles	No	No	-	-
Construction	No	Yes	-	N, Z
Powerplant	No	No	-	-
Ships	Yes	Yes	L, R, T, Z	N, Z[c]

[a]St. Paul Island rookeries: V = Vostochni and Morjovi; P = Little Polovina, Polovina Cliffs, and Polovina; L = Lukanin and Kitovi; R = Reef, Ardiguen, and Gorbatch; T = Tolstoi; Z = Zapadni Reef, Little Zapadni, and Zapadni.

[b]St. George Island rookeries: E = East Cliffs and East Reef; N = North; S = Staraya Artil; Z = Zapadni and South.

[c]Future potential impact.

Table 10.--Measured and estimated sound pressure levels (SPLs[a]) of primary noise sources.

	Measured SPL		Estimated SPL		
Source	SPL (dB)	Distance (m)	30 m (dB)	300 m (dB)	Source state
Aircraft					
DC-6	96.1	300	116.1	96.1[b]	takeoff
	114.5	15	108.2	88.2	takeoff
Electra	83.0	300	103.0	83.0[b]	passover
	102.2	30	120.2[b]	82.2	on ground
Hercules	100.4	50	104.8	84.8	on ground
	103.3	40	105.8	85.8	on ground
Navaho	97.0	40	99.5	79.5	on ground
Construction					
Caterpillar D9	99.7	10	90.2	70.2	passby
Caterpillar 777	101.0	5	85.4	65.4	passby
Euclid R50	102.0	10	92.5	72.5	backing up
Koehring 1208 Excavator	101.5	20	98.0	78.0	digging
Dumptruck	91.4	20	87.9	67.9	passby
Off-road vehicle					
Honda 200 ATV	104.2	2	80.7	60.7	revving
Shipping					
Trawler	81.7	700	109.1	89.1	running

[a]Maximum SPLs are in dB (re 20 μPa), measured using a linear sensitivity mode and a fast response time.

[b]Actual measurements.

Table 11.--Observed reactions of seals to different noise sources.

Source	Source state	Rookery	Distance (m)	Reaction[a] (% oriented/% moved)	
				Haulout	Rookery
St. Paul Island					
DC-6	takeoff	Polovina	300	50/0	0/0
FAA	overpass	Ardiguen	50	-	100/50
200'Trawler	running	Zapadni	1,000	50/0	-
St. George Island					
DC-6	takeoff	North	200	75/0	0/0
DC-6	landing	North	200	100.70[b]	50/0
DC-6	takeoff	Staraya Artil	300	100/0	-
		North	200	100/<10	-
DC-6	landing	North	200	50-70/20	-
	takeoff	North	200	80-100/30-40	-
Hercules	landing	North	200	100/50	50/0
Hercules	takeoff	Staraya Artil	300	100/<10	-
		North	200	100/<10[c]	70/0
Comanche	landing	North	200	<30/0	-
	takeoff	North	300	0/0	-
Koehring 1208 Excavator	digging	Zapadni	700	0/0	0/0

See notes on next page.

Table 11.--Continued.

[a]Estimated ratio of seals which sat up or pointed towards noise source (oriented) and which moved ≤10 m (moved).

[b]Approximately 70% of haul-out males laid back down after 20 minutes.

[c]Approximately 70% of haul-out males laid back down after 15 minutes.

note that the distances are estimated. The observations show that there are clear reactions involving movement of males from haul-out areas when airplanes are closer than 300 m. The only observed responses involving movement on the rookery were from a very low overflight (estimated at 50 m) of an FAA aircraft at Ardiguen rookery in 1988. It approached from land with a course perpendicular to the shore resulting in a sudden noise that caused a startle response. A collection of reactions by seabirds and northern fur seals to aircraft on St. George Island, including similar panic-type reactions by seals on the rookery, is provided by Herter and Koski (1988). It is important to note that responses of the breeding animals vary over time; both male and female site tenacity decreases as breeding season progresses and so the likelihood of movement increases with the progression of the breeding season.

Frequency of Noise Sources--Air traffic was the only noise source for which it was possible to estimate frequency of occurrence. On St. Paul Island during the summer months of 1990 a maximum of 21 flights per week were observed: 1) four-engine Lockheed Electra passenger service (daily); 2) Piper Navaho or Cessna Comanche passenger service (2/week); and 3) Hercules or DC-6 freight service (maximum 2/day). Appearances by a Coast Guard Bell Ranger II helicopter and the Hercules and FAA aircraft were intermittent. On St. George Island during the summer months of 1990, a maximum of 8 flights per week were observed: 1) Navaho or Comanche passenger service (maximum a/week); and 2)

Hercules and DC-6 freight service (3/week). The frequency of all flights varied considerably according to the weather.

<u>Impact From Indirect Noise Sources</u>

<u>Ambience shifts due to disturbance</u>--Background (L,,) and average (L,) noise levels every 5 minutes before, during, and after a disturbance (human walking near rookery or aircraft overflight) are plotted in Figures 10, 11, 12, and 13 for four different rookeries. Weather conditions were calm (<5 knot wind) and dry except for the measurement at Ardiguen rookery (Fig. 12) where it was raining with an approximate 15 knot wind.

The measurements indicate: 1) background and average noise levels increased during disturbances; 2) the increase in average noise level (up to 10 dB) was only partially reflected in the background noise level (up to 5 dB) indicating a sporadic source; 3) the return to normal background levels occurred in approximately 10-20 minutes; 4) a naturally occurring disturbance (e.g., males fighting) has the same or greater effect as human disturbances (Figs. 10 and 12); and 5) there is some evidence of increased calling due to sensitization (i.e., the nearby males reacted strongly to observer presence after the disturbance as well as during; Fig. 11). Observations made during the disturbances showed that initial trumpet roars (TR) (see Table 12 for definition of seal call types) by males were the primary contributor to noise levels. Following the peak of vocal activity, mother primary calls (MPC) from females, offspring

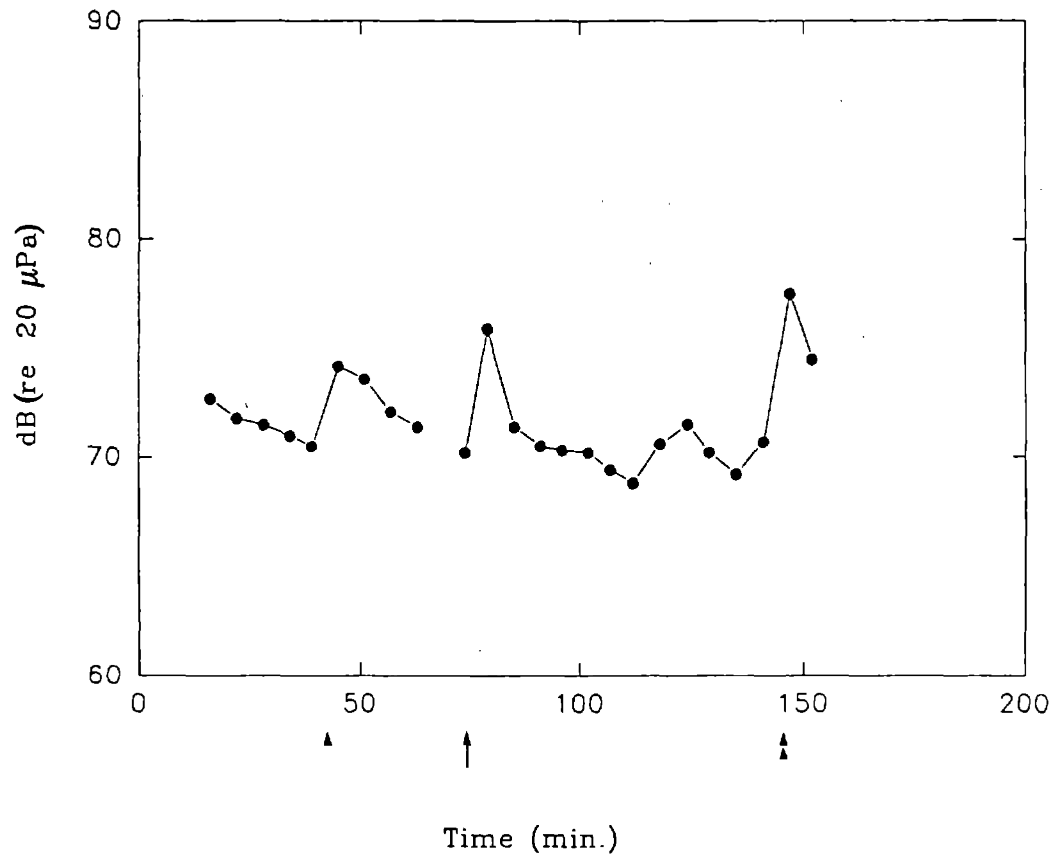

Figure 10.--Energy average L_{eq} (●) (equivalent continuous sound level) of northern fur seals before and after a human disturbance (↑) at Polovina Cliffs rookery, St. Paul Island, Alaska. An airplane passover (A) and a multi-male conflict (a) are also indicated.

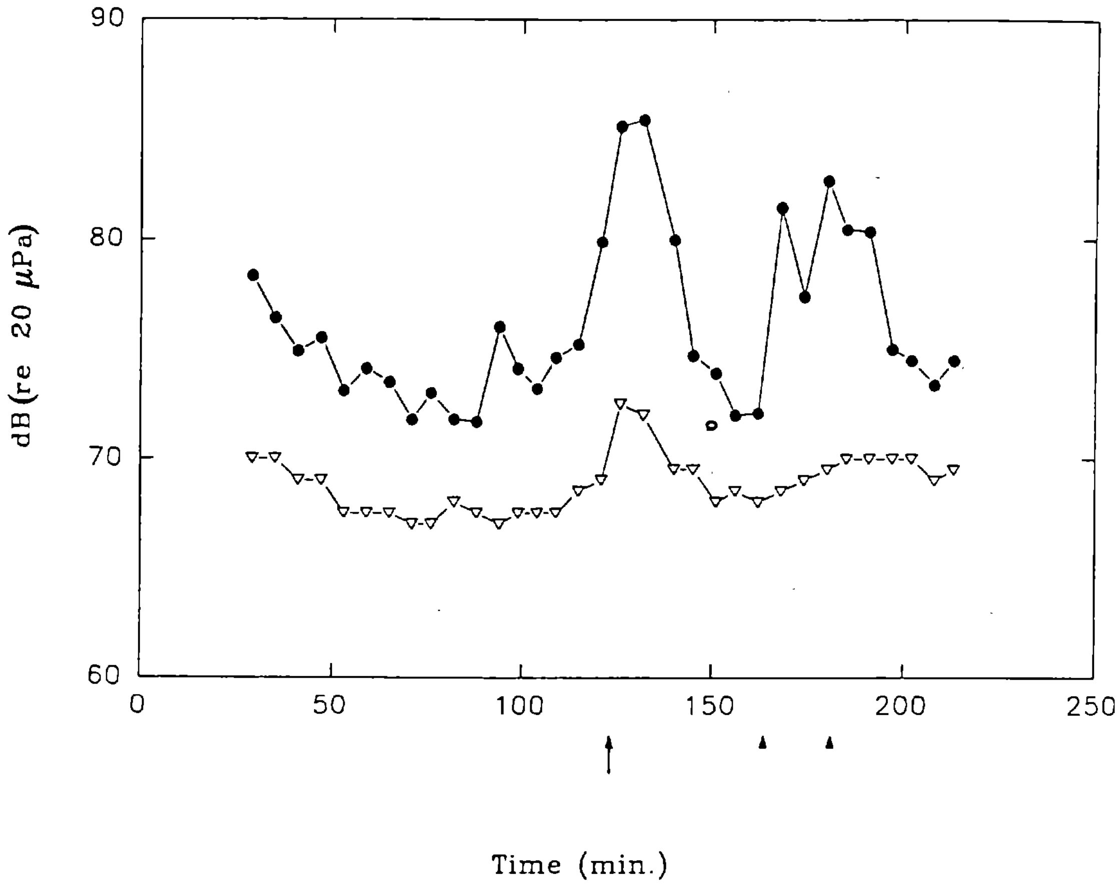

Figure 11.--Background noise L_{90} (▽) and energy average L_{eq} (●) (equivalent continuous sound level) of northern fur seals before and after a human disturbance (↑) at Zapadni rookery, St. Paul Island, Alaska. Nearby males reacting to continued presence of observer is also indicated (▲).

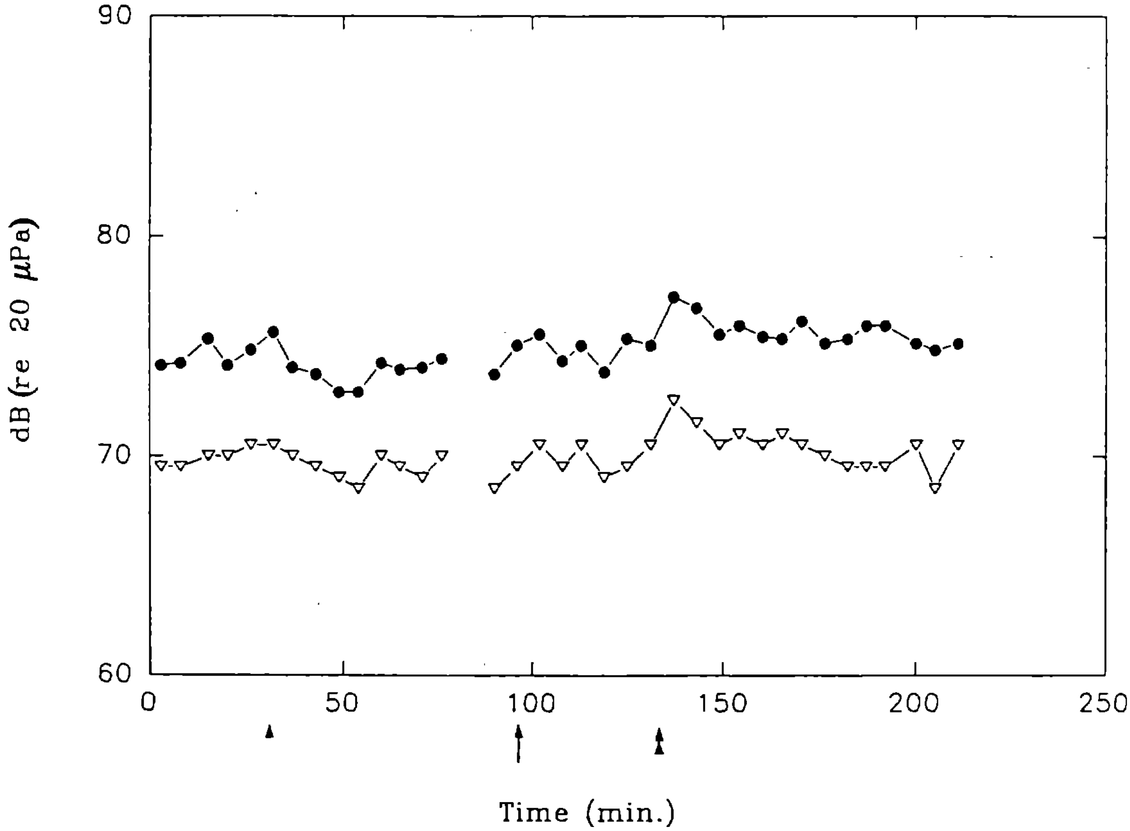

Figure 12.--Background noise L_{90} (▿) and energy average L_{eq} (●) (equivalent continuous sound level) of northern fur seals before and after a human disturbance (↑) at Ardiguen rookery, St. Paul Island, Alaska. An airplane passover (▲) and a male-male conflict (▲) are also indicated.

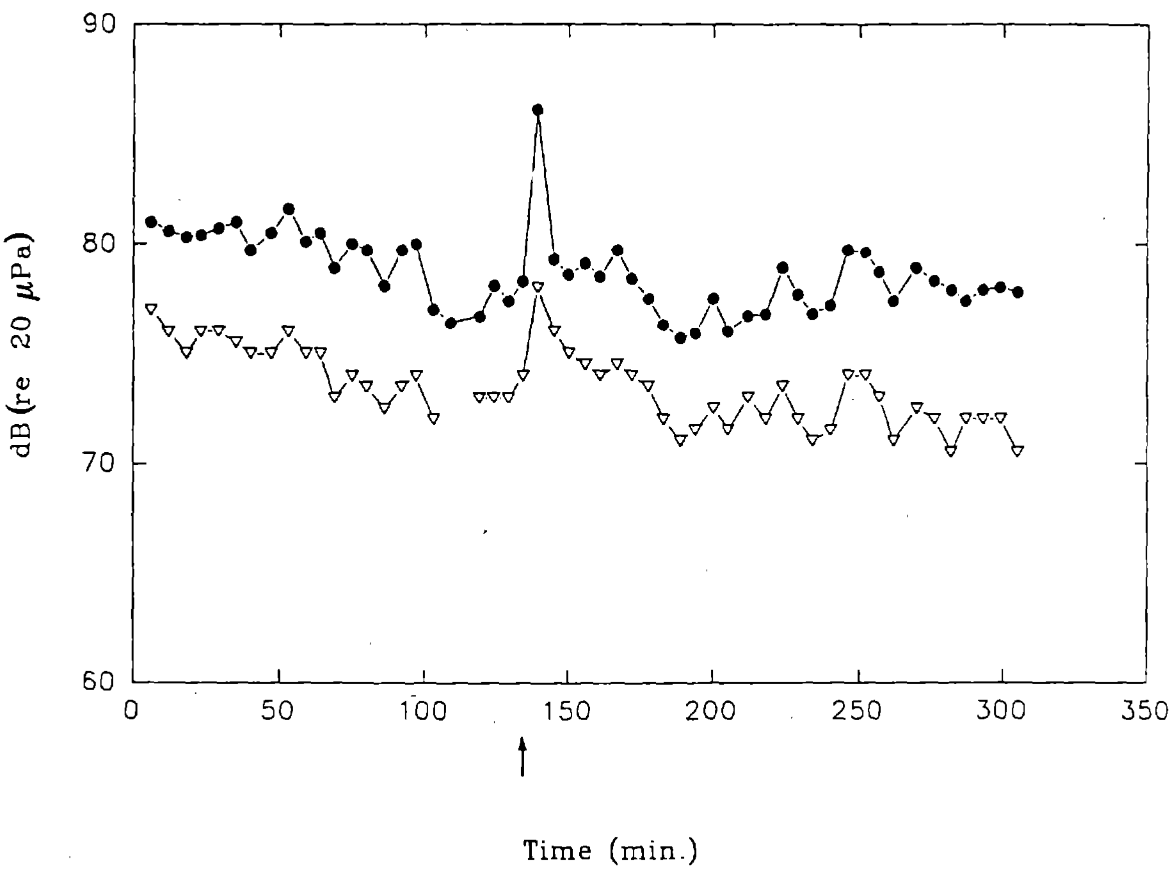

Figure 13.--Background noise L_{90} (▽) and energy average L_{eq} (●) (equivalent continuous sound level) of northern fur seals before and after a human disturbance (↑) at Vostochni rookery, St. Paul Island, Alaska.

primary calls (OPC) from pups (see Insley 1989 for mother-offspring call descriptions), and male whickering combined to determine noise levels. Although this research does show an increase in background noise caused by disturbance, it does not indicate that noise levels exceed natural fluctuations in background noise.

SPLs of fur seal vocalizations--Source SPLs are reported in Table 12. The variation between individuals in call amplitude is notable (i.e., 15.2, 14.0, and 10.0 dB between females, pups, and males, respectively). Given such variation, it is not clear if or how some individuals would be more susceptible to increased noise than others.

Expected call propagation made in the range of ambient noise levels given previously (Figs. l0-13 and Table 8) are listed in Table 13. The values in Table 13 can be used as an approximate guide to changes in audible range but with caution. These estimates indicate a substantial decrease in audible distance resulting from an increase in background noise level. There are two problems with the propagation estimates in Table 13: 1) the seals may be able to detect calls below the background noise level (e.g., humans can often detect a tonal or rhythmic signal l0-15 dB below the minimum noise level); and 2) the acoustic structure of a call in relation to the physical and acoustical environment affects its propagation and perception. Due to these limitations, the propagation distances given in Table 13 are probably underestimates of audible range. However, the change

Table 12.--Source sound pressure levels (SPL) of northern fur seal vocalizations calculated from measured levels.

Call[a]	No. calls	No. callers	$\bar{x}$ SPL @ 1m[b] (dB)	Range (dB)	SD (dB)
MPC	121	36	97.8	89.6-104.8	4.0
OPC	52	25	92.5	84.0- 98.0	3.1
TR	23	6	100.3	95.6-105.6	4.0

[a]Call abbreviations are as follows: the Mother Primary Call (MPC) made by adult females towards their pups; the Offspring Primary Call (OPC) made by nursing pups towards their mothers; and the Trumpet Roar (TR) made by territorial males toward other males.

[b]The source SPLs are grand means (mean of the means of each seal's calls) and the ranges and standard deviations (SD) are of these grand means. Original measurements were made using a linear sensitivity mode and fast response time in dB (re 20 μPa).

Table 13.--Estimation of northern fur seal call propagation distances to indicate change in audible range with different background noise levels.

Call[a]	Distance (m) propagated to reach specified SPL		
	70 dB	80 dB	90 dB
MPC	24.6	7.8	2.5
OPC	13.3	4.2	1.3
TR	32.7	10.4	3.3

[a]Call abbreviations are as follows: the Mother Primary Call (MPC) made by adult females towards their pups; the Offspring Primary Call (OPC) made by nursing pups towards their mothers; and the Trumpet Roar (TR) made by territorial males toward other males.

with distance remains the same.

Conclusions

The purpose of this study was to make a preliminary assessment of the potential impacts of noise on northern fur seals. Direct sources of noise included airplanes, off-road vehicles, construction activities such as blasting, and ship traffic.

Air traffic on the Pribilof Islands may disturb fur seals if aircraft fly too close to rookery or haul-out areas. To reduce the possibility of such disturbances, regulations controlling aircraft flight corridors must be strictly enforced. Additional protection must also be provided when considering plans for airport expansion or relocation.

Ship traffic is expected to increase substantially with the opening of new harbors on both islands. Specific distance guidelines including ocean markers must be recommended for the protection of fur seal breeding areas. Construction activities, especially blasting, should be monitored closely and strictly regulated. Similarly, off-road traffic, especially ATVs, pose a threat but only if they travel in areas that are posted as off limits.

The impact of indirect noise, although largely inconclusive, seems to be minimal unless disturbances are quite frequent. The impact of different levels of disturbance and especially the effect of sensitization remain untested.

STUDIES OF JUVENILE MALES TAGGED AS PUPS AND RESIGHTED DURING ROUNDUPS IN 1990

by

George A. Antonelis, Charles W. Fowler, and Jason D. Baker

A tagging project to examine the role of variability in population dynamics on the growth of northern fur seals on St. Paul Island began during the 1987 summer field season. This project was initiated after concerns were expressed about the decline of the northern fur seal population on the Pribilof Islands. The tagging program began as a feasibility study to test tagging methodologies. The primary objective was to evaluate the use of a newly developed monel cattle ear tag (with a round post) to estimate survival from birth to age 2-5 years for males based on the resighting of tagged individuals in subsequent years.

In addition to collecting tag resight data, information on other aspects of the fur seal population was collected during the first 4 years of this study. In this report, preliminary results are presented on tag resights and frequency of tag loss, homing tendencies of tagged males, the effects of body size and age on juvenile male haul-out patterns, and the influence of the weight of pups on their adult size.

Methods

In 1987, the total number of pups tagged on each rookery on St. Paul Island was approximately 4% of the estimated pup production from the previous year (none were applied on Little Polovina or Sea Lion Rock in any year). The application of tags was distributed among rookeries according to the proportion each rookery contributes to the total estimate of pups born. For example, if 200,000 pups are born on St. Paul Island, approximately 8,000 pups would be tagged (about 4,000 of each sex assuming a 50:50 sex ratio). If 10% of the total number of pups born was on a specific rookery, then 800 pups would be tagged on that rookery. After 1987, only small numbers (400-500) of females were tagged on St. Paul Island at selected study sites; application of tags to males continued at a rate of approximately 4%.

During the tagging procedure, groups of 50 to 100 pups were rounded up and slowly driven to tagging locations on grass or flat areas of the rookery whenever possible. At the tagging site, pups were herded against a 3-sided barricade placed between the pups and the ocean. On irregular terrain, natural seashore elements (such as rocks, logs, and boulders) were used as barricades. While pups were being held within the barricade, researchers were careful to prevent pups from climbing on top of each other to avoid the suffocation of those at the bottom of the pile.

The sex of each pup within the barricade was recorded whether or not the animal was tagged. During tag application, pups were restrained on a plywood board (1 cm x 100 cm x 150 cm) which was placed on level ground. A tag was attached to each foreflipper, approximately 1.0 cm to the distal side of the hairline and 1.7 cm from the posterior edge of the flipper.

Weight information was collected from at least 10% of the pups handled (both males and females) from each rookery. Pups were randomly selected for weighing. The minimum number of pups weighed at any rookery was 100. Pups were weighed by placing the animal head first into the weighing bucket or net, which was suspended by hand from a spring scale. All weights were measured to the nearest 0.25 kg.

The majority of the juvenile male seals were resighted in roundups conducted during the breeding season when fur seals are congregated at, or near, breeding rookeries along the shoreline. A few tagged seals were either resighted or killed in the subsistence harvest on either St. Paul or St. George Islands.

In order to allow comparison between rookeries, haulouts were assigned corresponding rookeries. In some cases, the assignment of haulouts to associated rookeries is subjective. For example, a hauling ground between Little Zapadni and Zapadni rookeries (referred to as Zapadni Sands) could be assigned to either rookery. It was assigned to Zapadni rookery, in view of location and movement of seals onto areas more clearly associated with this rookery. Zapadni Reef Sands, although somewhat removed

Zapadni Reef rookery, was assigned to this rookery. The very tip of Northeast Point is between Vostochni and Morjovi rookeries, but it was designated as part of the Morjovi rookery.

The methods for conducting roundups and resighting are described in Fowler and Ragen (1990) and Fowler et al. (1990a). During this procedure all seals judged to be of the size historically taken in the commercial harvest (approximately 105 to 125 cm in total length) are counted. Some of the animals seen in the early roundups are seen again in later roundups.

Data recorded at the time of recapture included the tag number, condition of the tag, presence of a tag on both flippers, and condition of the flippers, especially at the site of tag attachment. Seals were physically restrained using a restraint board according to procedures described in Gentry and Holt (1982). A nylon harness was used to suspend the restraint board and seal from a spring scale, which was attached to a metal pipe held by two workers while the weight was read. Weight was recorded to the nearest 0.9 kg. The weight of the restraint board was subtracted from the total to determine the weight of the seal. Seals killed during the subsistence harvest were weighed directly on a platform scale.

Results and Discussion

TaG Resights

Tag numbers, sex, and rookery where northern fur seal pups were tagged on St. Paul Island in 1987 and 1988 are listed in Tables 14 and 15, respectively. In cases where the total number

Table 14.--Ranges of tag numbers and numbers of monel tags applied to northern fur seal pups on the rookeries of St. Paul Island in 1987; the differences in tag totals represents seals of unidentified sex.

	Tag number		Males	Females	Tags applied
Rookery	Beginning	Ending	No.	No.	No.
Vostochni	A06859	A07706	430	413	847
Morjovi	A06449	A06858	239	168	408
Little Polovina	-	-	0	0	0
Polovina Cliffs	A01814 A07707	A02769 A08055	720	584	1,304
Polovina	A01659	A01813	84	70	155
Lukanin	A01009	A01658	344	305	650
Kitovi	A00001	A00607	322	282	605
Reef	A03945	A04651	375	331	706
Ardiguen	-	-	0	0	0
Gorbatch	A04652	A05195	281	263	544
Tolstoi	A02770	A03944	626	524	1,151
Zapadni Reef	A00608	A01008	234	166	400
Little Zapadni	A05959	A06448	264	224	488
Zapadni	A05196	A05958	400	361	762
Total	A00001	A08055	4,319	3,691	8,020

Table 15.--Ranges of tag numbers and numbers of monel tags applied to northern fur seal pups on the rookeries of St. Paul Island in 1988.

	Tag number		Males	Females	Tags applied
Rookery	Beginning	Ending	No.	No.	No.
Vostochni	A09494	A10419	498	428	926
Morjovi	A11106	A11528	229	189	418
Little Polovina	-	-	0	0	0
Polovina Cliffs	A09294 A11529	A09493 A12147	263	522	788
Polovina	A09194	A09293	43	57	100
Lukanin	A10654	A11105	83	358	444
Kitovi	A14115	A14386	155	111	266
Reef	A08056	A08667	307	300	609
Ardiguen	A09089	A09193	56	48	104
Gorbatch	A08668	A09088	219	199	419
Tolstoi	A13301	A14114	437	362	799
Zapadni Reef	A10420	A10653	120	112	233
Little Zapadni	A12148	A12598	246	189	438
Zapadni	A12599	A13300	385	286	672
Total	A08056	A14386	3,041	3,164	6,222

of tagged pups does not equal the total for the two sexes, there are data missing for the determination of the sex. No pups were tagged on Little Polovina rookery either year, and no seals were tagged on Ardiguen rookery in 1987.

One hundred twenty-two roundups of male northern fur seals were completed on St. Paul Island during July and early August of 1990 (See Appendix Table C-l). During these roundups, 25,829 male seals judged to be of the size historically taken in the commercial harvest were counted. A total of 386 seals with monel tags were resighted, 23.6% of which were resighted at least twice. This corresponds well with 25-30% resighting of seals from the entanglement research (for both unentangled and entangled animals; Fowler and Ragen 1990). Of the total, 76.4% were seen only once, 18.9% were seen twice, 4.4% three times, and 0.3% six times. Excluding those seals taken in the subsistence harvest, at least 319 3-year-olds and 56 2-year-olds remain in the tagged population of seals in this study.

Of the monel tagged seals resighted in 1990, 326 (84.5%) were 3-years-old (tagged in 1987) and 60 (15.5%) were 2-years-old (tagged in 1988). The relative accumulation of these totals (using only the first of the multiple resightings) over the season are shown in Figure 14 and indicates that most of the 2-year-old seals were resighted late in the series of roundups. In 1989, the total sample of 20 2-year-old seals were resighted by 26 July. In contrast in 1990, 31 (51.6%) of the 60 a-year-old seals had been seen by 26 July. Of the 326 3-year-old seals

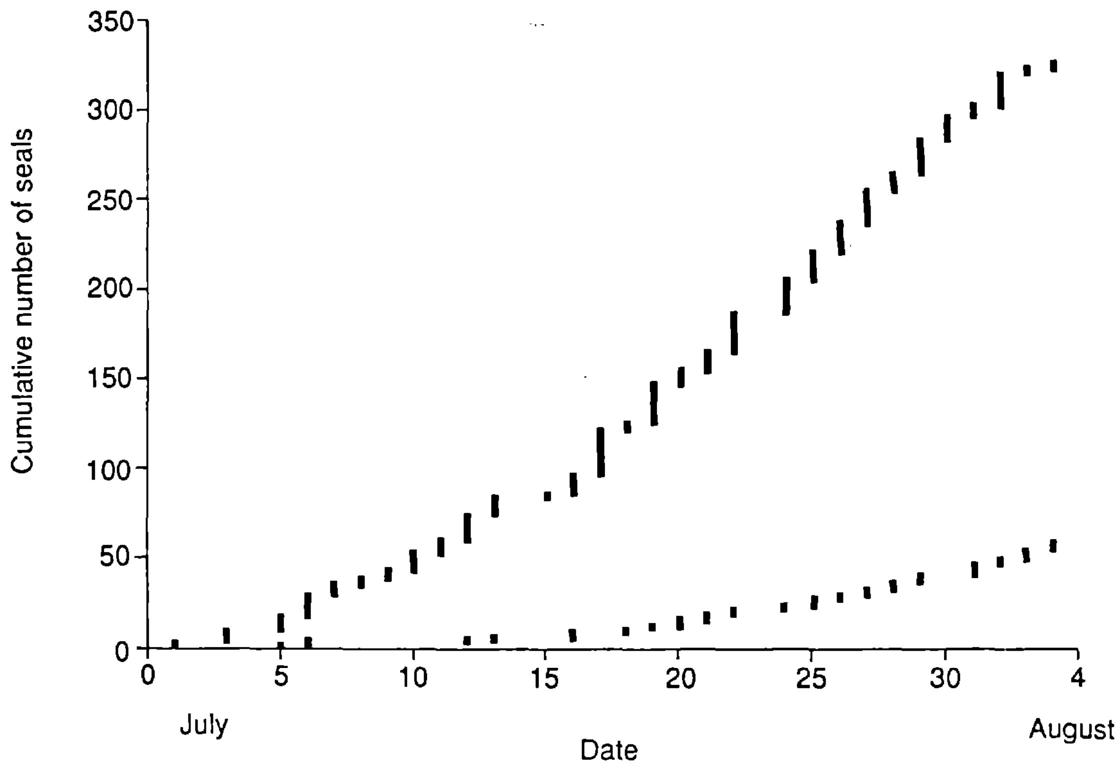

Figure 14. --Daily accumulation of tagged 2- (lower curve) and 3- (upper curve) years-old male northern fur seals resighted during roundups on St. Paul Island, Alaska, 1 July-5 August.

sighted in 1990, 50% had been seen by 21 July, and 72.4% by 26 July.

The rookery of tagging and the rookery where juvenile male seals were resighted for both 2- and 3-year-old animals in 1990 is listed in Table 16 for the first sightings of each seal. The fraction of 3-year-old seals tagged on each rookery that were resighted during the 1990 roundups is listed in Table 17. Roundups were not conducted on Little Polovina, Polovina Cliffs, or Ardiguen rookeries. The distribution of rookery of resighting compared to the rookery of tagging is shown for 3-year-old seals in Table 18 and for 2-year-old seals in Table 19 (both tables include the multiple sightings for 1990). These tables are arranged with the rookeries listed in clockwise arrangement for St. Paul Island starting with Vostochni rookery. In this manner the rookeries are listed so that the nearest rookeries are adjacent to each other in the table. For the larger sample of 3-year-old seals, the tendency for individuals to be resighted at the rookery where they were tagged is apparent from the larger numbers along the diagonal axis of the corresponding table.

Only 5 of the 20 a-year-old juvenile male seals sighted in 1989 were seen among the 326 3-year-old resights in 1990. Data such as these for the subsequent resighting of both 2- and 3-year-old seals will be used in estimating survival following the collection of similar data in 1991.

The numbers of seals with missing tags are summarized in Table 20. The percentage of tag loss for a-year-old seals is

Table 16.-- The numbers (and percentages) for the first resighting of juvenile male seals seen by rookery of tagging (as pups) and rookery where resighted during July 1990, St. Paul Island, Alaska.

Rookery	Three-year-old seals		Two-year-old seals	
	Total resighted by rookery of origin	Total by rookery of resighting	Total resighted by rookery of origin	Total by rookery of resighting
Vostochni	45(13.8)	65(20.1)	9(15.0)	15(26.3)
Morjovi	25(7.7)	30(9.3)	2(3.4)	2(3.5)
Little Polovina	0(0.0)	0(0.0)	0(0.0)	0(0.0)
Polovina Cliffs	58(17.8)	0(0.0)	9(15.3)	0(0.0)
Polovina	5(1.5)	39(12.1)	0(0.0)	7(12.3)
Lukanin	33(10.1)	33(10.2)	4(6.8)	5(8.8)
Kitovi	18(5.5)	10(3.1)	7(11.8)	1(1.8)
Reef	25(7.7)	22(6.8)	5(8.5)	2(3.5)
Ardiguen	0(0.0)	0(0.0)	0(0.0)	0(0.0)
Gorbatch	25(7.7)	29(9.0)	7(11.8)	8(14.0)
Tolstoi	39(12.0)	22(6.8)	7(11.8)	5(8.8)
Zapadni Reef	12(3.7)	31(9.6)	2(3.4)	0(0.0)
Little Zapadni	22(6.7)	4(1.2)	4(6.8)	0(0.0)
Zapadni	19(5.8)	38(11.8)	3(5.1)	12(21.1)
Total	326	323	59	57

Table 17.--The numbers of 3-year-old juvenile male northern fur seals sighted on St. Paul Island in 1990 corresponding to the rookery where they were tagged, also expressed as a fraction of the tags applied.

Rookery	Number Tagged	Number Resighted	Fraction resighted	Roundup days
Vostochni	322	45	0.14	6
Morjovi	240	25	0.10	6
Little Polovina	0	0	-	0
Polovina Cliffs	728	58	0.08	0
Polovina	84	5	0.06	5
Lukanin	345	33	0.10	5
Kitovi	322	18	0.06	5
Reef	375	26	0.07	4
Ardiguen	0	0	-	0
Gorbatch	281	25	0.09	8
Tolstoi	626	39	0.06	5
Zapadni Reef	234	12	0.05	6
Little Zapadni	264	22	0.08	3
Zapadni	400	19	0.05	6

Table 18.--Numbers of 3-year-old juvenile male northern fur seals seen during 1990 at the haulout of a particular rookery (identified on top row) as compared to the rookery where tagged (left column).[a]

	A	B	E	F	G	H	J	K	L	M	N
A	24	9	3	3	0	2	3	2	1	0	6
B	6	6	3	1	1	1	3	2	3	0	1
C	0	0	0	0	0	0	0	0	0	0	0
D	22	7	21	5	0	3	3	0	6	0	7
E	0	0	1	0	0	0	1	1	2	0	0
F	7	2	3	13	5	0	7	0	0	0	2
G	3	1	1	6	6	2	3	2	1	1	5
H	2	1	2	0	3	14	7	2	4	0	4
I	0	0	0	0	0	0	0	0	0	0	0
J	3	3	0	5	0	3	13	3	2	0	2
K	13	2	4	3	0	1	4	11	7	0	6
L	4	1	0	0	0	0	0	1	5	0	3
M	5	1	1	4	0	4	3	2	3	3	8
N	3	1	5	0	0	1	0	1	2	2	7

[a]Rookery identity for St. Paul Island as follows: A = Vostochni; B = Morjovi; C = Little Polovina; D = Polovina Cliffs; E = Polovina; F = Lukanin; G = Kitovi; H = Reef; I = Ardiguen; J = Gorbatch; K = Tolstoi; L = Zapadni Reef; M = Little Zapadni; N = Zapadni.

Table 19.--Numbers of 2- year-old juvenile male northern fur seals seen at the haulout of a particular rookery (identified on top row) as compared to the rookery where tagged (left column).*

	A	B	E	F	G	H	J	K	L	M	N
A	5	0	0	1	1	0	0	0	0	0	2
B	0	0	1	0	0	0	1	0	0	0	0
C	0	0	0	0	0	0	0	0	0	0	1
D	2	1	6	0	0	0	0	0	0	0	0
E	0	0	0	0	0	0	0	0	0	0	0
F	0	1	0	1	0	0	0	0	0	0	2
G	3	0	0	1	0	0	1	2	0	0	1
H	3	0	0	1	0	1	3	0	0	0	1
I	0	0	0	0	0	0	0	0	0	0	0
J	0	0	1	1	0	3	1	1	0	0	0
K	2	0	0	0	0	0	1	4	0	0	3
L	1	0	0	0	0	0	1	0	0	0	1
M	2	0	0	0	0	0	1	0	0	0	1
N	0	0	0	0	0	0	0	0	0	0	3

*Rookery identity for St. Paul Island as follows: A = Vostochni; B = Morjovi; C = Little Polovina; D = Polovina Cliffs; E = Polovina; F = Lukanin; G = Kitovi; H = Reef; I = Ardiguen; J = Gorbatch; K = Tolstoi; L = Zapadni Reef; M = Little Zapadni; N = Zapadni.

Table 20.--Listing of the numbers of tags lost by flipper (with percent of total in parentheses) and age for individual juvenile male northern fur seals seen in roundups during July 1990, St. Paul Islands, with the estimated double tag loss rate (percent) for each age[a].

Age	Seal numbers	Side of tag loss Left	Right	Neither	Double tag loss[b] (%)
2	60	3(5.0)	2(3.3)	55(91.7)	0.18
3	325	42(12.9)	36(11.1)	247(76.0)	1.85

[a]Seal number A06426 lost a tag between two sightings on the same day. Seals numbered A00532, A03004, and A04510 lost tags between first and subsequent sightings. All included in above calculations and tabulations.

[b]Calculated with the expression $p = (n_1 n_2)/((n_1+n_3)(n_2 n_3))$ where (assuming the probability of tag loss on one flipper is independent of loss on the other):

- p = the fraction with both tags lost.
- n_1 = the number of seals of a specific age with tags lost on the left side.
- n_2 = the number of seals of a specific age with tags lost on the right side.
- n_3 = the number of seals of a specific age with both tags present.

less than for 3-year-olds. Whether this is a result of continuing loss with age or a difference in the means of application is unknown. Whether or not the higher loss of tags on the left side for both ages is significant will require further sampling. Further information on the condition of the tags, tag holes, and flippers for evaluation of tagging procedures and effects on seals will be analyzed and presented in the future.

Weights of Tagged Fur Seals

A total of 376 juvenile males were weighed during the course of the season. Three-year-olds weighed an average of 28.1 kg (SD = 4.1; n = 318), and 2-year-olds weighed 21.7 kg on average (SD = 2.9; n = 58). The mean weight of an individual seal caught more than once was used in the above calculation. The weight distribution of 2- and 3-year-olds is shown in Figure 15.

The data on body weights collected during roundups support some of our information pertaining to the breeding season behavior of juvenile males, including the relative influence of factors such as age and size on their haul-out patterns. For example, it has long been known, and is clearly evident from Figure 14, that older males arrive on St. Paul Island earlier than younger males. We questioned whether this was truly an effect of age or whether, in general, smaller seals simply arrive later. If the latter were true, we would expect a relationship between weight and date of first sighting within an age class. Simple linear regression analysis indicated no such relationship

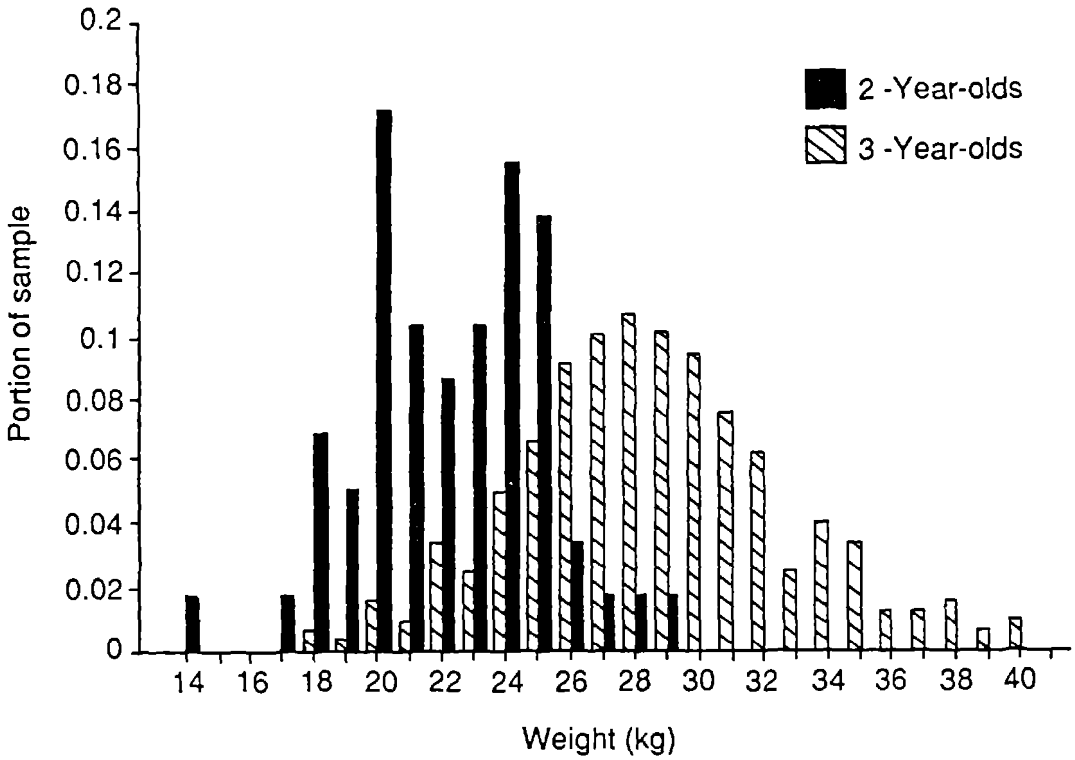

Figure 15.--Weight distributions (kg) of 2- and 3-year-old tagged northern fur seals captured during roundups on St. Paul Island, Alaska, 1990.

(for 3-year-olds, $r = 0.06$, $P = 0.14$; for 2-year-olds, $r = 0.01$, $P = 0.17$), and that date of arrival is a behavior more influenced by age than body size.

A related question pertains to the proportion of time seals spend ashore once they have returned to the island. If different size classes of males from the same cohort spend different proportions of time ashore, they should also have different capture probabilities during roundups. To investigate the possible effect of body size on probability of capture, we plotted the weights of individual 3-year-old tagged males against the number of times they were seen during the 1990 roundups (Fig. 16). The mean of all captures was used for each seal caught more than once. Regression analysis showed no significant relationship between weight and the number of times a seal was seen, indicating that body size (within the age class) did not affect the proportion of time spent ashore during the period we sampled. It may be that age within the age class is an important factor in this regard; however, we would need to conduct roundups for a longer period of time after 2-year-olds begin arriving in order to test for age-specific differences.

Weights of seals that were captured more than once during the season were strikingly variable, and distinct trends in this variability were identified. The subsequent weights of individuals as proportions of weight at first capture are given in Figure 17. There is a trend of decreasing weight following the first capture with some individuals losing as much as 30% of

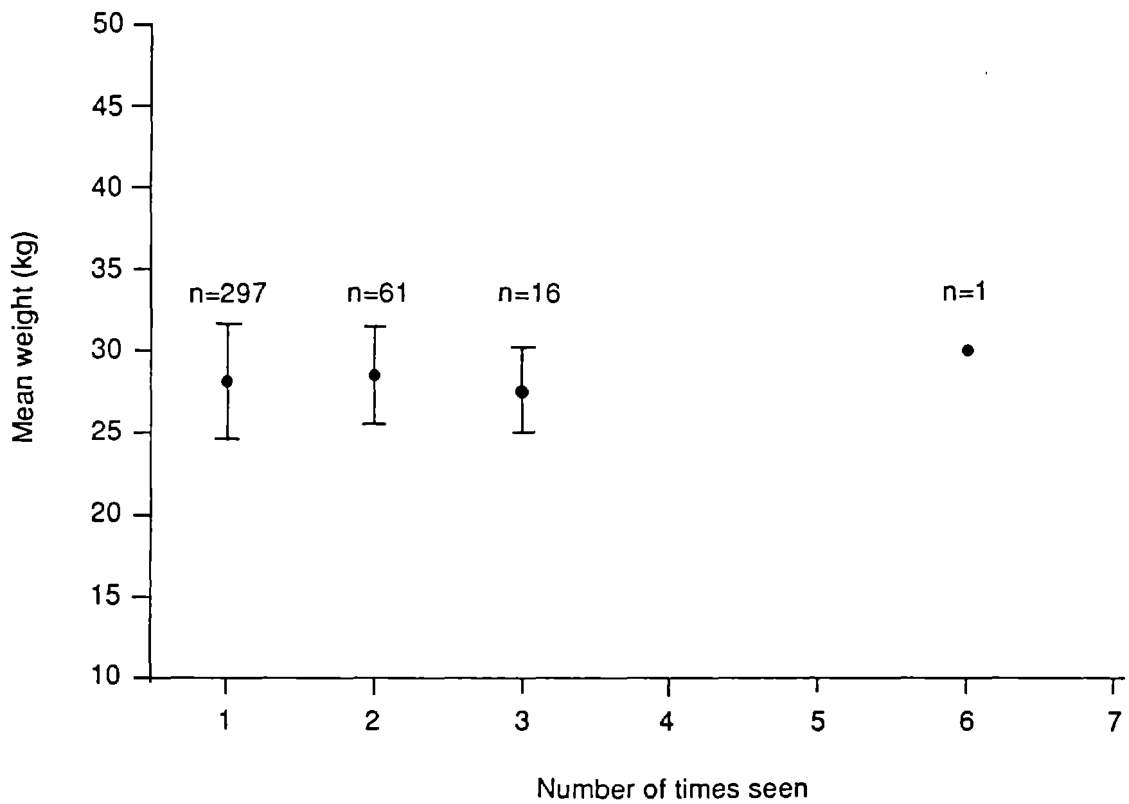

Figure 16. --Weights (kg) of 3-year-old male northern fur seals plotted against the number of times they were captured during roundups on St. Paul Island, Alaska, 1990. Means of multiple weighings were plotted for each animal captured more than once. The overall mean for animals captured once was 28.22 kg (SD = 4.22, n = 297), for those captured twice, the mean was 28.67 kg (SD = 3.76, n = 61), and seals captured three times weighed 27.80 kg (s = 2.98, n = 16) on average. The average weight of one animal captured six times was 29.8 kg.

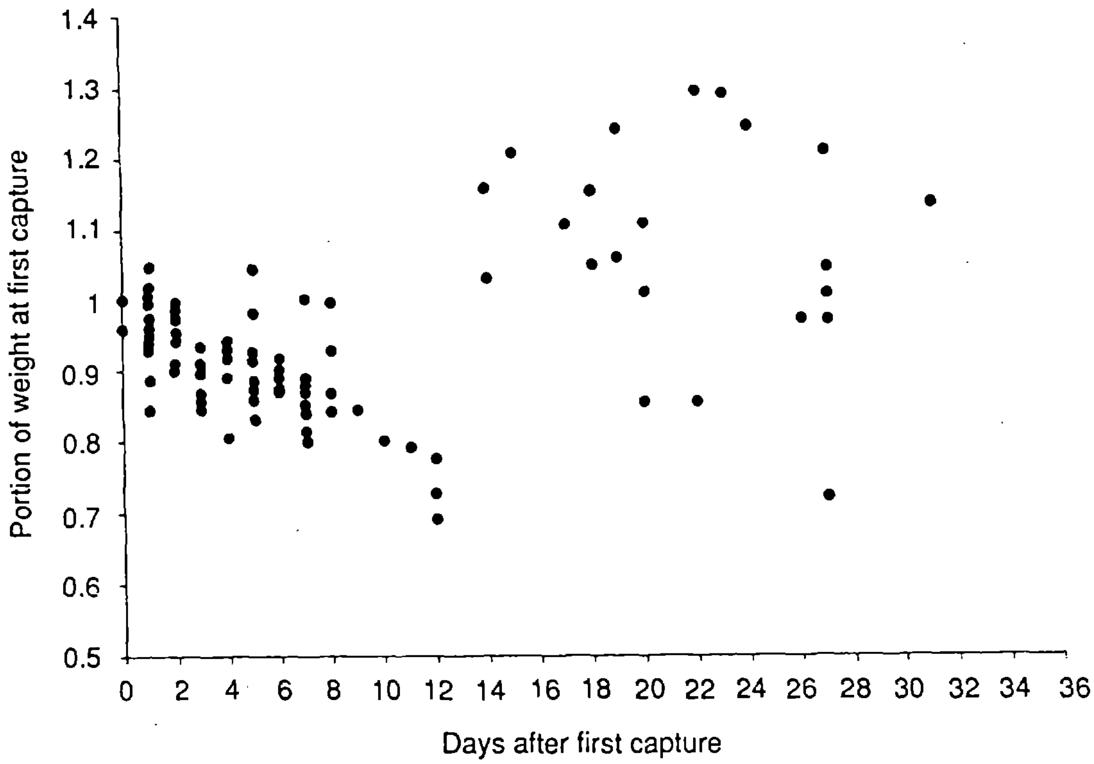

Figure 17. --Subsequent weights of juvenile male northern fur seals expressed as proportions of their weight at first capture and plotted against the number of days since the first capture on St. Paul Island, Alaska.

their body weight. After 12 days there is a discontinuity in the data where proportions of weight at first capture are more variable but have, on the average, increased. The mean proportion for seals weighed 14 or more days after their first capture was 1.08 (i.e., 8% more than they did at the first weighing; SD = 0.15; n = 22).

The conditions under which we weigh juvenile males are certainly less than ideal, and significant variance due to measurement error is expected. Yet, weight values through day 12 in Figure 17 indicate seals seem to be losing weight at a fairly constant rate, presumably while fasting on land. Because seals do not gain weight while on land, any points falling above 1.0 indicate either a feeding trip has been made or there was an error in the weighing procedure. The group of points above 1.0 starting at day 14 probably indicate that those animals have regained weight after a feeding trip, and are likely growing during the summer. The few points above 1.0 from before day 12 may either reflect measurement error or short feeding trips.

Some of the tagged juvenile males weighed in 1990 had previously been weighed as pups in late August, so it was possible to assess the effect of pup weight on weight later in life. Simple linear regression indicated a significant relationship between pup weight and weight at 2 and 3 years of age (Figs. 18 and 19; for 2-year-olds, ($r = 0.41$, $P = 0.02$; for 3-year-olds, $r = 0.28$, $P = 0.03$). Among these seals, the mean pup weight for resighted 3-year-old males was 9.70 kg (SD = 1.61,

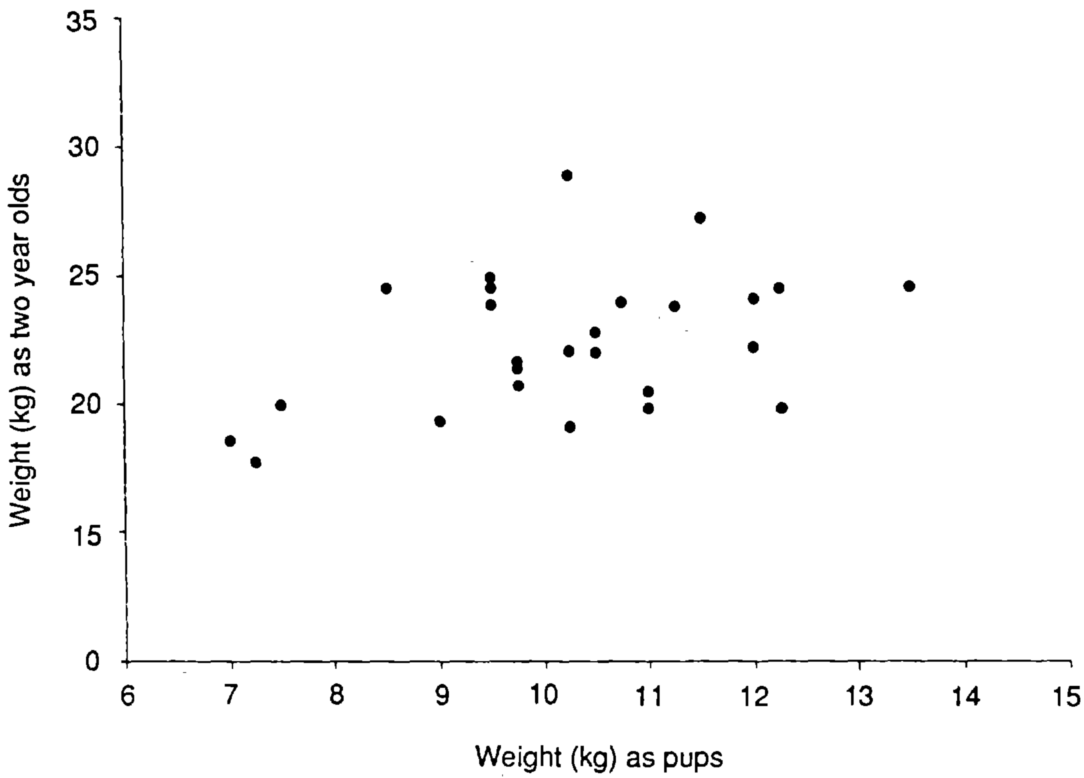

Figure 18.-- Relationship between male northern fur seal pup weight (measured in late August of the year of birth) and weight at age 2 during roundups on St. Paul Island, Alaska, 1990.

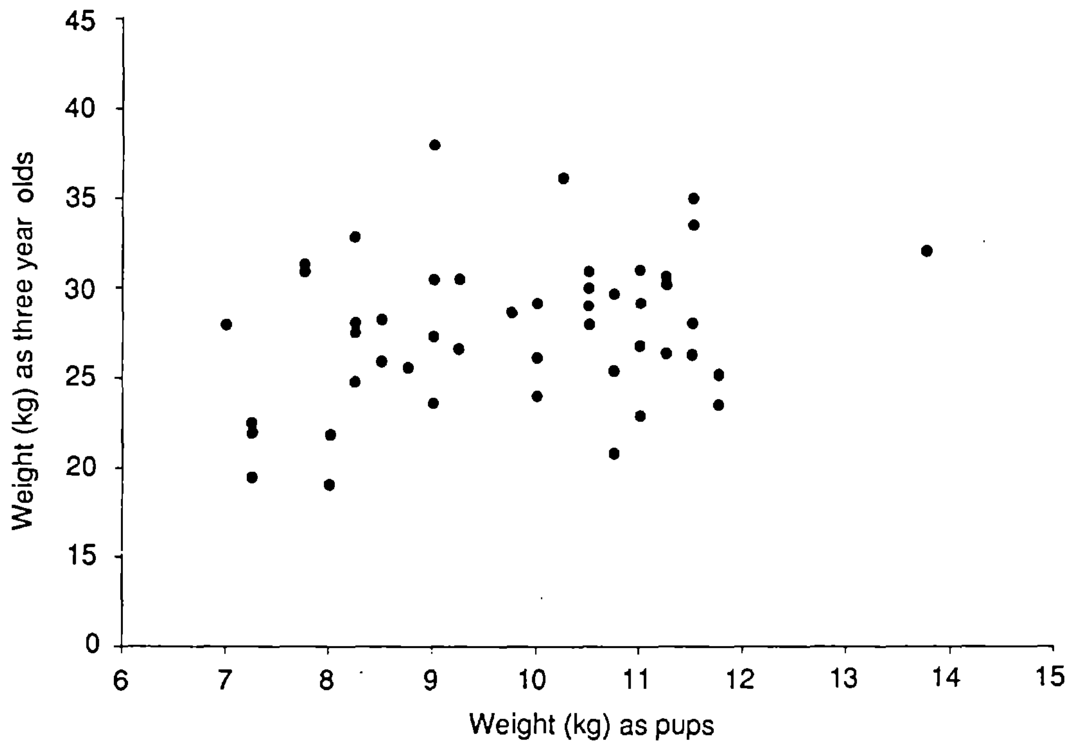

Figure lg.-- Relationship between male northern fur seal pup weight (measured in late August of the year of birth) and weight at age 3 during roundups on St. Paul Island, Alaska, 1990 n = 49) compared to 9.64 kg (SD = 1.94, n = 658) for all male pups weighed from the 1987 cohort (no significant difference, P = 0.833). Resighted 2-year-olds weighed an average of 10.21 kg (SD = 1.56, n = 30) as pups compared to 9.52 kg (SD = 1.77, n = 1,224) for all male pups weighed as pups in 1988 (a significant difference, P = 0.035).

Based on the regression analyses of data in Figures 18 and 19, there is evidence that pup size may influence adult body size. The acceptance of this relationship is based on the assumption that the timing of capture in the haul-out pattern of males 2 and 3 years of age (Fig; 17) is unrelated to pup weight. Such a relationship between pup weight and later growth probably reflects, in part, genetic determination of body size. However, managers must also consider both natural and anthropogenic factors, which may influence the weight of pups and could result in affecting their body size later in life.

The relationship between the mean weight of 3-year-olds and pup production on St. Paul Island is illustrated in Figure 20 (Fowler et al. 1990), with the addition of the new data point for 1990.

Miscellaneous Observations

The following tag resights of fur seals from the 1987-88 cohorts were obtained on the Commander Islands (U.S.S.R.).

Bering Island

November 8, 1989 - Al3599 (alive).

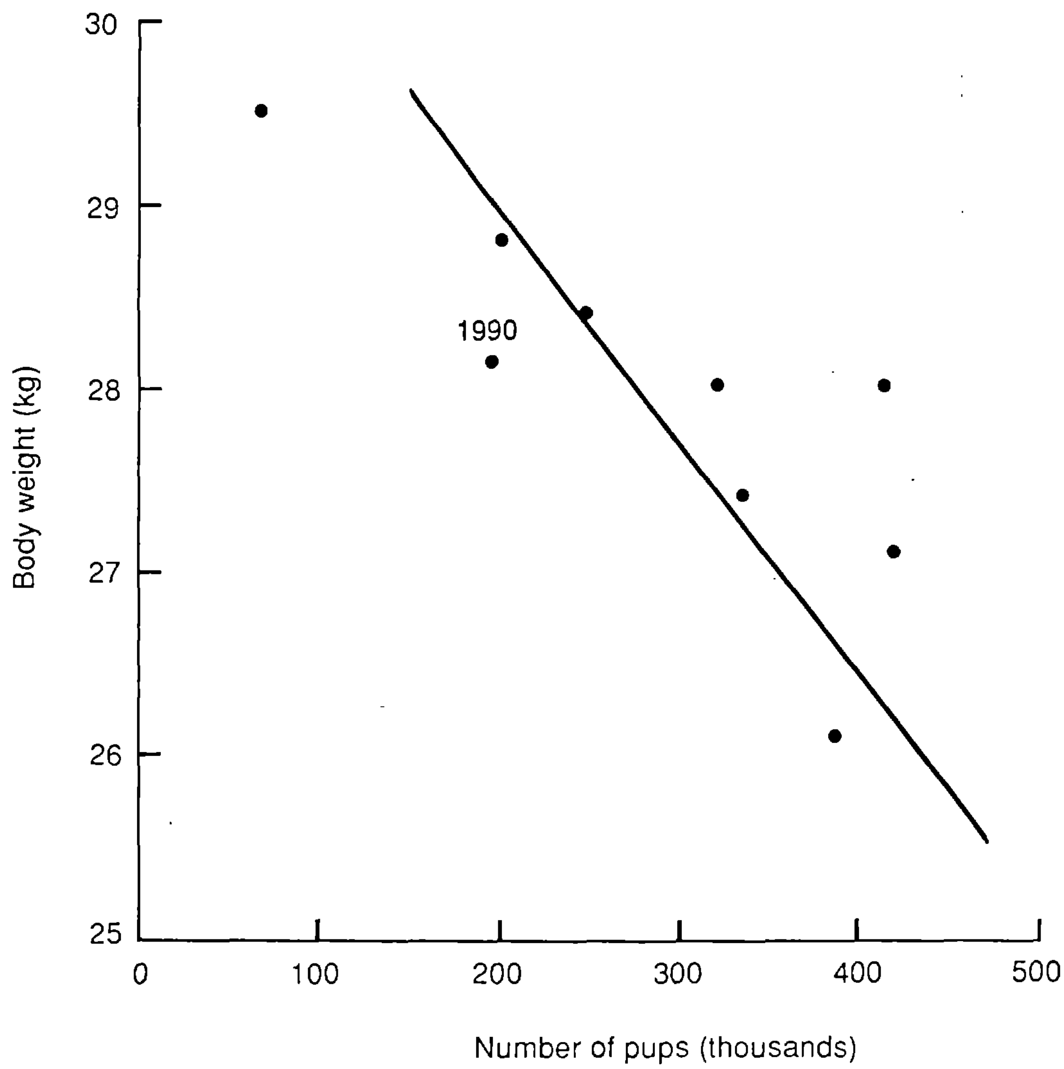

Figure 20.-- Relationship between mean weight (kg) of 3-year-old male northern fur seals and pup production 3 years previous on St. Paul Island, Alaska. This figure was taken from Fowler et al. 1990a (Marine Mammal Science 6(3):171-195). A data point for 1990 was using only the weights at first capture to calculate the mean as had been done in the other years.

Medny Island

July 27, 1990 - A03447 (alive), Al2627 (alive), and A06169 (dead).

August 16, 1990 - A08691 (alive) and A09795 (alive).

ENTERIC BACTERIAL PATHOGENS ASSOCIATED WITH NORTHERN FUR SEAL PUPS ON THE PRIBILOF ISLANDS AND AT MEDNY ISLAND, U.S.S.R.

by

Mathew A. Burd, James T. Harvey, and George A. Antonelis

Causes of the 1975-81 fur seal decline have not been specifically identified but may include the combined effects of a female harvest during 1956-68, entanglement in marine debris, weather, food resource availability, and disease (Laughlin 1989). In 1990, the National Marine Mammal Laboratory (NMML) contracted Moss Landing Marine Laboratories to survey bacterial pathogens in northern fur seal (*Callorhinus ursinus*) pups on the Pribilof Islands (St. Paul and St. George Islands) and Medny Island, U.S.S.R. The objectives of this study were to 1) identify bacterial pathogens in northern fur seal pups, 2) to determine interisland and interrookery pathogen incidence, and 3) to compare pathogen incidence with pup condition.

Methods

Between 14 and 31 August 1990, 4,443 northern fur seal pups were flipper tagged by NMML researchers. During this time, rectum, throat, and occular bacterial samples were collected from pups on 3 rookeries at St. George Island, 12 rookeries at St. Paul Island, and 1 rookery at Medny Island.

Thirty pups were randomly selected on each rookery, and sex, weight, length, cranial width, blubber thickness, and foreflipper length was recorded (Table 21). Sterile rayon swabs (Culture-Transport System, Difco) were used to obtain ocular, throat, and rectal samples from 449 fur seal pups. Chocolate agar plates were inoculated with ocular swabs and MacConkey II Agar and Hektoen Euteric Agar plates were inoculated with rectal swabs. Trypticase Soy Agar (TSA) + 5% sheep blood agar plates were inoculated with rectal swabs only from pups on St. George Island.

All plates were examined after 24 hours incubation and MacConkey II Agar and Hektoen Enteric Agar plates were examined for colonies suggestive of nonlactose fermenters and coliforms. Colony characteristics were described (e.g., Salmonellae sp.: round, blue colonies with black centers) and each colony type was stored on maintenance media at 2-8° C. All frozen swabs, plates, and pure cultures were shipped to Moss Landing Marine Laboratories for analysis.

Cultures showing typical Salmonellae characteristics were tested for oxidase, urease, and lysine decarboxylase activity and for motility. All cultures were identified using the Minitek Miniaturized Differentiation System (Becton, Dickenson & Co.). Escherichia coli cultures were inoculated onto TSA + 5% sheep blood agar plates to screen for hemolysis. Serological agglutination tests (Becton, Dickenson & Co.) will be used to definitively identify Salmonellae cultures.

Table 21.--Data collected on the Pribilof Islands, August 1990.

Study site:	St George Island, Alaska
Study animal:	*Callorhinus ursinus* pups
Study period:	14-19 August 1990
Rookeries:	3 (North, Zapadni, and East)
Crew size:	2 persons
Measurements:	Sex, weight, length, blubber thickness, cranial width and foreflipper length
Swab type:	Ocular, throat, and rectal
Total pups:	90 (30 per rookery)
Total swabs:	269
Dead pups examined:	10
Canines collected:	10 pairs
Study site:	St. Paul Island, Alaska
Study animal:	*Callorhinus ursinus* pups
Study period:	25-30 August 1990
Rookeries:	12 (Vostochni, Morjovi, Little Zapadni, Zapadni, Zapadni Reef, Lukanin, Polovina, Polovina Cliffs, Kitovi, Tolstoi, Reef, and Gorbatch)
Crew size:	2 to 3 persons
Measurements:	Sex, weight, length, blubber thickness, cranial width, and foreflipper length
Swab type:	Ocular, throat, and rectal
Total pups:	360
Total swabs:	1,080
Dead pups examined:	40
Canines collected:	40 pairs

Results and Discussion

Enteric Pathogens

St. Paul Island--Salmonella enteritidis was identified in 10% of pups sampled on Little Zapadni, 3.3% on Zapadni, and 13.3% on Zapadni Reef rookeries. Pseudomonas aeruginosa was isolated only on Morjovi rookery in 36% of pups sampled, and Acinetobacter lwoffi was isolated only on Reef rookery in 20% of pups sampled (Table 22).

St. George Island--Staphylococcus aureus was isolated only on North rookery in 24% of the pups sampled and Streptococcus sp. were found in 6% of pups sampled from North, 23.3% from East, and 20% from Zapadni rookeries (Table 22).

Medny Island--no primary enteric pathogens were isolated.

The incidence of Salmonella spp. within rookeries (3.3-13.3%) and in the sampled population (2.2%) was much less on the Pribilof Islands than that found by Gilmartin et al. (1979) in pups of northern. fur seals on San Miguel Island, California. Differences may be due to the greater sample size taken from the Pribilof Islands and the lack of selective enrichment procedures for Salmonella sp. Weights of pups with Salmonella from Little Zapadni, Zapadni, and Zapadni Reef rookeries were pooled and compared to the pooled weights of uninfected pups from these rookeries. Mean weight (7.02 kg) of pups with Salmonella was significantly less than the mean

Table 22.--Number of fur seal pups with a potential bacterial pathogen (n = 30 random samples) on St. Paul, St. George, and Medny Island rookeries.

	St. Paul												St. George			Medny
Rookery	V	M	LZ	Z	ZR	L	P	PC	K	T	R	G	N	E	Z	ME
Pathogens																
Salmonellae sp.	0	0	3	1	4	0	0	0	0	0	0	0	0	0	0	0
Pseudomonas aeruginosa	0	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Acinetobacter lwoffi	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0
Staphylococcus aureus[b]	-	-	-	-	-	-	-	-	-	-	-	-	7	0	0	-
Streptococcus sp.	-	-	-	-	-	-	-	-	-	-	-	-	2	7	0	-
Opportunistic pathogens																
Citrobacter sp.	4	12	11	13	9	6	12	3	6	4	4	1	8	3	6	4
Enterobacter sp.	8	2	8	5	5	0	3	6	2	7	4	1	3	2	2	5
Escherichia coli	23	14	22	25	18	11	16	20	9	16	23	18	11	21	14	17
Proteus sp.	8	9	10	10	4	0	7	3	0	8	6	6	9	5	8	2
Serratia sp.	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
Morganella morganii	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0
Klebsiella sp.	4	0	2	4	0	3	3	1	0	0	0	0	5	2	0	1

Table 22.--Continued.

Rookery	St. Paul V	M	LZ	Z	ZR	L	P	PC	K	T	R	G	St. George N	E	Z	Medny ME
Opportunistic pathogens																
Hafnia alvei	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0

[a]V=Vostochni, M=Morjovi, LZ=Little Zapadni, Z=Zapadni, L=Lukanin, P=Polovina, PC= Polovina Cliffs, K= Kitovi, T=Tolstoi, R=Reef, G=Gorbatch, N=North, E=East, Me=Medny

[b]a dash indicates swabs were not used to inoculate trypticase soy agar +5% sheep blood agar plates.

weight (9.20 kg) of uninfected pups ($t = 3.826$, $P = 0.0002$). Gilmartin et al. (1979) suggested that Salmonella serotypes cause only mild gastroenteritis followed by a prolonged carrier state and that maternally acquired antibodies protect young animals. Mortality due to Salmonella sp. does not appear to be a problem on San Miguel Island (Gilmartin et al. 1979). Data from this study may indicate that Salmonella infection is a more serious problem on the Pribilof Islands; however, data on the weights of infected and uninfected pups was not available from the San Miguel study for comparison.

Pseudomonas spp. are widely distributed in soil and water. Clinically significant pseudomonads are largely limited to the species P. aeruginosa, which is a frequent cause of bacteremia and pneumonia, especially in the immuno-supressed host (Washington 1985). Mean weight (8.8 kg), of pups infected with P. aerusinosa was not significantly different from uninfected pups (8.7 kg; $t = 0.322$, $P = 0.75$) and does not appear to be a threat to their health.

Acinetobacter calco/lwoffi was isolated from adult Antarctic fur seals (Arctocephalus sazella) with enteritis (Baker and McCann 1989). In the present study, mean weight (7.9 kg) of pups with A. lwoffi was significantly different from uninfected pups (9.9 kg; $t = 2.507$, $P = 0.018$).

Relatively few pathogens were isolated in pups on St. George Island. Staphylococcus aureus, the etiologic agent of staphylococcal entercolitis, is associated with infection in other mammals (Jang et al. 1990), but the weights of pups with this bacteria did not indicate that they were severely compromised. Mean weight (8.75 kg) of pups with S. aureus was not significantly different from uninfected pups (8.6 kg; t = 0.2, P = 0.843). Weights of pups with Streptococcus sp. from North, East, and Zapadni rookeries were pooled and compared to pooled weights of uninfected pups. Mean weight of pups infected with Streptococcus sp. (8.1 kg) was not significantly different from uninfected pups (8.8 kg; t = 1.64, P = 0.10).

Primary enteric pathogens do not appear to infect significant numbers of pups on all islands surveyed. Resource and time constraints and the broad nature of the survey prevented us from surveying for a single primary pathogen. This may have contributed to the apparent low incidence and distribution of Salmonella, Staphylococcus, and Streptococcus Spp.

Opportunistic pathogens were found in all pups from each rookery (Table 22), and the most frequently isolated organisms were nonhemolytic Escherichia coli, and unidentified Citrobacter, Proteus, and Enterobacter spp. Baker and McCann (1989) suggested the underdeveloped immune system in young animals makes them susceptible to infection by opportunistic pathogens. Opportunistic pathogens isolated from northern fur seal pups were similar to many isolated from Antarctic fur seals. Baker and McCann (1989) found opportunistic pathogens were important sources of mortality for Antarctic fur seals. The presence of these pathogens on the Pribilof Islands may result in a similar influence on mortality of animals there.

FISH NET DEBRIS AND BEACH LITTER ON ST. PAUL ISLAND, ALASKA

by

Norihisa Baba and Hiroshi Kajimura

Beach surveys were conducted on Zolotoi Sands (ZOL) and at Northeast-Point (NEP) on St. Paul Island, Alaska (Fig. 21) during 1983, 1984, 1986, 1988, and 1990 to determine the types of marine debris that accumulate on these beaches. Zolotoi Sands beach is a flat, sandy beach utililized by some subadult and bachelor male fur seals. In contrast, the section of beach surveyed on the westside of Northeast Point is a rocky boulder beach and is not utilized by fur seals.

The purpose of the beach surveys were to determine the deposition of debris on these two beach sites. The types of beach debris consisted of large and small fragments of trawl net, various sizes of rope and line, plastic banding material, and other plastic materials. In a study on debris accumulation on Amchitka Island, Merrell (1980) reported that there was little variation in composition of litter items on different beaches or in different years, but quantities of litter on different beaches varied greatly.

The National Academy of Sciences (1975) estimated that 6.4 million metric tons (t) of litter is discarded annually from ships. In Alaskan waters, Merrell (1980) estimated about 2,000 t of plastic litter is discarded or lost annually from fishing vessels.

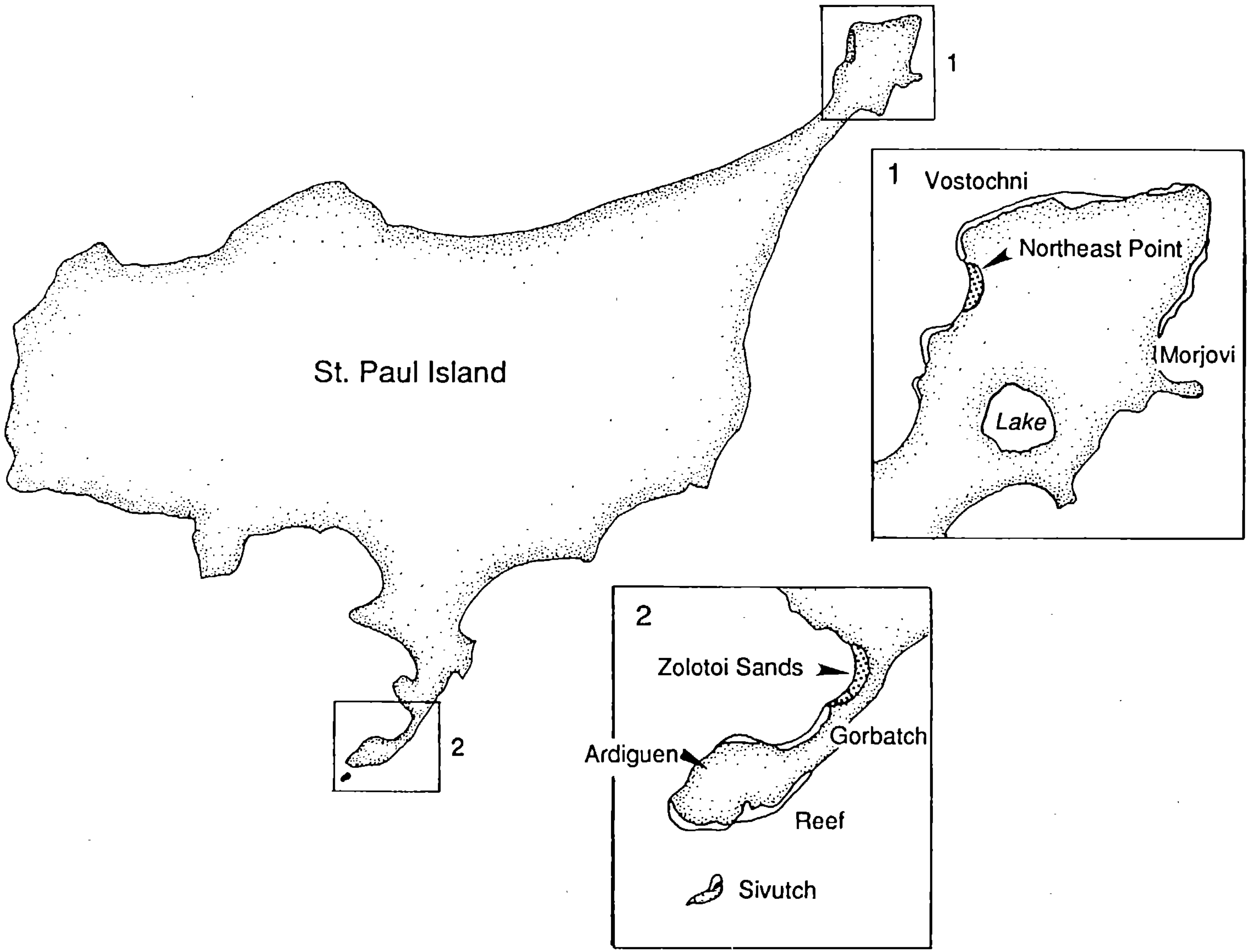

Figure 21.--Beach survey areas on St. Paul Island, Alaska, 1983-90.

Methods

Survey methods were similar for each of the years as one or both of the authors were present on each of the surveys. The survey party consisted of one to four persons during 1983-90. The survey area included the intertidal zone from the water's edge to the high-tide vegetation line. All beach surveys were conducted at low tide. Each year all removable pieces of debris (net, rope, string, and plastic banding material) were collected or removed to areas above the high-tide level. For those debris partially buried or too large to remove, samples were taken and the debris was marked by spray paint and noted for future surveys. During 1983-84, totals of 30.0 and 40.0 kg of webbing material were taken from NEP and ZOL beaches, respectively, for examination. The samples were sent to Japan where they were examined for mesh size and twine diameter. The net mesh size information (Table 23) given in this report is based on the samples sent to Japan as well as data collected in subsequent surveys conducted at the two beaches through 1990.

Results

Beach debris was grouped into four categories: 1) all net-entangling material; 2) plastic banding material; 3) rope and lines; and 4) miscellaneous (canvas strips, 6-pack yokes, and plastic rings). Plastic banding material, ropes and lines (including twine, string, and yarn) were the most abundant debris found at both NEP and at ZOL beaches (Table 24). Rope was the most abundant type of debris among this group. The longest rope

Table 23.--Frequency distribution of net fragments based on mesh size (cm) as found on Northeast Point and Zolotoi Sands beaches, St. Paul Island, Alaska 1983-90.

Mesh size(cm)	Northeast Point						Zolotoi Sands				
	1983	1984	1986	1988*	1990*	Total	1983	1984	1986	1988	Total
cm cm	No.	No.	No.	No.	No.	No.(%)	No.	No.	No.	No.	No.(%)
<7.5	7	2	2	-	1	11(9)	1	1	1	-	3(4)
7.5- 8.5	11	7	-	-	-	18(15)	2	4	-	2	8(12)
8.5- 9.5	5	1	-	-	-	6(5)	-	5	-	-	5(7)
9.5-10.5	5	2	5	-	1	12(10)	-	-	1	2	3(4)
10.5-11.5	1	-	-	-	-	1(1)	-	1	-	1	2(3)
11.5-12.5	8	2	5	-	-	15(12)	3	2	1	1	7(10)
12.5-13.5	3	1	-	-	-	4(3)	1	5	-	2	8(12)
13.5-14.5	10	6	-	-	-	16(13)	2	6	-	-	8(12)
14.5-15.5	2	-	1	-	-	3(2)	2	2	1	2	7(10)
15.5-16.5	3	2	-	-	-	5(4)	2	1	-	-	3(4)
16.5-17.5	2	2	-	-	-	4(3)	2	3	-	-	5(7)
17.5-18.5	2	-	-	-	-	2(2)	1	1	-	-	2(3)
18.5-19.5	1	-	-	-	-	1(1)	-	-	-	-	-
19.5-20.5	1	1	1	-	-	3(2)	-	-	-	-	-
20.5-21.5	1	-	-	-	-	1(1)	-	-	-	-	-
21.5-22.5	5	2	2	-	-	7(6)	-	2	-	-	2(3)
22.5-23.5	2	1	-	-	-	3(2)	-	2	-	-	2(3)
23.5-24.5	-	-	-	-	-	-	2	-	-	-	2(3)
24.5-25.5	-	-	-	-	-	-	-	1	-	-	1(1)
25.5-26.5	-	-	-	-	-	-	-	-	-	-	-
26.5-27.5	-	-	3	-	-	3(2)	-	-	-	-	-
27.5-28.5	1	-	-	-	-	1(1)	-	-	-	-	-
28.5-29.5	-	-	-	-	-	-	-	-	-	-	-
29.5-30.5	-	1	3	-	-	4(3)	-	-	-	-	-
>30.5	-	2	-	-	-	2(2)	-	-	-	-	-
Total	70	30	22	-	2	122(100)	18	36	4	10	68(100)

*No mesh size measurements taken for nine 1988 and five 1990 Northeast Point samples.

Table 24.--Number of beach debris at Northeast Point and Zolotoi Sands, St. Paul Island, Alaska 1983-90.

		Northeast Point					Zolotoi Sands			
		1983	1984	1986	1988	1990	1983	1984	1986	1988
Net	No.	78	36	39	9	18	24	54	11	36
	%	(33)	(13)	(13)	(7)	(9)	(17)	(14)	(9)	(15)
Plastic packing band	No.	133	136	106	44	144	41	96	40	37
	%	(56)	(50)	(36)	(36)	(69)	(29)	(25)	(31)	(16)
Ropes and lines	No.	26	98	145	70	48	76	240	78	163
	%	(11)	(36)	(49)	(57)	(23)	(54)	(62)	(60)	(69)
Miscellaneous	No.	-	-	3	-	-	-	-	-	1
	%			(1)						(0.4)
Total	No.	237	270	293	123	210	141	390	129	237
	%	(100)	(100)	(100)	(100)	(100)	(100)	(100)	(100)	(100)

was greater than 100 m long. Rope diameters ranged from 5 to 38 mm.

Beach debris of concern are the entanglement causing materials of trawl net, such as net webbing fragments, and closed loop bands, where animals are capable of putting their head through the mesh or the closed loop band.

Mesh sizes of nets and net fragments collected during the beach surveys ranged from 7.0 to 41.0 cm at NEP and from 7.0 to 25.0 cm at ZOL (Table 23). Mesh sizes of nets found on beaches were primarily smaller mesh nets, most occurring between 7.0 and 15 cm (Fig. 22).

Discussion

Johnson (1990) reported that the rate of deposition of debris on beaches is largely controlled by storms and the orientation of the beach to prevailing winds and currents. The accumulation of beach debris on both beaches surveyed on St. Paul Island shows a variable but decreasing trend among most categories of debris found since 1983. The only exception is in the marked accumulation of plastic banding material and the slight increase in net material at NEP during 1990. Although there was no survey conducted at ZOL beach in 1990, there was a slight increase in ropes and nets in 1988 (Fig. 23). In most other categories of debris there is a noted decrease in accumulation. This general decrease in debris accumulation is also reported by Merrell (1984) for other beaches surveyed in the Aleutian Islands and by Johnson (1990) for beaches in the Gulf of

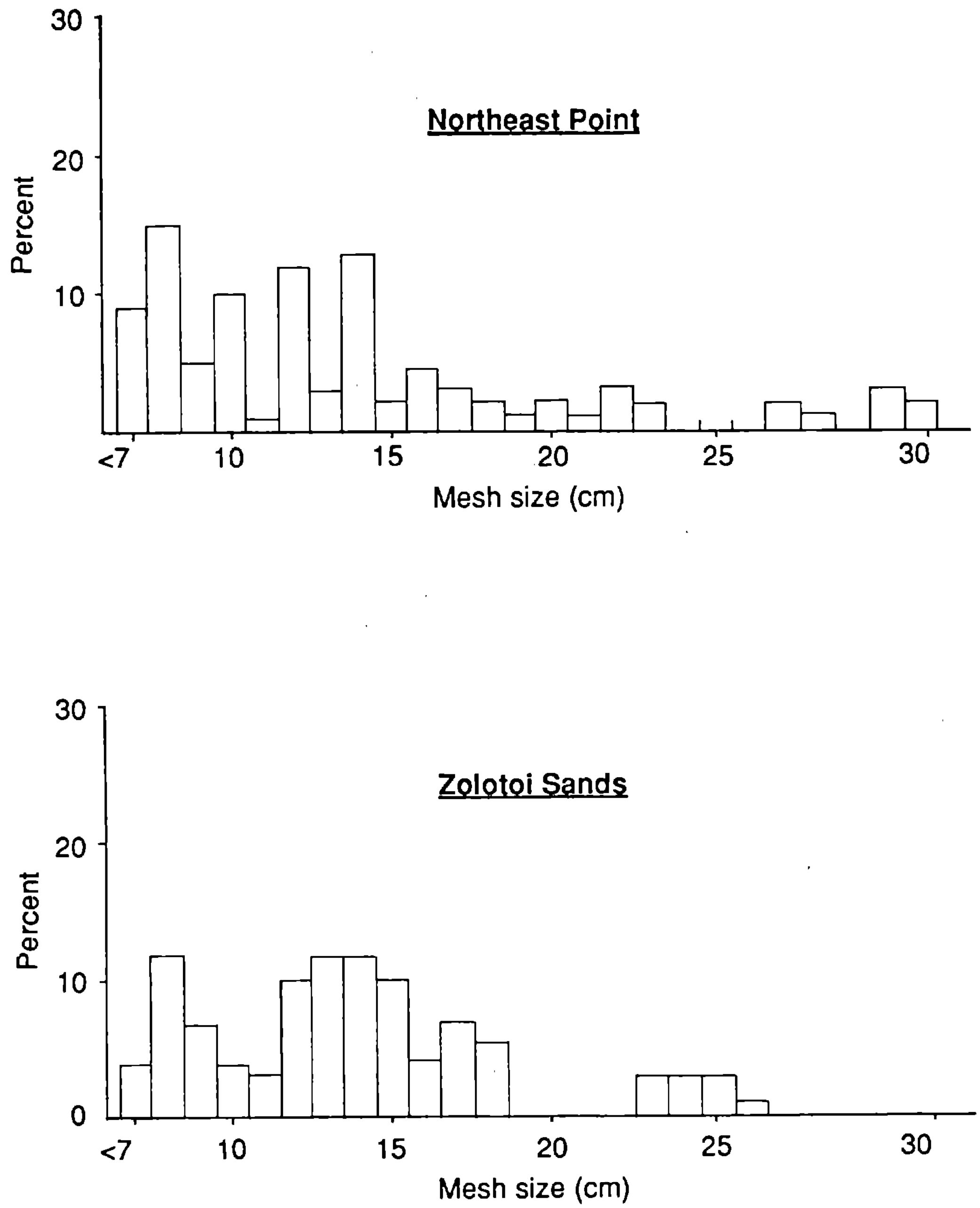

Figure 22. --Frequency of mesh size of net fragments as found on Northeast Point and Zolotoi Sands beaches, St. Paul Island, Alaska, 1983-90.

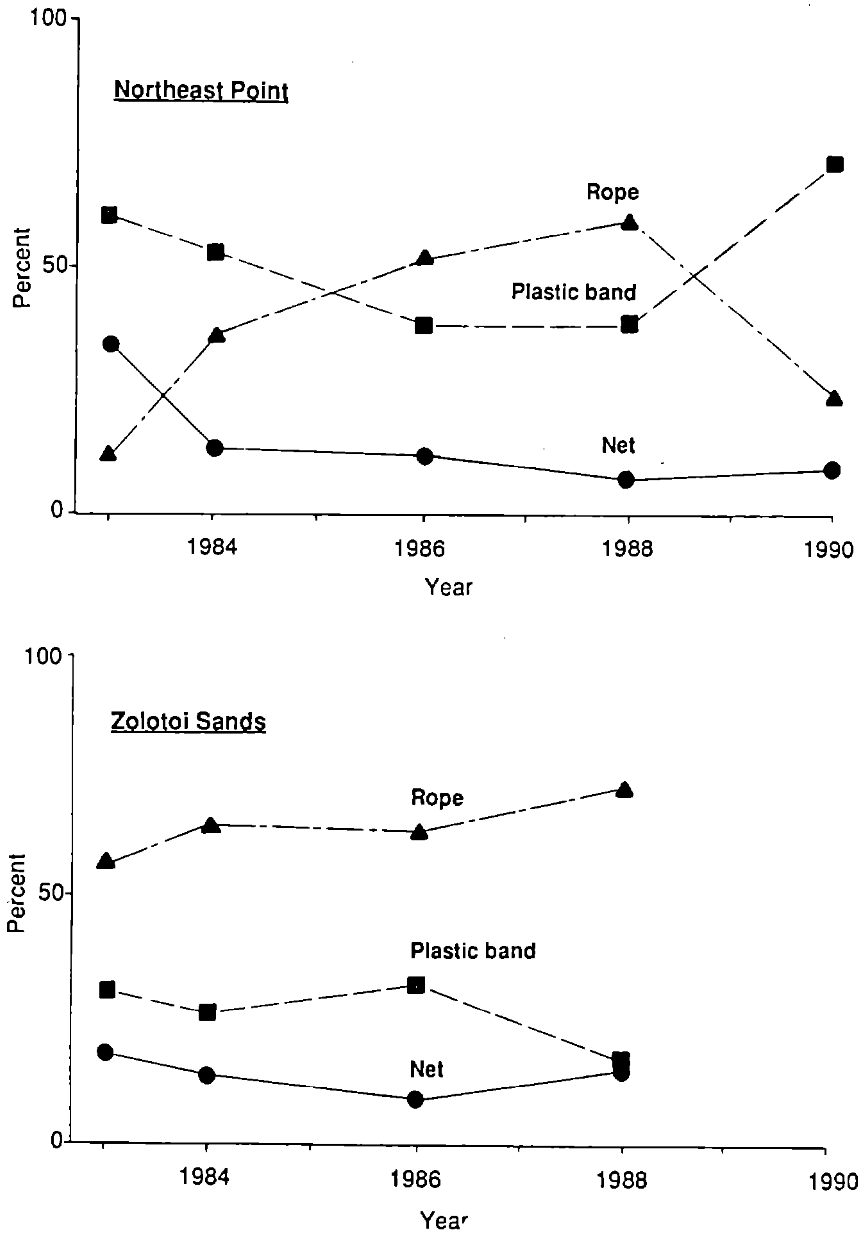

Figure 23. --Change of beach debris at Northeast Point and Zolotoi Sands beaches, St. Paul Island, Alaska, 1983-90.

Alaska. Fowler and Baba (this volume) report the continued reduction in the numbers of animals entangled in fragments of trawl netting.

CENSUS OF NORTHERN FUR SEALS ON BOGOSLOF ISLAND, ALASKA, 1990

by

Jason D. Baker and Masashi Kiyota

A census of northern fur seals on Bogoslof Island, Alaska, was conducted on 24 July 1990. This census was a cooperative effort involving National Marine Mammal Laboratory personnel, researchers from the Far Seas Fisheries Research Laboratory in Shimizu, Japan, and the Japanese research vessel *Shunyo Maru*. Transportation to Bogoslof Island was provided by the research vessel.

Methods

The census of northern fur seals was conducted from selected vantage points while walking all rookeries and haul-out areas on the island. Where practical, independent counts were made and subsequently averaged. However, in areas where one counter clearly had a better view than the other, the count from the better view was used. On the main rookery area on the northwest side of the island, the two scientists counted jointly as it was impossible for both to see all the animals independently, compared their notes, and agreed on the final count of fur seals.

Results

The locations of northern fur seals on Bogoslof Island in 1990 are shown in Figure 3. The numbers of fur seals counted at the different locations include 44 territorial males, 295 females, 181 live pups, 2 dead pups, and 951 nonterritorial males (Table 25). The nonterritorial male category includes mainly subadult animals but also includes adult males.

The rookery on the northwest side of the island is where most of the pups are born. Counting pups in this area has become difficult because 1) the animals at the southern end of this rookery have moved inland, and 2) males were still territorial at the time the census was taken. Because it was impossible to approach close enough to count all pups during this census, we suggest future censuses be conducted after the harem structure breaks down in early August. For example, there was one group of 22 females located on the slope to the water below the thickest part of the rookery. It was not possible for the scientists to safely enter this area to count pups. Therefore, the number of pups counted was certainly less than the actual number present.

The number of fur seals on the northeast side of the island has increased. In this area a small rookery with established territories along the beach is increasing within what has been almost exclusively a male haul-out area (only one pup was seen here in 1989).

A new development was the presence of fur seals on the sand spit on the southern end of the island. These fur seals were located high up on the beach, segregated from the northern sea lions (<u>Eumetopias jubatus</u>) distributed along the water's edge.

Table 25.--Numbers of northern fur seals counted on Bogoslof Island, Alaska, on 24 July 1990.

	Northwest side	Northeast side	South side	Total
Territorial males	29	14	1	44
Females	254	37	4	295
Live pups	162	18	1	181
Dead pups	1	1	0	2
Nonterritorial males	422	379	150	951
Total	868	449	156	1,473

Other Observations

A tagged territorial male with reddish pelage and a monel tag was present at the north end rookery on the northwest side of the island. The number could not be read because the monel tag was flipped upside-down. Also tag numbers could not be read on three females tagged with green Riese tags.

On the northeast side of the island, two females with monel tags were seen associated with an adult male. One live pup was with a female and a dead pup was nearby. The adults fled upon our approach so the tags could not be read. One tagged female had mixed black and white vibrissae indicating that she was about 4 to 5 years old.

One subadult male with a monel tag was seen. His left foreflipper appeared lame as he held it in the air and only walked on his right foreflipper. No swelling was visible on the damaged flipper, and the animal appeared healthy otherwise.

Three entangled subadult male northern fur seals were observed.

One northern sea lion pup tagged on 5 July 1990 on Bogoslof Island (red Allflex No. 255) was found dead on the sand spit.

One adult harbor seal (*Phoca vitulina*) was observed hauled out on the beach opposite the cliffs on the southeast side of the island.

POPULATION AND BEHAVIORAL STUDIES, SAN MIGUEL ISLAND, CALIFORNIA

(Adams Cove and Castle Rock)

by

Robert L. DeLong and Sharon R. Melin

At Adams Cove on 12 July 1990, there were 68 adult northern fur seal (Callorhinus ursinus) males defending territories containing females and pups and an additional 8 adult males defending territories with no females. This represented the largest number of territorial males recorded during the breeding season at Adams Cove. Pup counts in Adams Cove were conducted on 27 July and yielded counts of 1,137 live and 12 dead pups. PUP counts were conducted on Castle Rock on 29 July and yielded counts of 634 live and 14 dead pups.

Two hundred northern-fur seal pups were tagged with monel tags on 23 September in Adams Cove. The sex, weight, and tag numbers of each pup are listed in Appendix Table B-5. During the course of field studies, 218 individuals with tags. from previous studies were observed. Tag numbers were read with the aid of a spotting scope (Appendix Table B-6). In addition, three tagged animals were observed on beaches of coastal California (Appendix Table B-7).

Packages containing dummy instruments (items of the same approximate size and weight as radio tags and dive recorders) were attached to the pelage of four adult females and four subadult males in either late September or early November

(Appendix Table B-8). If these animals return with the packages intact in the spring of 1991, we will attach geolocation recording instruments to some fur seals the following autumn to assess their winter distribution from San Miguel Island.

California sea lion (Zalophus californianus) X northern fur seal hybrid pups continue to occur at San Miguel Island. In December 1989, a juvenile male hybrid approximately 3 years old was observed in Adams Cove. Unlike all hybrids seen in the past which had primarily fur seal characteristics, this animal had a number of physical characteristics resembling a California sea lion. The animal was tagged and was seen during June. In addition, during the pup counting activity on Castle Rock a hybrid pup with a fur seal mother was observed.

Tag resights from pups tagged in 1988 and 1989 in September and October are about equal with no evidence as yet of better survival of either group.

U.S. LAND-BASED RESEARCH IN THE U.S.S.R. IN 1990

by

Roger L. Gentry and George A. Antonelis

This research was conducted under the auspices of the marine mammal project of the U.S. -U.S.S.R. Joint Environmental Agreement. Some financial assistance was received from the National Geographic Society. The purpose was to compare the populations of northern fur seals breeding on the Pribilof Islands and those on Medny Island (of the Commander Islands).

Scientists from the United States included the authors and Mark Pierson of the Minerals Management Service. The Soviet team was comprised of 10 members from 4 institutions. Research was conducted at Urilie rookery, Medny Island, from 19 July to 28 August 1990. Transportation for the U.S. members was provided by the Soviet fisheries inspection vessel Merlang, originating in Dutch Harbor, Alaska, on 12 July and ending in Dutch Harbor on 5 September.

The central focus of this project was to examine the possible role that the continental shelf may have played in the 1956-81 decline in the northern fur seal population. Two features of the Medny Island population were of interest. First, the Commander Islands are surrounded by the narrowest ("1 km) continental shelf of any major northern fur seal rookery. The shelf break extends up to 60 km from shore at both the Pribilof Islands (Bering Sea) and at Robben Island (Sea of Okhotsk). Because dive studies show that most fur seals feed nightly on prey in the deep scattering layer, and because this layer forms beyond the shelf break, the nearness of the break at the Commander Islands suggests that females there would expend less effort in transit to foraging areas than females at the other large colonies. Second, the Commander Island population increased while the Robben and Pribilof Islands' populations declined to about one-half their 1960 abundance.

The project will attempt to determine 1) whether Commander Island females, by virtue of increased foraging efficiency, were providing their young with more energy (richer milk delivered more often) than females of other populations; and 2) whether the greater, resultant pup growth rates would translate into better pup survival to adulthood.

Data were collected for direct comparison to studies on the Pribilof Islands. These include the duration of female trips to sea; frequency, depth and location of diving; milk fat content; quantity of milk delivered to the pup per mother's visit using the doubly labeled water (isotope) method; and pup growth rates. Additional data were collected on attendance patterns of females of estimated age and known date of parturition using radio-telemetry methods, diet based on scat analysis, age-specific vibrissae and pelage color patterns of females, and potential bacterial pathogens of fur seal pups. These data are presently being analyzed.

ENTANGLEMENT STUDIES, ST. PAUL ISLAND, 1990
JUVENILE MALE NORTHERN FUR SEALS

by

Charles W. Fowler and Norihisa Baba

Entanglement in marine debris, specifically in plastics associated with the commercial fishing industry, has been documented for a number of species of seals and sea lions (Fowler 1988). The effects of entanglement in such debris have been the subject of a number of studies, especially as related to the impact on northern fur seals. Many of these studies have examined effects at the population level (Fowler 1982, 1985, 1987). Others have focused more on the effects at the level of the individual (see Fowler 1988).

Northern fur seals become entangled in plastic debris and scraps of fishing nets as they forage in the open ocean. Such entanglement, especially in scraps of net (owing to their frequency and a structure that enables entanglement), is a source of mortality for this species and has been the focus of research examining recent declines in the northern fur seal population on the Pribilof Islands (Fowler 1987; Bengtson et al. 1988; Fowler 1984, 1985, 1987; Fowler et al. 1989, 1990a, 1990b; Fowler and Ragen 1990).

Juvenile males (aged 2 to 5 years) from St. Paul Island, Alaska (in the eastern Bering Sea, west of mainland Alaska), are the component of the population most readily studied. This report presents the results of the 1990 field research conducted by the National Marine Mammal Laboratory, in cooperation with the National Research Institute of Far Seas Fisheries of the Fisheries Agency of Japan, to examine entanglement and its impact on juvenile male northern fur seals.

The objectives of this work are 1) continued monitoring of the proportion of seals entangled; 2) determination of the nature of entangling debris; 3) determination of the mortality caused by trawl webbing, especially as related to effects at the population level; and 4) assessment of the relative rates at which entangled and control animals are resighted. Part of the study of relative rates of resighting addresses the question of whether an animal's chances of being seen again are altered by being, or having been, entangled.

Methods

The studies reported here involved roundups, a procedure conducted near the breeding colonies of northern fur seals on St. Paul Island, Alaska. During roundups, seals are herded into a group and allowed to pass between observers who watch for animals with tags or entangling debris. When such seals are seen, the flow of seals is stopped while each tagged or entangled seal is captured and the relevant information (e.g., tag number, tag type, degree of wound, and type of debris) is determined and recorded. The general nature of the procedure is described in greater detail in Fowler and Ragen (1990) and Fowler et al. (1990b). Specific methods of importance to this study are explained below. All work was conducted during the breeding season while animals congregated at, or near, breeding rookeries along the shoreline of the island.

As in previous years, the seals on which entanglement research is primarily focused are those judged to be of the size historically taken in the commercial harvest (approximately 105 to 125 cm in total length). Unless indicated otherwise, data in this report apply to juvenile (subadult) male seals of this size. The total count and the count of entangled animals are used to estimate the entanglement rate for comparison with rates observed in the commercial harvest prior to 1985.

As in 1989, tags were applied to previously untagged seals, and debris was removed from each entangled seal. This is in contrast to roundup procedures in years prior to 1989 during which entangling debris was left on the animals. The color, weight, type of debris, and mesh and twine size if it was a net fragment were determined for each piece of debris. Samples were retained for any future analysis deemed necessary. Also, as in previous years of this study, two control seals about the same size as the entangled animal were also tagged to compare rates of return in succeeding years.

The removal of debris must be taken into account in calculating the proportion of seals entangled because, under circumstances of previous work, some of the resighted seals would have died and not been observed. This was done by applying the estimated survival of seals entangled in small debris (0.5 from past studies: Fowler 1984, 1985, 1987; Fowler et al. 1989, 1990a, 1990b; Fowler and Ragen 1990) to the number of seals resighted after having had their debris removed in 1989. Thus, half of the resighted seals from which debris had been removed last year were assumed to have been seals that would have been resighted as entangled seals this year to contribute to the observed proportion entangled. As in 1989, the 1990 sampling design included resightings of animals from which debris was removed during the same season; these animals were counted as entangled. The overall entanglement rate is estimated by the ratio of all (both initial and all subsequent) entanglement sightings to the total number of seals examined (Bengtson et al. 1988, Fowler et al. 1990b).

Some of the surviving seals from which the debris was removed last year had grown to be larger than those taken in the commercial harvests. To account for this in calculating the entanglement rate necessitates differentiating between those that are too large and those that should be counted for estimating entanglement rates. Because information regarding the size of resighted seals from the tagging in 1990 was not recorded, all tagged seals were included. This will result in a slightly inflated estimate of the entanglement rate.

Because some animals are rounded up more than once, the resulting sampling scheme is one of sampling with replacement, and the data for both the control animals and the entangled animals are treated accordingly. This is particularly important in estimating the proportion of seals entangled for comparison to historical data.

Analytical methods to estimate the survival rate of entangled seals are presented in Appendix D as modifications of those used by Fowler and Ragen (1990), and Fowler et al. (1990b). The differences between these methods and those of the original approach, also used here, are explained in Appendix D.

Results

Roundups

One hundred twenty-two roundups of subadult male northern fur seals were completed on St. Paul Island during July and early August of 1990 (Appendix Table C-l). During these roundups, 25,829 male seals judged to be of the size historically taken in the commercial harvest were counted. As explained below, about 25-30% of each of the total counts (unentangled and entangled) were repeat sightings. In all, 57 entangled subadult male seals judged to be of harvestable size were captured and double tagged with numbered, white Allflex tags bearing the address of the National Marine Mammal Laboratory (Appendix Table C-2).
A total of 114 similarly sized control seals with no entangling debris were tagged (Appendix Table C-2).

Tagged Seals from Previous Years

Seals tagged in previous years were resighted (Appendix Table C-3) along with seals tagged during the 1990 season. Of these resighted seals from previous years for which tags were read, 46 had Allflex tags from 1985, 1986, and 1988 applied during earlier phases of research to evaluate the mortality of young male seals entangled in debris. Forty-three of the 46 resighted seals were tagged in previous years as controls. Three had been entangled when tagged. Of the three seals resighted after having been tagged as entangled, all had lost their entangling debris (keeping in mind that debris was not removed from entangled seals during tagging in years prior to 1989). Two pieces of debris that were lost had been noted at their first sighting as being small (0-150 g in estimated weight) and one was large (over 500 g).

Thirty-seven seals were resighted with tags applied in 1989, the first year during which debris was removed from entangled juvenile male seals. Of these, 26 had been tagged as controls and 11 had been tagged after being disentangled.

Entanglement Rate

We examined 71 entangled juvenile male seals in the 1990 roundups (the 57 seals mentioned above, 12 that were judged to be larger than historically harvested, and 2 that died) to remove. and determine the nature of their entangling debris. The sizes and kinds of entangling debris, the extent of any wounds, and the tightness of the entangling debris on the animal are presented in Appendix Table C-4. A key to the tags applied during the 1990 field season is provided in Appendix Table C-2.

Of the 71 entangled seals examined, 23 (32.4%) were entangled in trawl webbing, 23 (32.4%) in plastic packing bands, and 16 (22.5%) in string, small line, or cords. The remaining nine (12.7%) were entangled in other debris. In all, there were 85 sightings that qualified for calculating the entanglement rate. These included 1) seals of harvestable size observed entangled, 2) the repeated sightings of animals from which debris had been removed in 1990, and 3) half of the seals resighted from 1989 after having had debris removed. The entanglement rate for 1990 was thus 0.33% (85/25,829), an estimate that is subject to slight upward bias owing to the inclusion of tagged seals that may have grown to be too large to count. Even so, the 1990 rate of entanglement continues to be less than the observed rate of about 0.4% between 1976 and 1985 (Fig. 24 from Fowler and Ragen 1990) but is slightly higher than the rates of 0.28 and 0.30 observed for 1988 and 1989, respectively (Appendix Table C-5).

Compared to the 1976-86 rates, the relatively smaller proportion of entangled juvenile male seals continues to be attributed to a reduction in the fraction entangled in trawl webbing (Appendix Table C-5). For the period 1982-86, the mean percent of seals entangled in trawl webbing was 0.27% (Fowler et al. 1990a). In 1988, the percent entangled in trawl webbing dropped to 0-15%, a reduction to 56% of earlier levels (Fowler et al. 1990a). This proportion remained low in 1989 (Fowler and Ragen 1990) and 1990 at about 0.12% (Appendix Table C-5).

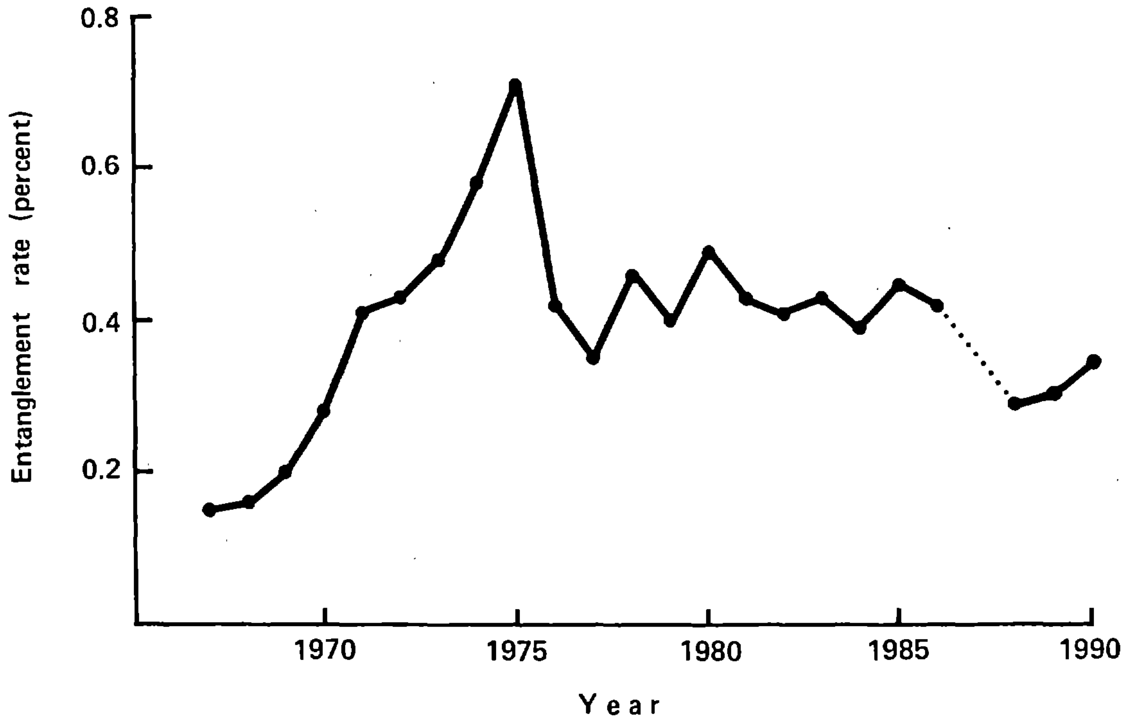

Figure 24. --The percentage of juvenile male northern fur seals found entangled in the commercial harvest from 1967 to 1984 and in research roundups from 1985 to 1990, on St. Paul Island, Alaska (updated from Fowler and Ragen 1990).

Resightings and Survival

An annual summary of the number of tags initially applied to juvenile males and the number resighted in each subsequent year is shown in Appendix Table C-6 for each year since 1985. No roundups were conducted in 1987. A total of 129 tagged seals judged to be of harvestable size were tagged and released in 1989. Of these, 86 were controls and 43 were entangled when captured. In 1990, 26 of these controls (30.2%) were resighted. Eleven (25.6% of the original group of 43) of the seals tagged after removing their debris in 1989 were resighted in 1990. This implies an 85% resighting rate for disentangled seals after 1 year as compared to the controls (25.6/30.2 = 0.85). This is not significantly different from a ratio of 1.0 (Chi-square test, $P > 0.05$). The resighting rate of disentangled seals relative to controls is significantly higher than that of entangled seals from previous years (Chi-square test, $P > 0.05$).

In 1990, 25 of 279 seals (or 9.0%) tagged as controls in 1986 were resighted. One seal (also observed in 1989 without its debris) was resighted out of a group of 128 animals tagged as entangled in 1986. The corresponding resighting rate is 0.8%, which is significantly different from the rate for controls (Chi-square test, P c 0.05).

No animals tagged as entangled in 1985 were resighted in 1990; however, seven controls from 1985 were resighted. This sample size is too small to test for a significant change from the original ratio of tagged entangled seals to controls for that year (Appendix Table C-6).

Data for relative resighting rates of seals tagged in 1985, 1986, 1988, and 1989, and those seen in 1990, are shown in Figure 25 along with data from previous work (Fowler et al. 1990b, Fowler and Ragen 1990). The 1990 data for seals resighted from tagging in years up through 1988 (Fig. 25) are consistent with the results of earlier work (Fowler et al. 1990b).

Using methods developed in Fowler et al. (1990b) and the data from Appendix Table C-6 and Appendix Table C-7 it is possible to estimate the effect on survival of entanglement in small debris (light enough for seals to return to the breeding islands). The estimated parameters are determined from regression analysis wherein the regression coefficient is the natural log of the survival (s,) attributable to entanglement. For the data in Appendix Table C-6 (excluding cases with no sightings for seals tagged as entangled; e.g., 1985 seals resighted in 1990), $\ln(s_e) = -0.6119$ ($R^2 = 0.919$, $P = 0.001$). The estimated survival of entangled animals from the effects of entanglement (i.e., the conditional probability of survival given survival from other natural effects) is thus 0.54 (calculated as $e^{-0.6119}$ with 95% confidence limits of 0.44 to 0.66').

A second approach to estimating survival simply involves making the assumption that the probability of resighting is the same for both categories of seals. This assumption is based on evidence presented in Fowler et al. (1990b) and below, which

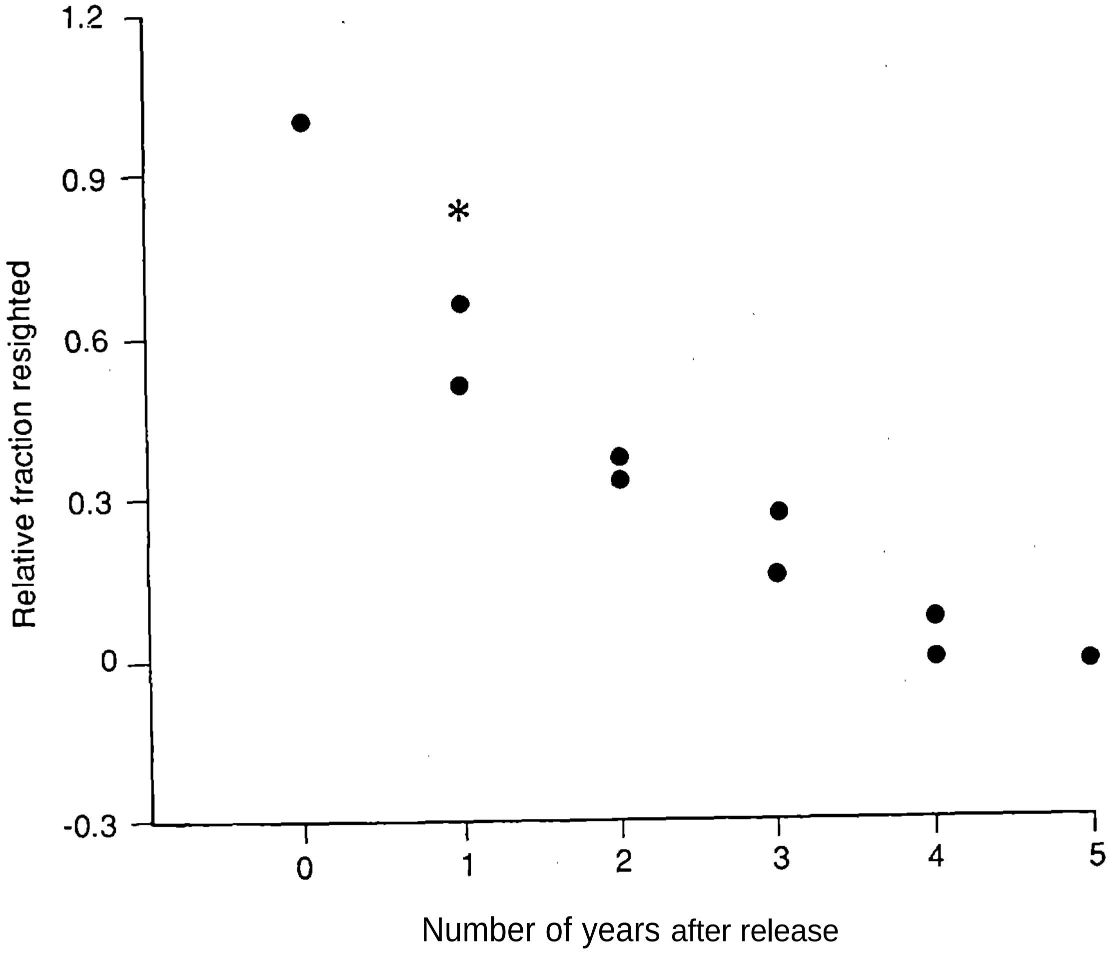

Figure 25. --Relative rates of return for entangled juvenile male northern fur seals compared to controls (nonentangled tagged seals) for varying time intervals (Updated from Fowler and Ragen 1990 with the data from this report). Each data point represents the fraction of entangled seals resighted divided by the fraction of controls (both from Appendix Table C-6) for the corresponding time interval (for example, there are 2 data points for 3 years corresponding to the 1985-88 and 1986-89 intervals). The star (*) corresponding to 1 year is the relative return rate for seals with debris removed in 1989 as observed in 1990.

indicates that seals entangled in debris small enough to allow their return to the island are sighted with probabilities that are statistically not significantly different from the probability of seeing a control. In this approach (explained in detail in Appendix D), the percent of the entangled seals resighted is divided by the percent of the controls resighted, and the ratio is raised to the power of l/n where n is the number of years since the tagged seals were released. For example, the 1988 resightings involved 1 entangled seal and 13 controls from seals released in 1985. This is 1.2% of the 85 entangled and 7.6% of the controls (Appendix Table C-6). The ratio of these percentages raised to the l/3 power (to account for the 3 years between 1985 and 1988) is 0.54. This is the estimated annual survival from, or the probability of surviving the hazard of, entanglement--assuming survival from entanglement in small debris is the same from year to year. Such calculations were carried out for all the returns shown in Appendix Table C-6 and a weighted mean found using the total sample of resighted seals from the corresponding year as weights (e.g., 14 seals from 1988 resighted in 1988). The weighted mean is 0.55 excluding the resightings of seals disentangled in 1989.

Thus, the cumulative data as presented in Appendix Table C-6 and Figure 25 continue to show estimated annual probability of surviving entanglement of about 0.5 for seals entangled in small debris.

Characteristics of Entangling Debris

Because the debris was removed from the entangled seals in 1990 (as in 1989, but not in previous years of roundup studies), it was possible to directly determine weights of the debris. The size-frequency distribution of the fragments of trawl webbing on seals is shown in Figure 26 for debris weights and in Figure 27 for mesh size. Specific weights and mesh sizes are listed in Appendix Table C-4. These distributions are very similar to those seen in previous studies (Fowler 1987; Fowler and Ragen 1990). For the combined data since 1983, about 74% of the debris found on seals weighed between 0 and 150 g, about 18% of the debris weighed between 150 and 500 g, and about 8% of the debris weighed over 500 g (Appendix Table C-8).

Within-Season Resighting Rate.

Although the data for 1990 indicate a higher resighting rate for controls than for disentangled seals (Appendix Table C-91, the more general picture from the collective results of 5 years shows that the fraction of seals tagged as entangled seals and resighted in the same field season are about the same as for controls, as seen in previous work (Fowler et al. 1990a). This resighted fraction has been close to 25% for previous years. With increased effort (sample size of 25,829 seals in 122 roundups) in 1990, the resighted fraction is larger for both groups. There is no statistically significant difference in the rates of resighting between the two groups (Chi-square test, P = 0.543).

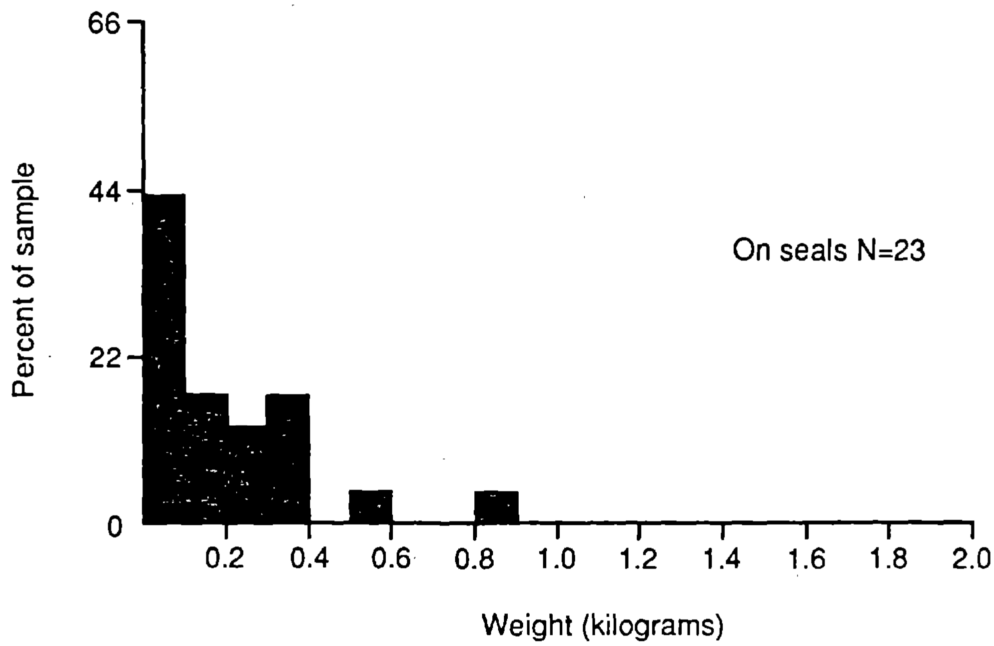

Figure 26.--Size frequency distribution of trawl net debris found on entangled juvenile male northern fur seals, July and August 1990, St. Paul Island, Alaska (size measured in kilograms).

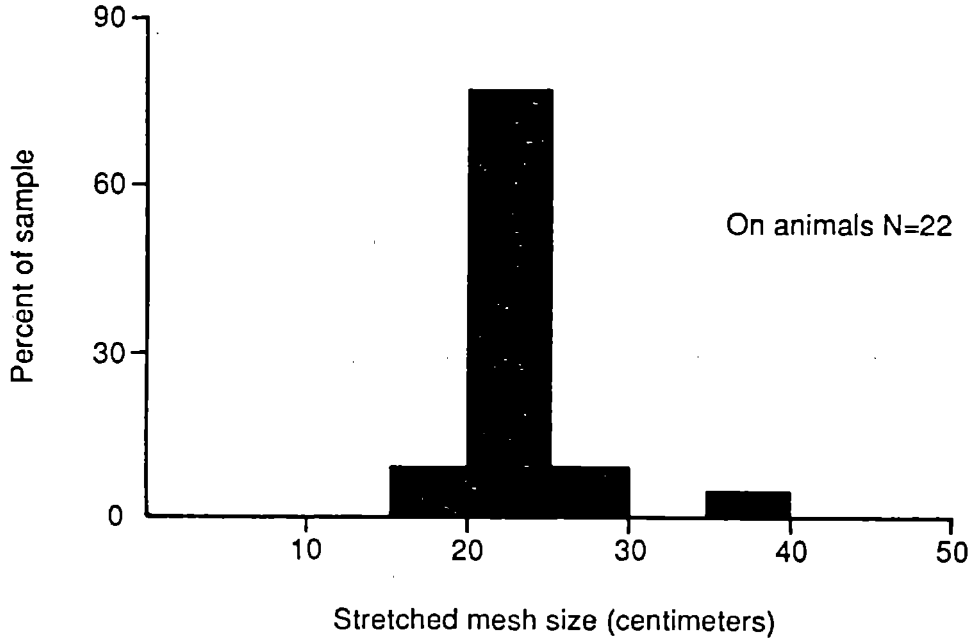

Figure 27.--Size frequency distribution of trawl net debris found on entangled juvenile male northern fur seals, July and August 1990, St. Paul Island, Alaska (size measured as length of stretched mesh of trawl net fragments).

Using the methods presented in Fowler et al. (1990a), it is possible to estimate the relative rate of resighting with the data from Appendix Table C-7. This approach is based on regression analysis wherein the intercept of the regression equation is the natural logarithm of the relative rates of resighting between entangled animals and controls. For the data in Appendix Table C-7 (excluding cases wherein there are no resighted seals tagged as entangled; e.g., of the entangled seals tagged in 1985, none were resighted in 1990) the intercept is estimated as 0.1615 (R^2 = 0.919, P = 0.46). These results imply that the ratio of the probabilities of being resighted is about 1.17 (calculated as, $e^{0.1615}$, with 95% confidence limits of 0.70 to 1.99). The chances of being resighted after being tagged as an entangled animal, given that the animal has survived, are estimated to be about 1.17 times that of being resighted as a control, but this does not differ significantly from 1.0 (i.e., equal probability of sighting controls or previously entangled seals, given their presence in the population).

Analysis of Wounds, Wound Growth, and Related Survival

For most years since 1983, data have been collected on the size of wounds of entangled fur seals. These data have been documented in the reports presenting each year's results, but they have not been summarized. Appendix Table C-10 is a compilation of data on wound development for entangled juvenile male seals. Eight of the 29 seals listed were first sighted with

360-degree wounds (i.e., the point of entanglement--usually the neck--was encircled). These wounds could encircle no more of the neck, of course, and could only get deeper as the seal grew. In one case, a wound may have partially healed over the debris (seal number 480 tagged in 1983). Such healing is occasionally observed on seals entangled with small pieces of monofilament. Of the remaining 21, only 3 did not develop wounds. The other l8 either developed wounds or had wounds that increased in size. Eight developed 360-degree wounds in 1 year's time after being first seen with no wound.

Appendix Table C-11 presents the frequency of occurrence of wound size on entangled juvenile male northern fur seals seen from 1983 to 1990. Note that most seals either had no wounds (most of the category 0-90 were observed without wounds) or 360-degree wounds. Like the rapid development of wounds presented in Appendix Table C-10, these results indicate that wounds develop rapidly once the skin has been broken.

Appendix Table C-12 contains counts of seals listed in Appendix Table C-11 that were seen again 1 year later. Each count is also presented as a percent of the total for the corresponding wound size category from the previous year (e.g., 16 of the 69 seals--23.2%--in the O-90 degree category for 1983 were seen again in 1984). There is not much change in the percent of survivors seen across wound-size categories when presented in this fashion, although a smaller fraction of seals with large wounds (271-360 degrees) were resighted than for the other categories. This is consistent with the view that seals with larger wounds tend to suffer higher mortality. The lower resight rate for the seals with no wounds is confounded by the fact that many are caught in large debris and most likely die from exhaustion before being seen again.

Miscellaneous Observations

Each year there are individual seals, items of debris, or circumstances of entanglement that are noted during the entanglement roundups. We report here a few that are particularly striking.

On two occasions, animals tagged as controls in earlier years have been resighted as entangled, but none within the same season. The first of these occurrences was noted in 1989 when a seal tagged in 1986 (tag no. 360, tagged on 22 July at Kitovi) was seen again on 25 July 1988 at Morjovi as an animal entangled in 19.5 g of gray trawl webbing with a 360-degree wound. Since there was only one tag (worn) left from the 1986 tagging, this seal was retagged with a broad orange Allflex tag numbered 1270. The second control seal to become entangled was tagged in 1989 (tag no. 1179, tagged on 15 July 1989 at Reef) and was resighted in 1990 on Reef entangled in a white packing band. Of the 641 seals tagged as controls prior to 1990 (Appendix Table C-6), these two seals represent 0.31%.

Entangled seals occasionally exhibit behavioral and physical features (e.g., pelt color, mane, or shape of head) of animals much older than would be consistent with their size. This was noted in 1990 for a seal entangled in a green packing band (tag no. 1320, tagged on 11 July 1990 on Zapadni). The same was noted for a seal seen on 22 July 1990 on Vostochni entangled in a combination of three kinds of debris (monofilament, twine, and float line) with a wound that had partially healed over the debris. Scars had shown that the seal earlier had a 360-degree wound such that the seal may have been in the debris for longer than most seals under similar circumstances.

There is evidence that a few seals become entangled more than once. In 1990, this was seen for a seal found on a hauling ground at Reef on 27 July entangled in two pieces of trawl net. The debris were separate pieces: one green and the other gray with no connection to each other. Other animals showed more than one scar or two or more wounds, as was noted for three seals in 1990 (tag no. 1334, seen on 15 July at Reef; tag no. 1359, seen on 17 July at Zapadni Reef Sands; and tag no. 1372, seen on 7 July at Tolstoi Sands). In all such cases, it is possible that the second wound could have been formed by one piece of debris moving from one wound to another. Such an explanation seems unlikely because debris in such deep wounds would have to pass over a part of the neck larger than the diameter of the debris.

Two seals encountered in 1990 had debris that had worn into bone tissue. A seal tagged with tag number 1357 on 17 July at Zapadni Reef Sands (in a 25.1 g piece of green trawl webbing) showed a 360-degree wound low on its neck. The animal died during restraint to remove the debris. Later examination showed that the debris had worn into bone near the shoulder joint and had partially healed over with new bone tissue. A second seal (tag no. 1436, disentangled and released on 7 July at Kitovi) was entangled in 0.1 g of monofilament webbing around the ears and back of the head in several places. This animal was found again, dead, 1 August also on Kitovi. Necropsy showed that the debris had cut through the skull into the brain leaving a notch in the skull about 5 cm in length, probably extending into brain tissue about 1 cm. Further details concerning these two cases will be developed in a separate publication.

A final observation concerns a seal seen on Northwest Point of Bering Island in the Commander Islands on 17 August 1989. This seal had been tagged on Morjovi (St. Paul) on 29 July 1988. At that time it had been entangled in a small piece of green trawl webbing and had a 360-degree wound. This seal was entangled when resighted and the debris (presumably the same seen in 1988) was removed.

Discussion

Entanglement related field studies of juvenile male northern fur seals in 1989 and 1990 were different from those of earlier years in that debris was removed from entangled animals. Accounting for this difference, which is reflected in the resighting of disentangled animals, the entanglement rate continues to be lower than in years prior to 1987, but not quite as low as those observed in 1988 or 1989. The third year (1990) has provided convincing evidence that a change has occurred in the entanglement rate. These data are especially convincing because the reduction for each year is attributable to less entanglement in trawl webbing. An explanation for such a change can not be conclusively established at this time. However, the differences between the 1988-90 rates of entanglement and those of previous years may be a result of changes in the rate of loss and discard of net fragments from fishing vessels. Various education programs at national and international levels have been in place for several years, and international regulations prohibit the discard of such debris. Other studies are necessary to determine if less debris is actually entering the marine environment.

Results of the 1990 studies are consistent with those of earlier work in showing that some animals escape from their entangling debris. However, as documented in Fowler et al. 1990, the animals that lose their debris are predominantly seals entangled in small debris (cl50 g). This is one mechanism contributing to survival from entanglement. The results of the 1990 studies are consistent with this conclusion through the demonstration of increased survival of tagged seals from which debris was removed during the 1989 field studies.

In summary, entanglement research on juvenile males in 1990 demonstrated:

1. A continued reduction of the overall entanglement rate from about 0.4% (1975-86) to less than 0.34% in 1988 through 1990.

2. Entanglement in trawl webbing in 1990 was less than half of entanglement levels observed for this kind of debris in previous years (1981 to 1986) and very similar to that observed in 1988 and 1989.
3. The rate of resighting for animals tagged in 1986 showed that entangled animals tagged that year were seen at a rate that was significantly less than that for controls.
4. Data for relative return rates of entangled seals for years in which debris was not removed continued to produce an estimated rate of mortality due to the hazard of entanglement alone (i.e., independent of natural causes of mortality) of about 0.5 per year.
5. There is evidence from the 1990 studies that the rate of return of tagged seals from which debris is removed is significantly higher than for tagged entangled seals.

A summary of accumulated data (i.e, including data beyond that collected in 1990) indicates that wounds tend to increase in size, presumably contributing to the reduced survival that entangled seals experience. Sometimes these wounds increase to encompass 360 degrees in 1 year.

ACKNOWLEDGMENTS

Research on the Pribilof Islands in 1990 was completed with the assistance and cooperation of Vyachesla Melovidov, Gregory Fratis, Patrick Kozloff, John Merculief, the cities of St. Paul and St. George, the Indian Reorganization Act (I.R.A.) Council, the Tanadgusix Corporation (TDX), and Steve Zimmerman and Brad Hansen (NMFS).

Research on San Miguel Island, California, was completed with the cooperation of the staff of the Channel Islands National Monument, U.S. National Park Service, Ventura, California, and the U.S. Navy Public Works Department, Pacific Missile Range Headquarters, Point Magu, California.

Entanglement research was partially funded by the National. Marine Fisheries Service's Marine Entanglement Program, James Coe, Program Manager.

We thank the captain and crew of the Japanese research vessel _Shunyo Maru_ for providing transportation and assistance in conducting the census of northern fur seals on Bogoslof Island and the Bruel and Kjaer Company for the use of their acoustic instruments. Roger Gentry provided the information concerning the tagged seal resighted on Bering Island, as reported to him by Victor Nikulan.

The authors of the various research reports in this volume acknowledge the NMML scientific staff and Cooperators (see Appendix E for names) for their assistance in the field and laboratory during the 1990 field season. Personnel assisting with beach surveys conducted during 1983-90 include D. Melovidov, M. Tomita, J. Scordino, K. Yoshida, Y. Fujimaki, A. Furuta, T. Ragen, and S. Insley.

We gratefully acknowledge the reviews and editorial help in the writing and improving of the reports in this volume as provided by J. Baker, P. Boveng, J. Coe, G. Duker, S. Giese, R. Merrick, T. Loughlin, C. Fowler, J. Lee, R. Svrjcek, and C. Lee.

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APPENDIX A

Glossary

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

Bachelor	Young male seals of age 2-5 years.
Check mark	A notch, slit, hole or other mark made on a seal flipper when a tag is applied to ensure recognition of an animal if the animal should lose its tag.

<u>Classifications of adult male fur seals</u>

Class 1 (shoreline)	Full-grown males apparently attached to "territories" spaced along the water's edge at intervals of l0-15 m. Most of these animals are wet or partly wet, and some acquire harems of one to four females between 10 and 20 July. They would then be called harem males (Class 3). Class 1 males should not be confused with Class 2 animals, which have definite territories, whereas the shoreline males appear to be attached to such sites but may not be in all cases.
Class 2 (territorial without females)	Full-grown males that have no females, but are actively defending territories. Most of these animals are located on the inland fringe of a rookery: some are between Class 1 (shoreline) and Class 3 (territorial with females) males, and a few are completely surrounded by Class 3 males and their harems.

Class 3 (territorial with females)	Full-grown males actively defending territories and females. Most Class 3 males and their harems combine to form a compact mass of animals. Isolated individuals, usually with small harems, may be observed at each end of a rookery, on sandy beaches, and in corridors leading to inland hauling grounds. Some territorial males have as few as one or two females. Should these females be absent during the counts, their pups are used as a basis for putting the adult male into Class 3 rather than Class 2.
Class 4 (back fringe)	Full- and partly grown males on the inland fringe of a rookery. A few animals too young and too small to include in the count may be found here. Though some Class 4 males may appear to be holding territories, most will flee when approached or when prodded with a pole.
Class 5 (hauling ground)	The hauling grounds contain males from May to late July and a mixture of males and females from then on. The counts include males that obviously are adults and all others that have a mane and the body conformation of an adult. Males included in this count are approximately 7 years of age and older. Prior to 1966, Class 3 males were called harem bulls, and Classes 1,2,4, and 5 were collectively called idle bulls. From 1966 through 1974, the adult male seals were classified into five groups (Classes 1, 2, 3, 4, and 5). Beginning in 1975, Classes 1 and 2 were combined and designated as Class 2, Class 3 remained the same, and Classes 4 and 5 were combined and designated as Class 5.
Drive	The act of surrounding and moving groups of seals from one location to another.
Hauling ground	An area, usually near a rookery, on which nonbreeding seals congregate. See Rookery.

Haul out	The act of seals moving from the sea onto shore at either a rookery or hauling ground.
Kleptogyny	The act of an adult male seal (primarily classes 1, 2, or 3) seizing an adult female from another male's territory.
Known-age	Refers to a seal whose age is known because the animal bears an inscribed tag or other type of mark.
Marked	Describes a seal that has been marked either by removing the cartilaginous tip of a digit from a hind flipper and attaching an inscribed metal or plastic tag to one or more of its flippers, by hair clipping, or by bleaching.
Mark recoveries	Recovery (sighting) of a seal that has been marked by one of several methods. See marked.
Rookery	An area on which breeding seals congregate. See Hauling ground.
Roundup	Biologists surround and herd juvenile male fur seals close to the location they haul out.
Vibrissae (facial whiskers)	To determine the relative age structure of females in a population, the color of their whiskers are used. Facial vibrissae are black at birth and remain black through age 3 years; become mixed (black and white) at ages 4 and 5 years; and by age 7, the vibrissae usually are entirely white.

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APPENDIX B

Tabulations of northern fur seal data collected on the Pribilof Islands and Bogoslof Island, Alaska, and on San Miguel Island, California, during 1990.

Table B-1.--Number of adult male northern fur seals counted by class[a] and rookery section, St. Paul Island, Alaska, 9-14 July 1990. A dash indicates no numbered sections.

Rookery and class of male	Section 1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total
Lukanin															
2	17	24	-	-	-	-	-	-	-	-	-	-	-	-	41
3	68	61	-	-	-	-	-	-	-	-	-	-	-	-	129
5	169	5	-	-	-	-	-	-	-	-	-	-	-	-	174
Kitovi[b]															
2	19(10)	5	27	26	16	-	-	-	-	-	-	-	-	-	103
3	33(16)	15	60	51	55	-	-	-	-	-	-	-	-	-	230
5	5(70)	17	15	31	236	-	-	-	-	-	-	-	-	-	374
Reef															
2	18	8	33	12	15	8	9	28	15	3	4	-	-	-	153
3	60	64	60	39	38	64	14	41	59	39	6	-	-	-	484
5	16	47	64	36	61	14	51	39	19	27	34	-	-	-	408
Gorbatch															
2	31	18	18	0	0	30	-	-	-	-	-	-	-	-	97
3	121	72	56	0	13	99	-	-	-	-	-	-	-	-	361
5	282	34	60	177	23	29	-	-	-	-	-	-	-	-	605
Ardiguen															
2	20	-	-	-	-	-	-	-	-	-	-	-	-	-	20
3	78	-	-	-	-	-	-	-	-	-	-	-	-	-	78
5	13	-	-	-	-	-	-	-	-	-	-	-	-	-	13
Morjovi[c]															
2	3(2)	15	14	9	20	11	-	-	-	-	-	-	-	-	74
3	12(32)	58	61	31	108	39	-	-	-	-	-	-	-	-	341
5	189(35)	33	313	22	37	180	-	-	-	-	-	-	-	-	809
Vostochni															
2	14	18	10	8	6	37	10	10	4	2	8	14	34	12	187
3	41	17	56	47	30	96	62	85	39	15	15	51	158	73	785
5	26	31	4	56	107	120	58	11	57	7	11	96	72	127	783
Little Polovina															
2	6	-	-	-	-	-	-	-	-	-	-	-	-	-	6
3	15	-	-	-	-	-	-	-	-	-	-	-	-	-	15
5	86	-	-	-	-	-	-	-	-	-	-	-	-	-	85
Polovina															
2	11	3	-	-	-	-	-	-	-	-	-	-	-	-	14
3	40	20	-	-	-	-	-	-	-	-	-	-	-	-	60
5	207	110	-	-	-	-	-	-	-	-	-	-	-	-	317
Polovina Cliffs															
2	12	17	3	22	21	22	22	-	-	-	-	-	-	-	119
3	38	37	26	53	63	72	118	-	-	-	-	-	-	-	407
5	31	12	18	22	26	53	159	-	-	-	-	-	-	-	321
Tolstoi															
2	16	20	29	16	17	23	35	31	-	-	-	-	-	-	187
3	52	55	69	80	82	103	61	50	-	-	-	-	-	-	552
5	9	14	15	21	66	99	51	707	-	-	-	-	-	-	982
Zapadni Reef															
2	46	13	-	-	-	-	-	-	-	-	-	-	-	-	59
3	108	34	-	-	-	-	-	-	-	-	-	-	-	-	142
5	55	85	-	-	-	-	-	-	-	-	-	-	-	-	140
Little Zapadni															
2	2	3	26	28	12	12	-	-	-	-	-	-	-	-	88
3	14	46	71	59	70	63	-	-	-	-	-	-	-	-	323
5	18	19	23	20	37	248	-	-	-	-	-	-	-	-	365
Zapadni[d]															
2	22(0)	39	31	32	34	34	43	7	-	-	-	-	-	-	242
3	51(0)	82	80	79	81	67	73	10	-	-	-	-	-	-	523
5	18(224)	22	17	25	172	48	43	294	-	-	-	-	-	-	863

[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]Numbers in parentheses are the adult males counted on the second point south of Sea Lion Neck.
[d]Numbers in parentheses are the adult males counted on Zapadni Point Reef.

Table B-2.--Number of harem and idle male northern fur seals counted in mid-July, Pribilof Islands, Alaska, 1981-1990. A dash indicates no data.

Year	St. Paul Island		St. George Island		Total	
	Harem	Idle	Harem	Idle	Harem	Idle
1981	5,120	4,003	1,472	1,646	6,592	5,649
1982	5,767	4,009	1,410	1,319	7,177	5,328
1983	4,827	4,242	-	-	4,827*	4,242*
1984	4,803	3,977	1,473	1,452	6,276	5,429
1985	4,372	3,363	1,286	1,601	5,658	4,964
1986	4,603	1,865	1,394	1,342	5,997	3,207
1987	3,636	1,892	1,303	1,283	4,939	3,175
1988	3,585	3,201	1,259	1,258	4,844	4,459
1989	4,297	6,400	1,241	1,163	5,538	7,563
1990	4,430	7,629	909	1,666	5,339	9,295

[a] The total for 1983 does not include males from St. George Island.

Table B-3.--Number of northern fur seals sheared on each rookery of St. Paul Island and Sea Lion Rock, Alaska, 1990.

Rookery	Date	Section 1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total
Ardiguen	9 Aug.	314														314
Gorbatch	9 Aug.	473	279	219	0	55	390									1,416
Lukanin	8 Aug.	255	264													519
Kitovi	9 Aug.	130	454[1]		425[1]											1,009
Kitovi Amph.	9 Aug.	59														59
Morjovi	7 Aug.	27	212	181	93	361	135									1,009
2nd Point South	7 Aug.	158														158
Polovina	11 Aug.	152	79													231
Polovina Cliffs	12 Aug.	152	148	138	221	248	281	471								1,659
Reef	5 Aug.	233	260	236	154	147	450[1]		162	230	177					2,049
Tolstoi	11 Aug.	200	221	261	457	322	402	242	193							2,298
Vostochni	6,7 Aug.	158	71	219	185	119	358	243	332	153	60	103	220	618	288	3,127
Zapadni	10 Aug.	207	319	312	310	312	284	295	35							2,074
Zapadni Reef	8 Aug.	339	131													470
Little Zapadni	8 Aug.	55	180	279	231	275	249									1,269
Total (St. Paul)	5-12 Aug.															17,661
Sea Lion Rock	18 Aug.	424	305	302												1,031

[1] Allocation of number of sheared pups were combined for these two sections because the distribution of animals had changed between the time of the bull count and shearing.

Table B-4.--Number of dead northern fur seal pups counted by section on the rookeries of St. Paul Island, Alaska (including Sea Lion Rock), 1990.

Rookery	Date	Section 1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total
Ardiguen	24 Aug.	121[a]	--	--	--	--	--	--	--	--	--	--	--	--	--	121
Gorbatch	24 Aug.	164	152	184	9	20	111	--	--	--	--	--	--	--	--	640
Lukanin	24 Aug.	295	291	--	--	--	--	--	--	--	--	--	--	--	--	586
Kitovi	24 Aug.	57[b]	6	149	145	67	--	--	--	--	--	--	--	--	--	424
Morjovi	20 Aug.	424[c]	114	56	58	83	43	--	--	--	--	--	--	--	--	396
Polovina	21 Aug.	45	9	--	--	--	--	--	--	--	--	--	--	--	--	54
Polovina Cliffs	21 Aug.	31	25	50	74	109	118	245	--	--	--	--	--	--	--	652
Reef	20 Aug.	79	107	209	127	173	164	362[d]	107	39	11	0	--	--	--	1,378
Tolstoi	23 Aug.	73	71	77	121	174	232	177	220	--	--	--	--	--	--	1,145
Vostochni	22 Aug.	25	18	105[e]		35	193	132[f]	85	36	7	22	43	213	67	981
Zapadni	22 Aug.	65	158	256	277	209	201	155	46	--	--	--	--	--	--	1,367
Zapadni Reef	23 Aug	335	108	--	--	--	--	--	--	--	--	--	--	--	--	443
Little Zapadni	23 Aug.	110	199	258	166	185	--	--	--	--	--	--	--	--	--	918
Total (excluding Sea Lion Rock and Little Polovina)																9,105
Sea Lion Rock	18 Aug.	198	124	105												427

[a]Includes 23 dead pups counted in a separate area between Gorbatch and Ardiguen.
[b]Includes 13 dead pups counted at Kitovi Amphitheater.
[c]Includes 38 dead pups from 2nd Point South of Sea Lion Neck
[d]Includes 315 pups taken for necropsies.
[e]Dead pups from sections 3 and 4 were not separated.
[f]Includes 46 pups taken for necropsies.

Table B-5.--Northern fur seal pups tagged with pink plastic roto tags at Adams Cove, San Miguel Island, California, 23 September 1990.

Left tag	Right tag	Sex	Weight (kg)
A001201	A001201	M	7.2
A001202	A001202	M	8.8
A001203	A001203	M	10.0
A001204	A001204	F	6.5
A001205	A001205	M	10.2
A001206	A001206	F	5.8
A001207	A001207	F	10.0
A001208	A001208	F	9.1
A001209	A001209	M	9.0
A001210	A001210	M	8.8
A001211	A001211	M	9.0
A001212	A001212	F	7.0
A001213	A001213	M	7.4
A001214	A001214	M	10.0
A001215	A001215	M	8.4
A001216	A001216	M	12.0
A001217	A001217	M	6.9
A001218	A001218	F	8.6
A001219	A001219	F	6.7
A001220	A001220	F	7.8
A001221	A001221	M	13.4
A001222	A001222	M	5.6
A001223	A001223	M	9.0
A001224	A001224	F	5.8
A001225	A001225	M	11.6
A001226	A001226	F	5.4
A001227	A001227	F	9.2
A001228	A001228	M	5.4
A001229	A001229	M	12.2
A001230	A001230	M	9.6
A001231	A001232	M	10.0
A001233	A001233	F	7.8
A001234	AO01234	F	7.4
A001235	A001235	M	11.6
A001236	A001236	F	8.0
A001237	A001237	F	7.8
A001238	A001238	M	15.0
A001239	A001239	M	8.2
A001240	A001240	M	10.2
A001241	A001241	M	6.0
A001242	A001242	F	11.4
A001243	A001243	F	5.4
A001244	A001244	M	11.0

Table B-5.--Continued.

Left tag	Right tag	Sex	Weight (kg)
A001245	A001245	M	9.4
A001246	A001246	M	8.4
A001247	A001247	M	6.9
A001248	A001248	F	9.4
A001249	A001249	F	6.6
A001250	A001250	F	9.4
A001251	A001251	M	8.9
A001252	A001252	F	7.4
A001253	A001253	M	12.4
A001254	A001254	F	8.2
A001255	A001255	F	7.4
A001256	A001256	F	5.6
A001257	A001257	F	10.9
A001258	A001258	M	6.2
A001259	A001259	M	8.4
A001260	A001260	M	7.6
A001261	A001261	F	8.9
A001262	A001262	F	7.2
A001263	A001263	M	8.4
A001265	A001265	M	7.2
A001264	A001264	F	9.4
A001266	A001266	F	6.0
A001267	A001267	M	10.7
A001268	A001268	F	7.2
A001269	A001269	M	7.4
A001270	A001270	M	9.2
A001271	A001271	F	8.7
A001272	A001272	M	9.2
A001273	A001273	F	8.7
A001274	A001274	M	12.8
A001275	A001275	M	6.4
A001276	A001276	F	7.7
A001277	A001277	F	9.6
A001278	A001278	M	10.8
A001280	A001279	F	9.8
A001281	A001281	F	6.8
A001282	A001282	M	8.6
A001283	A001283	M	13.8
A001284	A001284	M	9.2
A001285	A001285	M	7.2
A001286	A001286	M	12.2
A001287	A001287	F	9.0
A001288	A001288	M	7.7
A001289	A001289	F	9.2
A001290	A001290	F	10.2
A001291	A001291	M	15.0

Table B-5.--Continued.

Left tag	Right tag	Sex	Weight (kg)
A001292	A001292	M	9.8
A001293	A001293	F	10.8
A001294	A001294	M	9.2
A001295	A001295	M	7.4
A001296	A001296	F	5.7
A001297	A001297	F	9.0
A001298	A001298	M	11.2
A001299	A001299	M	8.4
A001300	A001300	F	8.6
A001301	A001301	M	6.6
A001302	A001302	F	8.2
A001303	A001303	M	13.4
A001304	A001304	M	11.9
A001305	A001305	F	9.7
A001306	A001306	M	12.6
A001307	A001307	M	12.7
A001308	A001308	M	8.4
A001309	A001309	F	6.2
A001310	A001310	M	5.8
A001311	A001311	M	5.2
A001312	A001312	M	8.2
A001313	A001313	M	7.2
A001314	A001314	M	12.0
A001315	A001315	M	7.6
A001316	A001316	F	7.2
A001317	A001317	M	8.7
A001318	A001318	M	6.6
A001319	A001319	M	8.0
A001320	A001320	M	8.2
A001321	A001321	F	8.0
A001322	A001322	M	9.5
A001323	A001323	M	6.2
A001324	A001324	M	9.6
A001325	A001325	M	7.2
A001326	A001326	F	6.4
A001327	A001327	M	7.7
A001328	A001328	F	12.2
A001329	A001329	M	8.2
A001330	A001330	F	7.4
A001331	A001331	M	7.2
.A001332	A001332	F	9.4
A001333	A001333	M	6.7
A001334	A001334	M	8.0
A001335	A001335	F	6.2
A001336	A001336	M	8.0
A001337	A001337	M	10.2

Table B-5. --Continued.

Left tag	Right tag	Sex	Weight (kg)
A001338	A001338	F	8.6
A001339	A001339	M	10.2
A001340	A001340	M	9.6
A001341	A001341	F	7.4
A001342	A001342	F	8.8
A001343	A001343	F	5.9
A001344	A001344	F	7.6
A001345	A001345	F	7.4
A001346	A001346	F	9.2
A001347	A001347	M	9.2
A001348	A001348	M	6.8
A001349	A001349	M	9.0
A001350	A001350	F	8.6
A001351	A001351	F	11.0
A001352	A001352	F	8.6
A001353	A001353	F	6.2
A001354	A001354	F	7.6
A001355	A001355	F	6.4
A001356	A001356	M	11.2
A001357	A001357	F	5.6
A001358	A001358	F	7.4
A001359	A001359	M	8.6
A001360	A001360	M	7.8
A001361	A001361	F	8.1
A001362	A001362	F	8.2
A001363	A001363	M	10.2
A001364	A001364	F	7.8
A001365	A001365	F	6.2
A001366	A001366	M	9.0
A001367	A001367	M	8.4
A001368	A001368	M	9.6
A001369	A001369	F	7.2
A001370	A001370	F	8.8
A001371	A001371	F	8.0
A001372	A001372	F	7.6
A001373	A001373	F	7.0
A001374	A001374	M	7.4
A001375	A001375	F	12.1
A001376	A001376	M	9.6
A001377	A001377	F	6.1
A001378	A001378	M	8.6
A001379	A001379	M	8.4
A001380	A001380	M	6.4
A001381	A001381	M	5.6
A001382	A001382	M	6.5
A001383	A001383	M	12.6

Table B-5.--Continued.

Left tag	Right tag	Sex	Weight (kg)
A001384	A001384	M	8.0
A001385	A001385	M	7.0
A001386	A001386	F	8.8
A001387	A001387	M	11.2
A001388	A001388	F	11.0
A001389	A001389	M	10.4
A001390	A001390	F	7.6
A001391	A001391	M	9.2
A001392	A001392	M	13.4
A001393	A001393	M	9.9
A001394	A001394	M	10.2
A001395	A001395	F	8.9
A001396	A001396	M	7.4
A001397	A001397	M	8.2
A001398	A001398	F	7.6
A001399	A001399	M	6.6
A001400	A001400	F	9.1
A001401	A001401	M	11.0
A001402	A001402	U	7.6

Table B-6.--Northern fur seals resighted on San Miguel Island, California, 1 January-31 December 1990.

Cohort	Date resighted	Left tag	Tag type[a]	Right tag	Tag type[a]	Sex	Condition[b]
1980	07 27 90	0000481	P RT			M	02
1980	10 24 90	SMI2130	S ML			F	02
1980	10 24 90			0000487	P RT	F	02
1981	07 27 90	SMI2402	S ML			M	02
1981	03 24 90	SMI2402	S ML			M	02
1981	03 23 90	SMI2402	S ML			M	02
1981	03 22 90	SMI2402	S ML			M	02
1981	03 25 90	SMI2402	S ML			M	02
1981	07 27 90			A000026	P RT	M	02
1981	03 24 90			A000026	P RT	M	02
1981	03 25 90			A000026	P RT	M	02
1981	03 26 90			A000026	P RT	M	02
1981	03 27 90			A000026	P RT	M	02
1981	03 28 90			A000026	P RT	M	02
1981	03 29 90			A000026	P RT	M	02
1981	03 31 90			A000026	P RT	M	02
1981	09 21 90	A000001	P RT	A000001	P RT	F	02
1981	09 22 90	A000001	P RT	A000001	P RT	F	02
1981	09 21 90			A000044	P RT	F	02
1981	09 22 90			A000044	P RT	F	02
1981	09 22 90	SMI2456	S ML	SMI2457	S ML	F	02
1981	09 22 90	A000055	G RE	A000055	G RE	F	02
1981	09 26 90	A000020	P RT			F	02
1981	09 21 90	A000001	P RT	A000001	P RT	F	02
1981	09 26 90	A000020	P RT			F	02
1981	11 05 90	A000052	P RT	A000052	P RT	F	02
1982	07 27 90			A000158	P RT	M	02
1982	09 22 90			SMI2676	S ML	F	02
1984	04 02 90	A000358	P RT	A000358	P RT	F	02
1984	05 15 90			A000340	P RT	M	02
1984	07 27 90			A000333	P RT	M	02
1984	03 25 90	A000387	P RT			M	02
1984	03 26 90	A000387	P RT			M	02
1984	03 27 90	A000387	P RT			M	02
1984	03 28 90	A000387	P RT			M	02
1984	03 29 90	A000387	P RT			M	02
1984	03 26 90	A000343	P RT	A000343	P RT	F	02
1984	03 28 90	A000343	P RT	A000343	P RT	F	02
1984	03 27 90	A000343	P RT	A000343	P RT	F	02
1984	03 31 90	A000343	P RT	A000343	P RT	F	02
1984	03 27 90	A000311	P RT	A000311	P RT	M	02
1984	03 28 90	A000311	P RT	A000311	P RT	M	02
1984	09 21 90	A000365	P RT	A000365	P RT	F	02
1984	09 22 90	A000365	P RT	A000365	P RT	F	02

Table B-6.--Continued.

Cohort	Date resighted	Left tag	Tag type'	Right tag	Tag type"	Sex	Condition[b]
1984	09 21 90	A000395	P RT	A000395	P RT	F	02
1984	09 21 90			A000321	P RT	F	02
1984	09 25 90	A000316	P RT			M	02
1984	09 26-90			A000371	P RT	F	02
1984	09 21 90	A000365	P RT	A000365	P RT	F	02
1984	09 21 90	A000395	P RT	A000395	P RT	F	02
1984	11 05 90	A000325	P RT	A000325	P RT	F	02
1984	11 04 90			A000314	P RT	F	02
1985	07 29 90			coo0435	P RT	M	02
1985	04 02 90	A000571	P RT	A000571	P RT	M	02
1985	05 15 90	A000571	P RT	A000571	P RT	M	02
1985	03 28 90	A000571	P RT	A000571	P RT	M	02
1985	03 30 90	A000571	P RT	A000571	P RT	M	02
1985	04 02 90	A000517	P RT	A000517	P RT	M	02
1985	04 02 90	A000517	P RT	A000570	P RT	M	02
1985	05 15 90			A000555	P RT	M	02
1985	02 24 90	A000578	'P RT	A000578	P RT	M	02
1985	03 22 90	A000540	P RT	A000540	? RT	M	02
1985	03 23 90	A000540	P RT	A000540	P RT	M	02
1985	09 21 90			COO0446	P RT	M	02
1985	09 21 90	A000576	P RT	A000576	P RT	M	02
1985	09 22 90	A000576	P RT	A000576	P RT	M	02
1985	09 21 90	A000555	P RT	A000555	.P RT	M	02
1985	09 21 90	A000507	P RT	A000507	P RT	F	02
1985	09 22 90	A000507	P RT	A000507	P RT	F	02
1985	09 21 90	A000549	P-RT			F	02
1985	09 22 90	A000540	P RT	A000540	P RT	M	02
1985	09 22 90	A000517	P RT			M	02
1985	09 26 90			A000517	P RT	M	02
1985	09 25 90	A000515	P RT	A000515	P RT	M	02
1985	09 26 90	A000515	P RT	A000515	P RT	M	02
1985	09 21 90			COO0446	P RT	M	02
1985	09 21 90	A000576	P RT	A000576	P RT	M	02
1985	09 21 90	A000555	P RT	A000555	P RT	M	02
1985	09 21 90	A000507	P RT	A000507	P RT	F	02
1985	11 05 90	A000564	P RT	A000564	P RT	F	02
1985	11 11 90	A000553	P RT			F	02
1986	02 24 90			A000449	P RT	M	02
1986	03 22 90			A000449	P RT	M	02
1986	02 24 90	A000483	P RT	A000483	P RT	M	02
1986	02 24 90	A000441	P RT			M	02
1986	07 27 90			A000492	P RT	F	02
1986	07 27 90	A000447	P RT	A000447	P RT	F	02
1986	07 27 90	A000433	P RT	A000433	P RT	M	02

Table B-6.--Continued.

Cohort	Date resighted	Left tag	Tag type"	Right tag	Tag type"	Sex	Condition[b]
1986	07 27 90	A000468	P RT	A000468	P RT	F	02
1986	03 22 90	A000404	P RT			M	02
1986	03 22 90	A000490	P RT			M	02
1986	03 2s 90	A000471	P RT	A000471	P RT	M	02
1986	03 23 90	A000404	P RT			M	02
1986	09 21 90	COOO240	P RT			F	02
1986	09 21 90	A000459	P RT	A000459	P RT	F	02
1986	09 22 90	A000422	P RT	A000422	P RT	M	02
1986	09 22 90	A000472	P RT	A000472	P RT	F	02
1986	09 26 90	A000420	P RT			F	02
1986	09 24 90	A000487	P RT			M	02
1986	09 21 90	COO0240	P RT			F	02
1986	09 21 90	A000459	P RT	A000459	P RT	F	02
1986	09 26 90	A000420	P RT			F	02
1986	10 30 90			A000492	P RT	F	02
1986	11 OS 90	A000494	P RT	A000494	P RT	F	02
1986	11 OS 90	COO0240	P RT			F	02
1986	11 OS 90	A000405	P RT			M	02
1986	11 11 90	A000460	P RT			F	02
1987	04 02 90	A000694	P RT	A000694	P RT	M	02
1987	OS 1s 90	A000689	P RT	A000689	P RT	F	02
1987	03 2s 90	A000603	P RT	A000603	P RT	M	02
1987	03 26 90	A0006CI3	P RT	A000603	P RT	M	02
1987	03 27 90	A000603	P RT	A000603	P RT	M	02
1987	03 28 90	A000603	P RT	A000603	P RT	M	02
1987	03 29 90	AOOO'603	P RT	A000603	P RT	M	02
1987	03 20 90	A000663	P RT			F	02
1987	03 22 90	A000663	P RT			F	02
1987	03-23 90	A000663	P RT				02
1987	03 28 90	A000663	P RT			F	02
1987	03 29 90	A000663	P RT			F	02
1987	03 22 90	A000605	P RT	A000605	P RT	M	02
1987	03 24 90	A000605	P RT	A000605	P RT	M	02
1987	03 2s 90	A000605	P RT	A000605	P RT	M	
1987	03 28 90	A000605	P RT	A000605	P RT	M	02
1987	03 30 90	A000605	P RT	A000605	P RT	M	02
1987	03 20 90	A000622	P RT	A000622	P RT	M	02
1987	03 22 90	A000622	P RT	A000622	P RT	M	02
1987	03 23 90	A000632	P RT	A000632	P RT	M	02
1987	03 24 90	A000632	P RT	A000632	P RT	M	02
1987	.03 24 90	A000673	P RT			M	02
1987	03 27 90	A000642	P RT	A000642	P RT	M	02
1987	03 27 90	A000618	P RT	A000618	P RT	M	02
1987	03 28 90	A000618	P RT	A000618	P RT	M	02

Table B-6.--Continued.

Cohort	Date resighted	Left tag	Tag type"	Right tag	Tag type"	Sex	Condition[b]
1987	09 21 90	A000603	P RT	A000603	P RT	M	02
1987	09 22 90	A000603	P RT	A000603	P RT	M	02
1987	09 21 90	A000669	P RT	A000669	P RT	F	02
1987	09 22 90	A000669	P RT	A000669	P RT	F	02
1987	09 25 90	A000669	P RT	A000669	P RT	F	02
1987	09 21 90	A000606	P RT	A000606	P RT	F	02
1987	09 21 90	A000645	P RT	A000645	P RT	M	02
1987	09 21 90	A000605	P RT	A000605	P RT	M	02
1987	09 22 90	A000605	P RT	A000605	P RT	M	02
1987	09 25 90	A000605	P RT	A000605	P RT	M	02
1987	09 22 90			A000601	P RT	F	02
1987	09 22 90			A000625	P RT	F	02
1987	09 22 90	A000657	P RT			F	02
1987	09 22 90			A000609	P RT	M	02
1987	09 26 90	A000620	P RT	A000620	P RT	F	02
1987	09 26 90	A000624	P RT	A000624	P RT	F	02
1987	09 26 90	A000634	P RT			F	02
1987	09 26 90	A000626	P RT	A000626	P RT	F	02
1987	09 26 90	A000669	P RT	A000669	P RT	F	02
1987	09 26 90	A000606	P RT	A000606	P RT	F	02
1987	11 OS 90	A000606	P RT	A000606	P RT	F	02
1987	11 04 90	A000606	P RT	A000606	P RT	F	02
1987	11 OS 90	A000626	P RT	A000626	P RT	F	02
1987	11 11 90	A000669	P RT	A000669	P RT	F	02
1987	11 OS 90	A000620	P RT	A000620	P RT	F	02
1987	12 13 90	A000634	P RT	‘A000634	P RT	F	02
1987	12 13 90			A000661	P RT	F	02
1988	03 2s 90	coo0717	P RT	coo0717	j? RT	M	02
1988	03 28 90	coo0717	P RT	coo0717	P RT	M	02
1988	04 02 90	coo0717	P RT	coo0717	P RT	M	02
1988	OS 1s 90			A000721	P RT	M	02
1988	03 20 90	A000721	P RT	A000721	P RT	M	02
1988	07 27 90	COO0332	P RT	COO0332	P RT	F	02
1988	07 27 90			A000754	P RT	F	02
1988	03 25 90	A000720	P RT	A000720	P RT	F	02
1988	03 26 90	COO0720	P RT	COO0720	P RT	M	02
1988	03 26 90	A000720	P RT	A000720	P RT	M	02
1988	03 27 90	COO0720	P RT	COO0720	P RT	M	02
1988	03 27 90	coo0713	P RT	coo0713	P RT	M	02
1988	03 28 90	coo0713	P RT	coo0713	P RT	M	02
1988	02 07 90	A000862	P RT	A000862	P RT	F	03
1988	03 21 90			A000838	P RT	F	02
1988	09 21 90			c000753	P RT	M	02
1988	09 21 90	coo0771	P RT			F	02

Table B-6.--Continued.

Cohort	Date Resighted	Left tag	Tag type[a]	Right tag	Tag type[a]	Sex	Condition[b]
1988	09 21 90	A000737	P RT	A000737	P RT	F	02
1988	09 21 90	A000730	P RT	A000730	P RT	F	02
1988	09 22 90	C000743	P RT			F	02
1988	09 22 90	C000400	P RT	C000400	P RT	M	02
1988	09 22 90	A000810	P RT	A000810	P RT	F	02
1988	09 22 90			A000847	P RT	M	02
1988	09 22 90	A000735	P RT	A000735	P RT	F	02
1988	09 22 90	C000783	P RT	C000783	P RT	M	02
1988	09 22 90	C000723	P RT	C000723	P RT	M	02
1988	09 22 90	C000784	P RT	C000784	P RT	M	02
1988	09 25 90			A000840	P RT	M	02
1988	09 26 90	A000840	P RT	A000840	P RT	M	02
1988	09 25 90	A000847	P RT	A000847	P RT	M	02
1988	09 26 90	A000826	P RT	A000826	P RT	F	02
1988	09 26 90	C000390	P RT			F	02
1988	09 26 90	C000784	P RT	C000784	P RT	M	02
1988	09 26 90	C000723	P RT	C000723	P RT	M	02
1988	09 26 90			C000771	P RT	M	02
1988	09 21 90	C000771	P RT			M	02
1988	09 26 90	C000390	P RT			F	02
1988	09 26 90	C000784	P RT	C000784	P RT	M	02
1988	10 30 90	C000339	P RT	C000339	P RT	M	02
1988	10 30 90	C000750	P RT	C000750	P RT	M	02
1988	10 30 90	A000818	P RT	A000818	P RT	M	02
1988	10 30 90	A000720	P RT	A000720	P RT	F	02
1988	11 05 90			C000355	P RT	F	02
1988	11 05 90	C000332	P RT	C000332	P RT	F	02
1988	11 05 90	C000383	P RT	C000383	P RT	M	02
1988	11 05 90	C000743	P RT	C000743	P RT	F	02
1988	11 05 90	A000720	P RT	A000720	P RT	F	02
1988	11 05 90	A000754	P RT	A000754	P RT	M	02
1988	11 05 90	C000744	P RT	C000744	P RT	M	02
1988	11 05 90	C000740	P RT	C000740	P RT	F	02
1988	11 11 90	A000818	P RT	A000818	P RT	M	02
1988	11 11 90	C000771	P RT			M	02
1988	11 11 90	A000745	P RT	A000745	P RT	M	02
1988	09 21 90			A000838	P RT	F	02
1988	11 04 90			A000701	P RT	F	02
1988	11 05 90			A000865	P RT	M	02
1988	11 05 90			A000865	P RT	M	02
1989	03 20 90	C000521	P RT	C000522	P RT	M	02
1989	02 20 90	C000824	P RT	C000824	P RT	F	03

[a] Tag Types: P RT = Pink roto; S ML = Silver Monel; G RE = Green Reise
[b] 02 = Alive 03 = Dead

Table B-7.--Northern fur seals resighted along the Pacific coast, l January-31 December 1990.

Cohort	Date resighted	Latitude	Longitude	Left tag	Tag type[a]	Right tag	Tag type[a]	Sex	Condition[b]
1981	09 07 90	374150	1230000	C000028	P RT	C000028	P RT	M	02
1986	07 29 90	340317	1202612	C000280	P RT			F	02
1989	01 13 90	334225	1181740	C000834	P RT	C000834	P RT	M	03

[a] P RT = Pink Roto tags
[b] 02 = Alive; 03 = Dead

Table B-8.--Northern fur seal adult females and juvenile males fitted with dummy instrument packages at Adams Cove, San Miguel Island, California, September and November 1990.

Date	Left tag	Right tag	Tag type	Sex	Package type
September					
25	A000002	A000002	White Roto	F	Small
25	A000003	A000003	White Roto	F	Large
25	A000004	A000004	White Roto	F	Large
November					
5	A000007	A000007	White Roto	F	Geolocation
5	A000008	A000008	White Roto	M	Geolocation
5	A000011	A000011	White Roto	M	Geolocation
5	A000014	A000014	White Roto	M	Geolocation
5	A000818	A000818	Pink Roto	M	Geolocation

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APPENDIX C

Tabulations of northern fur seal entanglement data.

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APPENDIX C (Continued)

Table C-l.--Summary of roundups of juvenile (subadult) northern fur seal males conducted on St. Paul Island, Alaska, during July and August 1990.

Date	Location	Total[a] seals in roundup	Tagged seals[b] resighted	Total seals tagged
7/1	Zapadni Reef	6	0	0
7/1	Tolstoi Sands	59	0	1
7/1	Tolstoi Sands	73	2	2
7/1	Tolstoi Sands	138	3	3
7/2	Zoltoi Sands	732	9	1
7/3	Zapadni Reef Sands	361	10	1
7/5	Zapadni	65	0	0
7/5	Little Zapadni	85	1	0
7/5	Zapadni Sands	93	0	0
7/5	Zapadni	100	1	0
7/5	Zapadni	200	1	0
7/5	Kitovi	209	2	0
7/5	Zapadni Sands	233	3	0
7/5	Zapadni Sands	288	1	3
7/5	Zapadni	359	2	3
7/6	Polovina	34	1	0
7/6	Polovina	132	0	0
7/6	Polovina	211	3	0
7/6	Morjovi	248	5	0
7/6	Lukanin	259	9	3
7/7	Vostochni	35	1	1
7/7	Vostochni	75	1	0
7/7	Vostochni	152	5	0
7/7	North East Point	182	0	0
7/7	Vostochni Sands	209	6	11
7/7	Vostochni	249	2	0
7/8	Reef	16	0	0
7/8	Reef	20	0	0
7/8	Reef	147	1	0
7/8	Reef	447	9	0
7/9	Reef	65	1	0
7/9	Reef	146	2	0
7/9	Reef	153	0	0
7/9	Gorbatch	338	6	0
7/10	Zapadni Reef Sands	83	4	0
7/10	Zapadni Reef Sands	252	8	2
7/10	Zoltoi Sands	263	4	0
7/11	Zapadni Sands	22	0	0
7/11	Zapadni	68	2	0
7/11	Zapadni	108	0	0
7/11	Zapadni	112	4	3
7/11	Zapadni Sands	176	2	0
7/11	Zapadni Sands	406	5	3

Table C-1---Continued.

Date	Location	Total[a] seals in roundup	Tagged seals[b] resighted	Total seals tagged
7/12	Tolstoi Sands	35	0	0
7/12	Tolstoi Sands	55	1	3
7/12	Lukanin	378	15	2
7/12	Tolstoi Sands	525	10	3
7/13	Polovina	20	1	0
7/13	Polovina	136	7	0
7/13	Kitovi	160	3	0
7/13	Polovina	202	2	0
7/15	Reef	38	0	0
7/15	Reef	54	0	0
7/15	Reef	136	0	0
7/15	Reef	229	3	3
7/16	Little Zapadni	72	1	0
7/16	Vostochni Sands	325	8	8
7/16	Gorbatch	568	20	3
7/17	Vostochni	59	0	0
7/17	Vostochni	59	2	0
7/17	Vostochni	61	0	1
7/17	Vostochni	75	1	1
7/17	Zapadni Reef Sands	182	4	14
7/17	Vostochni	485	15	0
7/17	Morjovi	740	15	3
7/18	Tolstoi Sands	115	0	0
7/18	Tolstoi Sands	178	7	3
7/18	Zoltoi Sands	349	6	0
7/19	Kitovi	101	5	1
7/19	Polovina	148	5	0
7/19	Lukanin	155	11	0
7/19	Polovina	228	11	0
7/20	Zapadni	524	20	0
7/21	Vostochni Sands	581	30	8
7/22	Vostochni	191	8	8
7/22	Vostochni	603	15	3
7/22	Vostochni	713	29	12
7/24	Vostochni	38	2	0
7/24	Vostochni	55	3	0
7/24	Vostochni	75	1	3
7/24	Morjovi	225	10	03
7/24	Zapadni Reef Sands	363	11	0
7/25	Zoltoi Sands	323	9	0
7/25	Tolstoi	443	16	9
7/26	Kitovi	98	3	3
7/26	Lukanin	161	8	4
7/26	Zapadni	274	5	0
7/26	Zapadni	449	8	3

Table C-l. --Continued.

Date	Location	Total[a] seals in roundup	Tagged seals[b] resighted	Total seals tagged
7/26	Zapadni Sands	513	13	9
7/27	Reef	105	0	0
7/27	Reef	110	0	0
7/27	Reef	223	1	3
7/27	Reef	266	11	3
7/27	Reef	298	7	3
7/27	Gorbatch	592	23	1
7/28	Vostochni Sands	76	2	0
7/28	Vostochni	108	4	0
7/28	Vostochni	376	17	12
7/28	Vostochni	410	14	0
7/29	Polovina	125	5	3
7/29	Morjovi	349	10	0
7/29	Polovina	498	14	4
7/30	Tolstoi Sands	120	2	0
7/30	Tolstoi Sands	147	7	0
7/30	Little Zapadni	152	4	0
7/30	Zapadni Reef Sands	170	7	0
7/30	Zoltoi Sands	198	5	0
7/31	Zapadni	148	2	0
7/31	Zapadni	234	4	0
7/31	Zapadni	241	7	0
7/31	Zapadni	285	7	0
8/1	Reef	106	3	0
8/1	Kitovi	132	11	0
8/1	Reef	145	8	0
8/1	Lukanin	163	8	1
8/1	Reef	178	8	0
8/2	Vostochni	63	2	0
8/2	Vostochni Sands	111	5	3
8/2	Vostochni	115	4	0
8/2	Vostochni	151	8	3
8/3	Morjovi	110	2	3
8/3	Polovina	218	8	0
	Totals	25,829	680	186

[a]Seals that are judged to be of the size that were taken in the commercial harvest prior to 1985.

[b]Seals that had any kind of tag (including monel tags applied to pups in 1987 or 1988) in either foreflipper and that were successfully restrained to read the tag. Includes any that were resighted more than once this year.

Table C-2.--List of white broad-banded Allflex tags applied to subadult male northern fur seals during roundups conducted on St. Paul Island, Alaska, 1990. Entangling debris was removed from entangled seals prior to their being released.

Tag number	Date	Sex	Location	Entangled (e) Control (c)
1301	7/7	m	Vostochni	c
1302	7/7	m	Vostochni	c
1303	7/7	m	Vostochni	c
1304	7/7	m	Vostochni	c
1305	7/7	m	Vostochni	c
1306	7/7	m	Vostochni	c
1307	7/7	m	Vostochni	c
1308	7/7	m	Vostochni	c
1309	7/7	m	Vostochni	e
1310	7/8	f	Zapadni Reef	-a*
1311	7/8	f	Zapadni Reef	-
1312	7/8	f	Zapadni Reef	-
1313	7/10	m	Zapadni Reef Sands	c
1314	7/10	m	Zapadni Reef Sands	c
1315	7/10	f	Zapadni Reef	-
1316	7/10	f	Zapadni Reef	-
1317	7/11	m	Zapadni Sands	e
1318	7/11	m	Zapadni Sands	c
1319	7/11	m	Zapadni Sands	c
1320	7/11	m	Zapadni	e
1321	7/11	m	Zapadni	c
1322	7/11	m	Zapadni	c
1323	7/11	m	Tolstoi Sands	e
1324	7/12	m	Tolstoi Sands	c
1325	7/12	m	Tolstoi Sands	c
1326	7/11	m	Tolstoi Sands	e
1327	7/12	m	Tolstoi Sands	c
1328	7/12	m	Tolstoi Sands	c
1329	7/12	m	Lukanin	e
1330	7/12	m	Lukanin	c
1331	7/13	m	Polovina	c
1332	7/13	m	Polovina	e
1333	7/13	m	Polovina	c
1334	7/15	m	Reef	e
1335	7/15	m	Reef	c
1336	7/15	m	Reef	c
1337	7/15	m	Reef	c
1338	7/15	m	Reef	c
1339	7/15	m	Reef	e
1340	7/16	m	Gorbatch	e

Table C-2. --Continued.

Tag number	Date	Sex	Location	Entangled (e) Control (c)
1341	7/16	m	Gorbatch	c
1342	7/16	m	Gorbatch	c
1343	7/16	m	Vostochni Sands	e
1344	7/16	m	Vostochni Sands	c
1345	7/16	m	Vostochni Sands	c
1346	7/16	m	Vostochni Sands	c
1347	7/16	m	Vostochni Sands	e
1348	7/16	m	Vostochni Sands	e
1349	7/16	m	Vostochni Sands	c
1350	7/16	m	Vostochni Sands	c
1351	7/17	m	Vostochni	e
1352	7/17	m	Vostochni	e
1353	7/17	m	Morjovi	e
1354	7/17	m	Morjovi	c
1355	7/17	m	Morjovi	c
1356	7/17	m	Zapadni Reef Sands	e
1357	7/17	m	Zapadni Reef Sands	e
1358	7/17	m	Zapadni Reef Sands	e
1359	7/17	m	Zapadni Reef Sands	e
1360	7/17	m	Zapadni Reef Sands	c
1361	7/17	m	Zapadni Reef Sands	c
1362	7/17	m	Zapadni Reef Sands	c
1363	7/17	m	Zapadni Reef Sands	c
1364	7/17	m	Zapadni Reef Sands	e
1365	7/17	m	Zapadni Reef Sands	c
1366	7/17	m	Zapadni Reef Sands	c
1367	7/17	m	Zapadni Reef Sands	c
1368	7/17	m	Zapadni Reef Sands	c
1369	7/17	m	Zapadni Reef Sands	e
1370	7/18	m	Tolstoi Sands	c
1371	7/18	m	Tolstoi Sands	c
1372	7/18	m	Tolstoi Sands	e
1373	7/19	m	Kitovi	e
1374	7/21	m	Vostochni Sands	e
1374	7/21	m	Vostochni Sands	c
1376	7/21	m	Vostochni Sands	e
1377	7/21	m	Vostochni Sands	e
1378	7/21	m	Vostochni Sands	c
1379	7/21	m	Vostochni Sands	c
1380	7/21	m	Vostochni Sands	c
1381	7/21	m	Vostochni Sands	c
1382	7/22	m	Vostochni	e
1383	7/22	m	Vostochni	e
1384	7/22	m	Vostochni	e

Table C-2. --Continued.

Tag number	Date	Sex	Location	Entangled (e) Control (c)
1385	7/22	m	Vostochni	e
1386	7/22	m	Vostochni	c
1387	7/22	m	Vostochni	c
1388	7/22	m	Vostochni	c
1389	7/22	m	Vostochni	c
1390	7/22	m	Vostochni	e
1391	7/22	m	Vostochni	c
1392	7/22	m	Vostochni	c
1393	7/22	m	Vostochni	c
1394	7/22	m	Vostochni	c
1395	7/22	m	Vostochni	e
1396	7/22	m	Vostochni	e
1397	7/22	m	Vostochni	c
1398	7/22	m	Vostochni	c
1399	7/24	m	Vostochni	e
1400	7/24	m	Vostochni	c
1401	7/1	m	Tolstoi Sands	e
1402	7/1	m	Tolstoi Sands	c
1403	7/1	m	Tolstoi Sands	c
1404	7/1	m	Tolstoi Sands	e
1405	7/1	m	Tolstoi Sands	c
1406	7/1	m	Tolstoi Sands	c
1407	7/2	m	Zoltoi Sands	e
1408	7/3	m	Zapadni Reef Sands	e
1409	7/5	m	Zapadni Sands	e
1410	7/5	m	Zapadni Sands	c
1411	7/5	m	Zapadni Sands	c
1412	7/5	m	Zapadni	e
1413	7/5	m	Zapadni	c
1414	7/5	m	Zapadni	c
1415	7/6	m	Lukanin	e
1416	7/6	m	Lukanin	c
1417	7/6	m	Lukanin	c
1418	7/7	m	Vostochni	e
1419	7/7	m	Vostochni Sands	e
1420	7/7	m	Vostochni	e
1421	7/24	m	Vostochni	c
1422	7/25	m	Tolstoi Sands	e
1423	7/25	m	Tolstoi Sands	e
1424	7/25	m	Tolstoi Sands	e
1425	7/25	m	Tolstoi Sands	c
1426	7/25	m	Tolstoi Sands	c
1427	7/25	m	Tolstoi Sands	c
1428	7/25	m	Tolstoi Sands	c

Table C-2.--Continued.

Tag number	Date	Sex	Location	Entangled (e) Control (c)
1429	7/25	m	Tolstoi Sands	c
1430	7/25	m	Tolstoi Sands	c
1431	7/25	m	Zoltoi Sands	e
1432	7/26	m	Lukanin	e
1433	7/26	m	Lukanin	c
1434	7/26	m	Lukanin	c
1435	7/26	m	Lukanin	c
1436	7/26	m	Kitovi	e
1437	7/26	m	Kitovi	c
1438	7/26	m	Kitovi	c
1439	7/26	m	Zapadni Sands	e
1440	7/26	m	Zapadni Sands	c
1441	7/26	m	Zapadni Sands	c
1442	7/26	m	Zapadni Sands	e
1443	7/26	m	Zapadni Sands	c
1444	7/26	m	Zapadni Sands	c
1445	7/26	m	Zapadni Sands	c
1446	7/26	m	Zapadni Sands	e
1447	7/26	m	Zapadni Sands	c
1448	7/26	m	Zapadni	e
1449	7/26	m	Zapadni	c
1450	7/26	m	Zapadni	c
1451	7/27	m	Gorbatch	e
1452	7/27	m	Reef	e
1453	7/27	m	Reef	c
1454	7/27	m	Reef	c
1455	7/27	m	Reef	e
1456	7/27	m	Reef	c
1457	7/27	m	Reef	c
1458	7/27	m	Reef	e
1459	7/27	m	Reef	c
1460	7/27	m	Reef	c
1461	7/28	m	Vostochni	e
1462	7/28	m	Vostochni	e
1463	7/28	m	Vostochni	e
1464	7/28	m	Vostochni	e
1465	7/28	m	Vostochni	c
1466	7/28	m	Vostochni	c
1467	7/28	m	Vostochni	c
1468	7/28	m	Vostochni	c
1469	7/28	m	Vostochni	c
1470	7/28	m	Vostochni	c
1471	7/28	m	Vostochni	c
1472	7/28	m	Vostochni	c

Table C-2.--Continued.

Tag number	Date	Sex	Location	Entangled (e) Control (c)
1473	7/29	m	Polovina	c
1474	7/29	m	Polovina	c
1475	7/29	m	Polovina	e
1476	7/29	m	Polovina	e
1477	7/29	m	Polovina	c
1478	7/29	m	Polovina	c
1479	7/29	m	Polovina	e
1480	8/1	m	Reef	e
1481	8/2	m	Vostochni Sands	e
1482	8/2	m	Vostochni Sands	c
1483	8/2	m	Vostochni Sands	c
1484	8/2	m	Vostochni	e
1485	8/2	m	Vostochni	c
1486	8/2	m	Vostochni	c
1487	8/3	m	Morjovi	e
1488	8/3	m	Morjovi	c
1489	8/3	m	Morjovi	c

*Female seal tagged by biologists from Far Seas Fisheries Research Laboratory, Shimizu, Japan, with radio transmitters for behavioral or feeding studies.

Table C-3. --List of tagged northern fur seals seen during July juvenile male roundup activities on St. Paul Island, 1990. Tags were seen on both foreflippers unless noted otherwise. Debris was removed from entangled seals.

Date	Location	Tag number	Tag type	Tag color	Entanglement status*	Notes
7/1	Tolstoi Sands	1157	Allflex	orange	e[r]	Tagged 15 July 1989 on Zoltoi Sands.
7/1	Tolstoi Sands	5112	Allflex	white	c	Tagged 15 Oct. 1986 on Little Zapadni.
7/2	Zoltoi Sands	102	Allflex	blue	c	Tagged 26 July 1988 on Reef.
7/2	Zoltoi Sands	0330	Allflex	orange	c	Tagged 19 July 1986 on Reef.
7/2	Zoltoi Sands	0579	Allflex	orange	c	Tagged 5 Aug. 1986 on Reef.
7/2	Zoltoi Sands	0909	Allflex	orange	c	Tagged 6 Oct. 1986 on Tolstoi.
7/2	Zoltoi Sands	1163	Allflex	orange	c	Tagged 15 July 1989 on Zoltoi Sands.
7/2	Zoltoi Sands	1166	Allflex	orange	c	Tagged 15 July 1989 on Zapadni Reef Sands.
7/2	Zoltoi Sands	1183	Allflex	orange	c	Tagged 15 July 1989 on Reef.
7/2	Zoltoi Sands	1240	Allflex	orange	c	Tagged 22 July 1989 on Kitovi.
7/2	Zoltoi Sands	1257	Allflex	orange	c	Tagged 23 July 1989 on Zapadni.
7/3	Zapadni Reef Sands	1172	Allflex	orange	c	Tagged 15 July 1989 on Zapadni Reef Sands. Right tag only.
7/5	Kitovi	1240	Allflex	orange	c	Tagged 22 July 1989 on Kitovi.
7/5	Zapadni	0245	Allflex	orange	c	Tagged 10 Aug. 1985 on Vostochni. Tags looked a lot like orange instead of white Allflex.
7/5	Zapadni	5144	Allflex	white	c	Tagged 1 Aug. 1986 on Zapadni. Tags looked a lot like orange instead of white Allflex.
7/5	Zapadni Sands	0903	Allflex	orange	c	Tagged 6 Oct. 1986 on Tolstoi.
7/5	Zapadni Sands	1401	Allflex	white	c	Tagged 1 July 1990 on Tolstoi Sands.
7/6	Lukanin	0957	Allflex	orange	c	Tagged 8 Oct. 1986 on Tolstoi Sands.

Table C-3.--Continued.

Date	Location	Tag number	Tag type	Tag color	Entanglement status*	Notes
7/6	Morjovi	79	Allflex	blue	e^r	Tagged 25 July 1988 on Tolstoi.
7/6	Morjovi	1222	Allflex	orange	e^r	Tagged 19 July 1989 on Vostochni.
7/6	Polovina	1246	Allflex	orange	e^r	Tagged 23 July 1989 on Polovina.
7/7	Vostochni	1200	Allflex	orange	c	Tagged 18 July 1989 on Morjovi. No note of tag on left.
7/7	Vostochni	5180	Allflex	white	c	Tagged 3 Aug. 1986 on Tolstoi. Tag on right only.
7/7	Vostochni	0444	Allflex	orange	c	Tagged 31 July 1986 on Vostochni.
7/7	Vostochni	0499	Allflex	orange	c	Tagged 25 Aug. 1986 on Polovina. Tag seen on right side but number not verified.
7/7	Vostochni	1155	Allflex	orange	e^r	Tagged 14 July 1989 on Zapadni Reef Sands.
7/7	Vostochni	1272	Allflex	orange	c	Tagged 25 July 1989 on Morjovi.
7/7	Vostochni	bB2253		monel		
7/7	Vostochni	ME3307		monel		
7/7	Vostochni Sands	133	Allflex	blue	c	Tagged 29 July 1988 on Vostochni. Tag seen on right side but number not verified.
7/8	Reef	1152	Allflex	orange	c	Tagged 15 July 1989 on Tolstoi Sands.
7/8	Reef	1176	Allflex	orange	e^r	Tagged 15 July 1989 on Reef.
7/8	Reef	1233	Allflex	orange	e^r	Tagged 21 July 1989 on Reef.
7/8	Reef	1242	Allflex	orange	c	Tagged 23 July 1989 on Lukanin.
7/8	Reef	MK1861		monel		Soviet tagged seal.
7/9	Gorbatch	1242	Allflex	orange	c	Tagged 23 July 1989 on Lukanin.
7/9	Gorbatch	1415	Allflex	white	e^r	Tagged 6 July 1990 on Lukanin.
7/9	Reef	55	Allflex	blue	c	Tagged 20 July 1988 on Vostochni.
7/9	Reef	0587	Allflex	orange	c	Tagged 5 July 1986 on Reef. Left tag not read but present.

Table C-3.--Continued.

Date	Location	Tag number	Tag type	Tag color	Entanglement status*	Notes
7/9	Reef	1179	Allflex	orange	e	Tagged as a control 15 July 1989 on Reef; became entangled since being tagged.
7/10	Zapadni Reef Sands	1176	Allflex	orange	e^{r}	Tagged 15 July 1989 on Gorbatch.
7/10	Zapadni Reef Sands	1257	Allflex	orange	c	Tagged 23 July 1989 on Zapadni.
7/10	Zapadni Reef Sands	1285	Allflex	orange	c	Tagged 25 July 1989 on Vostochni.
7/10	Zapadni Reef Sands	1307	Allflex	white	c	Tagged 7 July 1990 on Vostochni.
7/10	Zoltoi Sands	0346	Allflex	orange	c	Tagged 22 July 1986 on Polovina.
7/11	Zapadni Sands	1180	Allflex	orange	c	Tagged 15 July 1989 on Reef.
7/11	Zapadni Sands	1188	Allflex	orange	e^{r}	Tagged 16 July 1989 on Little Zapadni.
7/12	Kitovi	0082	Allflex	orange	c	Tagged 23 July 1985 on Tolstoi.
7/12	Lukanin	1402	Allflex	white	e^{r}	Tagged 1 July 1990 on Tolstoi Sands.
7/12	Polovina	1247	Allflex	orange	c	Tagged 23 July 1989 on Polovina.
7/12	Tolstoi Sands	5117	Allflex	white	c	Tagged 16 Oct. 1986 on Reef. Left tag not noted.
7/12	Tolstoi Sands	0239	Allflex	orange	c	Tagged 10 Oct. 1985 on Vostochni.
7/12	Tolstoi Sands	0423	Allflex	orange	e^{r}	Tagged 27 July 1986 on Tolstoi.
7/12	Tolstoi Sands	0916	Allflex	orange	c	Tagged 6 Oct. 1986 on Tolstoi.
7/12	Tolstoi Sands	1285	Allflex	orange	c	Tagged 25 July 1989 on Vostochni.
7/12	Tolstoi Sands	1320	Allflex	white	e^{r}	Tagged 11 July 1990 on Zapadni.
7/13	Polovina	1419	Allflex	white	e^{r}	Tagged 7 July 1990 on Vostochni.
7/15	Reef	1244	Allflex	orange	c	Tagged 23 July 1989 on Polovina.
7/16	Gorbatch	158	Allflex	blue	c	Tagged 31 July 1988 on Kitovi.
7/16	Gorbatch	1243	Allflex	orange	c	Tagged 23 July 1989 on Lukanin.
7/16	Gorbatch	1326	Allflex	white	e^{r}	Tagged 12 July 1990 on Tolstoi Sands.
7/16	Gorbatch	1336	Allflex	white	c	Tagged 13 July 1990 on Reef.
7/16	Gorbatch	1338	Allflex	white	c	Tagged 15 July 1990 on Reef.
7/16	Gorbatch	1339	Allflex	white	e^{r}	Tagged 15 July 1990 on Reef.

Table C-3. --Continued.

Date	Location	Tag number	Tag type	Tag color	Entanglement status*	Notes
7/16	Reef	1158	Allflex	orange	e^r	Tagged 15 July 1989 on Zoltoi Sands.
7/16	Vostochni Sands	1277	Allflex	orange	c	Tagged 25 July 1989 on Morjovi.
7/16	Vostochni Sands	1286	Allflex	orange	e^r	Tagged 25 July 1989 on Vostochni.
7/16	Vostochni Sands	bH3487		monel		
7/17	Morjovi	bA657	monel			Soviet tagged seal with tag on one side only; not noted which side.
7/17	Morjovi	1344	Allflex	white	c	Tagged 16 July 1990 on Vostochni Sands.
7/17	Vostochni	1285	Allflex	orange	c	Tagged 25 July 1989 on Vostochni. No note of tag on left.
7/17	Vostochni	0494	Allflex	orange	c	Tagged 25 Aug. 1986 on Morjovi. No tag on right.
7/17	Vostochni	0959	Allflex	orange	c	Tagged 8 Oct. 1986 on Morjovi.
7/17	Vostochni	1271	Allflex	orange	c	Tagged 25 July 1989 on Morjovi.
7/17	Vostochni	1305	Allflex	white	c	Tagged 7 July 1990 on Vostochni.
7/17	Vostochni	1345	Allflex	white	c	Tagged 16 July 1990 on Vostochni Sands.
7/17	Vostochni	1348	Allflex	white	e^r	Tagged 16 July 1990 on Vostochni Sands.
7/17	Vostochni	1350	Allflex	white	c	Tagged 16 July 1990 on Vostochni Sands.
7/18	Tolstoi Sands	1361	Allflex	white	c	Tagged 17 July 1990 on Zapadni Reef Sands.
7/18	Tolstoi Sands	1365	Allflex	white	c	Tagged 17 July 1990 on Zapadni Reef Sands.
7/18	Zoltoi Sands	58	Allflex	blue	c	Tagged 20 July 1988 on Vostochni.
7/18	Zoltoi Sands	0383	Allflex	orange	c	Tagged 23 July 1986 on Gorbatch.
7/18	Zoltoi Sands	bE1185		monel		Soviet tagged seal.
7/19	Kitovi	0229	Allflex	orange	c	Tagged 9 Aug. 1985 on Kitovi.

Table C-3.--Continued.

Date	Location	Tag number	Tag type	Tag color	Entanglement status*	Notes
7/19	Polovina	0123	Allflex	orange	c	Tagged 29 July 1985 on Polovina.
7/19	Polovina	159	Allflex	blue	c	Tagged 31 July 1988 on Kitovi.
7/19	Polovina	0421	Allflex	orange	c	Tagged 27 July 1986 on Zapadni Reef.
7/19	Polovina	1250	Allflex	orange	c	Tagged 23 July 1989 on Polovina.
7/20	Vostochni	1309	Allflex	white	e[r]	Tagged 7 July 1990 on Vostochni.
7/20	Zapadni	24	Allflex	blue	c	Tagged 17 July 1988 on Reef.
7/20	Zapadni	1365	Allflex	white	c	Tagged 17 July 1990 on Zapadni Reef Sands.
7/20	Zapadni	1366	Allflex	white	c	Tagged 17 July 1990 on Zapadni Reef Sands.
7/20	Zapadni	1371	Allflex	white	c	Tagged 18 July 1990 on Tolstoi Sands.
7/21	Vostochni Sands	0420	Allflex	orange	c	Tagged 27 July 1986 on Vostochni Sands.
7/21	Vostochni Sands	1214	Allflex	orange	e[r]	Tagged 18 July 1989 on Vostochni Sands.
7/21	Vostochni Sands	1225	Allflex	orange	c	Tagged 19 July 1989 on Vostochni.
7/21	Vostochni Sands	1280	Allflex	orange	c	Tagged 25 July 1989 on Vostochni.
7/21	Vostochni Sands	1343	Allflex	white	e[r]	Tagged 16 July 1990 on Vostochni Sands.
7/21	Vostochni Sands	1348	Allflex	white	e[r]	Tagged 16 July 1990 on Vostochni Sands.
7/21	Vostochni Sands	1349	Allflex	white	c	Tagged 16 July 1990 on Vostochni Sands.
7/21	Vostochni Sands	1350	Allflex	white	c	Tagged 16 July 1990 on Vostochni Sands.
7/21	Vostochni Sands	1409	Allflex	white	e[r]	Tagged July 5 1990 on Zapadni Sands.
7/21	Vostochni Sands	bH3487		monel		Soviet tagged seal.

Table C-3.--Continued.

Date	Location	Tag number	Tag type	Tag color	Entanglement status*	Notes
7/22	Vostochni	59	Allflex	blue	c	Tagged 20 July 1988 on Vostochni. Fit with a radio tag at that time.
7/22	Vostochni	59	Allflex	blue	c	Tagged 20 July 1988 on Vostochni. Fit with a radio tag on that time.
7/22	Vostochni	94	Allflex	blue	c	Tagged 26 July 1988 on Vostochni.
7/22	Vostochni	0497	Allflex	orange	c	Tagged 25 July 1986 Morjovi.
7/22	Vostochni	0499	Allflex	orange	c	Tagged 25 Aug. 1986 Polovina.
7/22	Vostochni	1210	Allflex	orange	e[r]	Tagged 18 July 1989 Vostochni. Too big to count in 1989.
7/22	Vostochni	1343	Allflex	white	e[r]	Tagged 16 July 1990 Vostochni Sands.
7/22	Vostochni	1346	Allflex	white	c	Tagged 16 July 1990 Vostochni Sands.
7/22	Vostochni	1346	Allflex	white	c	Tagged 16 July 1990 Vostochni Sands.
7/22	Vostochni	1348	Allflex	white	c	Tagged 16 July 1990 Vostochni Sands.
7/22	Vostochni	1349	Allflex	white	c	Tagged 21 July 1990 Vostochni Sands.
7/22	Vostochni	1379	Allflex	white	c	Tagged 16 July 1990 Vostochni Sands.
7/22	Vostochni	1388	Allflex	white	c	Tagged 22 July 1990 Vostochni.
7/22	Vostochni	1420	Allflex	white	e[r]	Tagged 7 July 1990 Vostochni.
7/22	Vostochni	bH3487		monel		Soviet tagged seal. Weighed 45.5 lbs.
7/24	Morjovi	1392	Allflex	white	c	Tagged 22 July 1990 on Vostochni.
7/24	Morjovi	1417	Allflex	white	c	Tagged 6 July 1990 on Lukanin.
7/24	Zapadni Reef Sands	1366	Allflex	white	c	Tagged 17 July 1990 on Zapadni Reef Sands.

Table C-3.--Continued.

Date	Location	Tag number	Tag type	Tag color	Entanglement status*	Notes
7/25	Tolstoi Sands	1165	Allflex	orange	c	Tagged 15 July 1989 on Zapadni Reef Sands.
7/26	Kitovi	0094	Allflex	orange	c	Tagged 24 July 1985 on Morjovi.
7/26	Kitovi	0163	Allflex	orange	c	Tagged 5 Aug. 1985 on Zapadni.
7/26	Lukanin	1285	Allflex	orange	c	Tagged 25 July 1989 on Vostochni. No note of tag on left.
7/26	Lukanin	1417	Allflex	white	c	Tagged 6 July 1990 on Lukanin.
7/26	Zapadni	1198	Allflex	orange	e[r]	Tagged 18 July 1989 on Morjovi.
7/26	Zapadni	1265	Allflex	orange	c	Tagged 24 July 1989 on Zapadni Reef Sands.
7/26	Zapadni	1427	Allflex	white	c	Tagged 25 July 1990 on Tolstoi Sands.
7/26	Zapadni	1430	Allflex	white	c	Tagged 7 July 1990 on Tolstoi Sands.
7/26	Zapadni	1444	Allflex	white	c	Tagged earlier in the day on Zapadni Sands.
7/26	Zapadni	bK1526		monel		Soviet tagged seal. No tag on the right.
7/26	Zapadni Sands	1165	Allflex	orange	c	Tagged 15 July 1989 on Zapadni Reef Sands.
7/26	Zapadni Sands	1371	Allflex	white	c	Tagged 18 July 1990 on Tolstoi Sands.
7/26	Zapadni Sands	XM6525		monel		Soviet tagged seal. No tag on the right.
7/27	Gorbatch	24	Allflex	blue	c	Tagged 17 July 1988 on Reef.
7/27	Gorbatch	136	Allflex	blue	e[r]	Tagged 29 July 1988 on Vostochni.
7/27	Gorbatch	158	Allflex	blue	c	Tagged 31 July 1988 on Kitovi.
7/27	Gorbatch	1159	Allflex	orange	c	Tagged 15 July 1989 on Zoltoi Sands.
7/27	Gorbatch	1170	Allflex	orange	c	Tagged 15 July 1989 on Zapadni Reef Sands.

Table C-3.--Continued.

Date	Location	Tag number	Tag type	Tag color	Entanglement status*	Notes
7/27	Gorbatch	1257	Allflex	orange	c	Tagged 23 July 1989 on Zapadni.
7/27	Reef	69	Allflex	blue	c	Tagged 22 July 1988 on Polovina.
7/27	Reef	105	Allflex	blue	c	Tagged 16 July 1988 on Reef.
7/27	Reef	120	Allflex	blue	c	Tagged 29 July 1988 on Vostochni.
7/27	Reef	1244	Allflex	orange	c	Tagged 23 July 1989 on Polovina.
7/27	Reef	1434	Allflex	white	c	Tagged 26 July 1990 on Lukanin.
7/27	Reef	1435	Allflex	white	c	Tagged 26 July 1990 on Lukanin.
7/28	Vostochni	0449	Allflex	orange	c	Tagged 31 July 1986 on Vostochni.
7/28	Vostochni	1219	Allflex	orange	c	Tagged 19 July 1989 on Vostochni.
7/28	Vostochni	1286	Allflex	orange	e[r]	Tagged 25 July 1989 on Vostochni.
7/28	Vostochni	1378	Allflex	white	c	Tagged 21 July 1990 on Vostochni Sands.
7/28	Vostochni	1385	Allflex	white	e[r]	Tagged 22 July 1990 on Vostochni.
7/28	Vostochni	1386	Allflex	white	c	Tagged 22 July 1990 on Vostochni.
7/28	Vostochni	1388	Allflex	white	c	Tagged 22 July 1990 on Vostochni.
7/28	Vostochni	1390	Allflex	white	e[r]	Tagged 22 July 1990 on Vostochni.
7/28	Vostochni	1396	Allflex	white	e[r]	Tagged 22 July 1990 on Vostochni.
7/28	Vostochni	1398	Allflex	white	c	Tagged 22 July 1990 on Vostochni.
7/28	Vostochni	bK3965		monel		Soviet tagged seal.
7/28	Vostochni Sands	1280	Allflex	orange	c	Tagged 25 July 1989 on Vostochni.
7/28	Vostochni Sands	1393	Allflex	white	c	Tagged 22 July 1990 on Vostochni.
7/29	Morjovi	1462	Allflex	white	e[r]	Tagged 28 July 1990 on Vostochni.
7/29	Morjovi	1469	Allflex	white	c	Tagged 28 July 1990 on Vostochni.
7/29	Polovina	1374	Allflex	white	c	Tagged 21 July 1990 on Vostochni Sands.
7/30	Tolstoi Sands	1429	Allflex	white	c	Tagged 25 July 1990 on Tolstoi Sands.

Table C-3.--Continued.

Date	Location	Tag number	Tag type	Tag color	Entanglement status*	Notes
7/30	Zapadni Reef Sands	0377	Allflex	orange	c	Tagged 23 July 1986 on Gorbatch.
7/30	Zapadni Reef Sands	1426	Allflex	white	c	Tagged 25 July 1990 on Tolstoi Sands.
7/30	Zoltoi Sands	1243	Allflex	orange	c	Tagged 23 July 1989 on Lukanin.
7/30	Zoltoi Sands	1407	Allflex	white	e^r	Tagged 2 July 1990 on Zoltoi Sands.
7/30	Zoltoi Sands	1444	Allflex	white	c	Tagged 26 July 1990 on Zapadni Sands.
7/31	Zapadni	1439	Allflex	white	e^r	Tagged 26 July 1990 on Zapadni Sands.
7/31	Zapadni	1441	Allflex	white	c	Tagged 26 July 1990 on Zapadni Sands.
7/31	Zapadni	1446	Allflex	white	e^r	Tagged 26 July 1990 on Zapadni Sands.
8/1	Kitovi	0745	Allflex	orange	c	Tagged 24 Aug. 1986 on Kitovi.
8/1	Kitovi	1373	Allflex	white	e^r	Tagged 19 July 1990 on Kitovi. Too large to count.
8/1	Lukanin	1432	Allflex	white	e^r	Tagged 26 July 1990 on Lukanin.
8/1	Reef	69	Allflex	blue	c	Tagged 22 July 1988 on Polovina. No note of tag on left.
8/1	Reef	78	Allflex	blue	c	Tagged 24 July 1988 on Reef. Also fitted with a radio transmitter at that time.
8/1	Reef	0583	Allflex	orange	c	Tagged 5 Aug. 1986 on Reef.
8/1	Reef	1198	Allflex	orange	e^r	Tagged 18 July 1989 on Morjovi.
8/1	Reef	1225	Allflex	orange	c	Tagged 19 July 1989 on Vostochni.
8/1	Reef	1240	Allflex	orange	c	Tagged 22 July 1989 on Kitovi.
8/2	Vostochni	1309	Allflex	white	e^r	Tagged 7 July 1990 on Vostochni.

Table C-3.--Continued.

Date	Location	Tag number	Tag type	Tag color	Entanglement status*	Notes
8/2	Vostochni	1465	Allflex	white	c	Tagged 28 July 1990 on Vostochni.
8/2	Vostochni	1470	Allflex	white	c	Tagged 18 July 1990 on Vostochni.
8/2	Vostochni	1472	Allflex	white	c	Tagged 28 July 1990 on Vostochni.
8/2	Vostochni	bK3965		monel		Soviet tagged seal; second sighting. Weight 61 lbs.
8/2	Vostochni	MK2228		monel		Soviet tagged seal. Weighed 50.5 lbs.
8/2	Vostochni Sands	0716	Allflex	orange	c	Tagged 24 Aug. 1986 on Vostochni.
8/2	Vostochni Sands	1376	Allflex	white	e^r	Tagged 21 July 1990 on Vostochni Sands. Too large to count.
8/2	Vostochni Sands	1398	Allflex	white	c	Tagged 22 July 1990 on Vostochni.

*c = seals that were controls when tagged, e = seals that were entangled at time of being sighted, e^r = seals from which debris had been removed earlier.

Table C-4. --List of juvenile male northern fur seals tagged as entangled animals during surveys conducted in July and August 1990, St. Paul Island, Alaska, showing the nature of the debris on each animal.

			Description of debris							
Tag number	Date	Location (Rookery name)	Type	Wt. (g)	Color	Tightness[1]	Wound (deg.)	Mesh size (cm)	Twine size (mm)	Footnote
1179	7/9	Reef	packing band	1.6	white	t	0	24.1		2
1309	7/7	Vostochni	trawl	202.6	white	t	360	22.8	3.0	
1317	7/11	Zapadni	trawl	27.4	orange	t	0	22.6	4.5	
1320	7/11	Zapadni	packing band	6.7	green	vt	360	25.2		
1323	7/11	Tolstoi	packing band	1.8	yellow	t	0	22.9		
1326	7/11	Tolstoi	packing band	4.5	black	t	360	24.7		
1329	7/12	Lukanin	trawl	70.6	green	m	0	17.1	5.0	
1332	7/13	Polovina	packing band	1.9	white	t	0	19.7		
1334	7/15	Reef	seine webbing	214.1	green	vt	360	15.1	1.5	
1339	7/15	Reef	trawl	219.6	green	t	0	23.5	3.0	
1340	7/16	Gorbatch	packing band	1.5	yellow	t	0	19.1		
1343	7/16	Vostochni	packing band	2.2	yellow	t	0	23.1		
1347	7/16	Vostochni	trawl	101.4	green	m	0	21.9	3.0	
1348	7/16	Vostochni	trawl	17.7	green	t	0	22.3	2.5	
1351	7/17	Vostochni	twine	1.2	white	t	360	33.0		3
1352	7/17	Vostochni	packing band	1.8	white	t	360			3
1353	7/17	Morjovi	packing band	1.3	blue	t	0	22.1		
1356	7/17	Zapadni Reef	twine	19.8	green	t	220	17.6		
1357	7/17	Zapadni Reef	trawl	25.1	green	t	360	26.4	3.0	4
1358	7/17	Zapadni Reef	trawl	196.2	gray	t	0	29.0	4.0	3
1359	7/17	Zapadni Reef	packing band	7	white	t	360	21.5		
1364	7/17	Zapadni Reef	twine	8.1	white	t	360	31.1		
1369	7/17	Zapadni Reef	trawl	800.6	grey	t	-	23.5	3.0	
1372	7/18	Tolstoi	packing band	2.1	yellow	t	360	20.8		
1373	7/19	Kitovi	trawl	14.5	blue	t	360	3.5		3
1374	7/21	Vostochni	rope	29.1	orange	t	0	20.6	12.0	

Table C-4.--Continued.

Tag number	Date	Location (Rookery name)	Description of debris: Type	Wt. (g)	Color	Tightness[1]	Wound (deg.)	Mesh size (cm)	Twine size (mm)	Footnote
1376	7/21	Vostochni	trawl	518.90	grey	t	0	23.3	3.5	3
1377	7/21	Vostochni	twine	9.1	yellow	l	0	32.6		
1382	7/22	Vostochni	packing band	1.8	white	m	0	28.0		3
1383	7/22	Vostochni	seine	105.7	grey	t	330	8.4	2.0	
1384	7/22	Vostochni	see note	16.1		t	200			
1385	7/22	Vostochni	trawl	14	white	t	300	21.9	2.0	
1390	7/22	Vostochni	packing band	4.8	yellow	t	360	20.5		
1395	7/22	Vostochni	string	7.6	blue	vt	360	34.3		3
1396	7/22	Vostochni	packing band	1.7	blue	vt	0	21.9		
1399	7/24	Vostochni	packing band	2.8	yellow	m	0	25.7		
1401	7/1	Tolstoi	twine	13.6	blue	t	200	63.9		
1404	7/1	Tolstoi	trawl	142.1	green	t	220	21.5	2.6	
1407	7/2	Zoltoi Sands	twine	2.2	blue	vt	360	22.2		3
1408	7/3	Zapadni Reef	trawl	357.1	green	vt	o	21.8	2.5	
1409	7/5	Zapadni	chord	12.6	white	t	0	26.4		
1412	7/5	Zapadni	packing band	3.5	yellow	-	-	25.1		
1415	7/6	Lukanin	packing band	2.0	white	m	0	23.2		
1418	7/7	Vostochni	trawl net	32.6	green	t	360	21.8	3.0	
1419	7/7	Vostochni	packing band	1.9	white	t	0	24.0		
1420	7/7	Vostochni	chord	6.6	white	t	180			
1422	7/25	Tolstoi	trawl	244.8	*	t	0	19.5	6.0	5
1423	7/25	Tolstoi	chord	26.6	white	l	0	26.8	5.5	
1424	7/25	Tolstoi	chord	129.1	grey	t	360	26.7	5	
1431	7/25	Zoltoi Sands	chord	239.5	grey	t	150	24.5	5	3
1432	7/26	Lukanin	twine	3.9	green	t	360	22.8		
1436	7/26	Kitovi	monofilament	0.1	clear	t	note	19.0		6
1439	7/26	Zapadni	trawl	345.1	green	t	0	23.5	3.0	
1442	7/26	Zapadni	trawl	148.2	green	t	360	22.2	2.5	

Table C-4.--Continued.

Tag number	Date	Location (Rookery name)	Description of debris: Type	Wt. (g)	Color	Tight-ness[1]	Wound (deg.)	Mesh size (cm)	Twine size (mm)	Foot-note
1446	7/26	Zapadni	packing band	0.7	green	t	0	23.8		
1448	7/26	Zapadni	rubber ring	3.1	brown	m	0	19.2		
1451	7/27	Gorbatch	trawl	97.6	*		0	36.8	3.0	3,7
1452	7/27	Reef	trawl	398.6	*	t		*	3.0	2,3
1455	7/27	Reef	syn. filament	0.1	white	t	360	18.0		
1458	7/27	Reef	twine	0.1	white	t	360	31.8		
1461	7/28	Vostochni	packing band	3.8	white	t	360	-		
1462	7/28	Vostochni	packing band	2.5	yellow	m	0	23.0		
1463	7/28	Vostochni	chord	2.6	white	t	0	25.2		
1464	7/28	Vostochni	seine	35.0	green	t	0	22.1	1.5	
1475	7/29	Polovina	trawl	65.6	grey	t	0	23.5	2.5	
1476	7/29	Polovina	chord	2.5	black	m	320	24.7		
1479	7/29	Polovina	trawl	78.9	*	t	0	23.1	3.0	9
1480	8/1	Reef	packing band	1.2	green	vt	360	25.0		3
1481	8/2	Vostochni	twine	6.7	blue	t	360	34.4		
1484	8/2	Vostochni	trawl	311.6	green	t	0	22.5	2.5	
1487	8/3	Morjovi	packing band	1.0	blue	t	20	20.3		

(see footnotes on page 176)

Table C-4.--Continued (footnotes).

[1] l = loose, m = moderately tight, t = tight, vt = very tight.
[2] This seal was tagged as a control July 15, 1989, at Reef; it became entangled since being tagged.
[3] Seals tagged with numbers 1351, 1352, 1358, 1373, 1376, 1382, 1395, 1407, 1431, 1451, 1452, and 1480 were larger than harvestable size and not counted in the calculation of the entanglement rate.
[4] Animal died during restraint to remove debris. Later examination showed that the debris had worn into the left humerus and bone tissue had grown over that part of the wound.
[5] This debris was a grey/white color.
[6] This seal was entangled in debris located around the ears and back of the head in several places making it difficult to estimate the extent of the wound. This animal was found dead on 1 Aug. 1990 on the Kitovi haul-out site. Necropsy showed that the debris had cut through the skull into the brain.
[7] The color of this webbing was a red-orange.
[8] This webbing was a combination of green and grey with mesh sizes of 23.5 and 22.2 cm. This seal had become entangled twice since there were two separate pieces of webbing.
[9] This debris was a combination of faded green and orange. This animal was later killed in the subsistence harvest on Zapadni, 2 Aug. 1990. Barnacles were noted on the debris.

Table C-5. --Debris found on juvenile male northern fur seals in 1990, compared to seven earlier years, expressed as the observed percent of juvenile males entangled by debris category (data for 1992-89 from Fowler and Ragen 1990).

Type of debris	Entanglement (%)							
	1982	1983	1984	1985	1986	1988	1989	1990
Trawl net fragments	0.24	0.30	0.22	0.36	0.27	0.15	0.12	0.11
Monofilament net fragments	0.01	0.01	0.02	0.01	0.01	0.00	0.02	0.01
Plastic packing bands	0.10	0.07	0.09	0.05	0.06	0.07	0.10	0.11
Chord, rope, string	0.04	0.02	0.05	0.08	0.07	0.05	0.06	0.07
Miscellaneous items	0.01	0.03	0.01	0.01	0.01	0.01	0.01	0.03
Total	0.41	0.43	0.39	0.51	0.42	0.28	0.30	0.33
Sample size*	102	112	87	76	70	53	47	71

*Sample sizes occasionally include debris from seals larger than would be counted for determining the proportion of the juvenile males that are entangled.

Table C-6.--Comparison of numbers of tags applied (in parentheses) and resighted (percent resighted shown in brackets below the numbers resighted) by year for entangled and unentangled male northern fur seals from 1985 through 1990, each row corresponding to the tags released in the first year for that row.*

Controls (unentangled)	Year 1985	1986	1987	1988	1989	1990
	(172)	37	-	13	8	7
		[21.5]	-	[7.6]	[4.7]	[4.1]
		(279)	-	40	32	25
			-	[14.3]	[11.5]	[9.0]
			-	-	-	-
			-	-	-	-
				(104)	20	11
					[19.2]	[10.6]
					(86)	26
						[30.2]
						(114)

Entangled	Year 1985	1986	1987	1988	1989	1990
	(85)	12	-	1	0	0
		[14.1]	-	[1.2]	[0]	[0]
		(128)	-	6	4	1
			-	[4.7]	[3.1]	[0.8]
			-	-	-	-
			-	-	-	-
				(52)	5	2
					[9.6]	[3.8]
					(43)	11
						[25.6]
						(57)

*Updated from Fowler et al. (1989).

Table C-7.--List of data extracted from Table C-6 for regression analysis to estimate entanglement-related survival for a linear model of y = a + bx. See Fowler et al. (1990) for details.

A Yr i	B Yr k	C[a] $N_{c,i}/N_{e,i}$	D ln(C)	E[b] $N_{e,ik}/N_{c,ik}$	F ln(E)	y D+F	x B-A
1985	1986	172/85	0.7048	12/37	-1.1260	-0.42	1
1985	1988	172/85	0.7048	1/13	-2.5649	-1.86	3
1985	1989	172/85	0.7048	0/8	-	-	4
1985	1990	172/85	0.7048	0/7	-	-	5
1986	1988	279/128	0.7792	6/40	-1.8971	-1.12	2
1986	1989	279/128	0.7792	4/32	-2.0794	-1.30	3
1986	1990	279/128	0.7792	1/25	-3.2189	-2.44	4
1988	1989	114/52	0.7849	5/20	-1.3863	-0.60	1
1988	1990	114/52	0.7849	2/11	-1.7047	-0.92	2

[a]$N_{c,i}$ = the number of seals tagged as controls in year i;
$N_{e,i}$ = the number of seals tagged as entangled animals in year i.
[b]$N_{e,ik}$ = the number of seals tagged in year i as entangled animals and resighted in year k (regardless of whether or not they were entangled when resighted), k > i;
$N_{c,ik}$ = the number of control seals tagged in year i and resighted in year k, k > i.

Table C-8. --Annual percentage frequency distribution of the size of debris on entangled male northern fur seals that were tagged and released (data for 1983 to 1989 from Fowler and Ragen 1990).

Year	n	<150 g (%)	150-500 g (%)	>500 g (%)
1983	84	53(63)	19(23)	12(14)
1984	57	46(81)	7(12)	4(7)
1985	78	56(72)	16(20)	6(8)
1986	128	92(72)	27(21)	9(7)
1988	53	38(72)	8(15)	7(13)
1989	43	34(79)	7(16)	2(5)
1990	71	59(83)	10(14)	2(3)
Total	514	378(74)	94(18)	42(8)

Table C-9.--Comparison of numbers of tags applied to entangled and control juvenile male northern fur seals in 1985, 1986, 1988, 1989, and 1990 with the numbers in each category resighted the same season. The numbers in parentheses are the percent of the tags applied that were resighted.

	Number of tags			
	Controls		Entangled	
Year	Applied	Resighted	Applied	Resighted
1985	170	35(20.6)	76	21(27.6)
1986	165	54(32.7)	70	19(27.1)
1988	104	21(20.2)	52	15(28.8)
1989	86	20(23.5)	43	8(18.6)
1990	114	56(49.1)	57	18(31.6)
Total	639	186(29.1)	298	81(27.2)

Table C-10.--List of juvenile male northern fur seals by tag number and wound size (in degrees), both at the time of tagging and at subsequent resightings, St. Paul Island, Alaska.

Year tagged	Tag number	Degree of wound at			
		tagging	1 year	2 years	3 years
1983	404	360		360	
1983	411	0	0		
1983	423	360	360		
1983	424	360		360	
1983	436	0	cut	360	
1983	442	270	360		
1983	444	0	360		
1983	464	270	360		
1983	468	0	360		
1983	471	0	0		
1983	472	0	360		
1983	480	360	180		
1983	487	0	360		
1983	497	360	bad cut		
1984	555	0	360		
1984	560	0	360		
1984	581	0	360		
1985	0019	180	360		
1985	0047	360	360		
1985	0065	360	360		
1985	0202	180	200		
1986	0352	220		360	
1986	5193	30		360	
1986	5137	360			360
1988	14	300	360		
1988	18	0	360		
1988	66	0	0		
1988	88	180	360		
1988	123	100	360		

Updated from Bengtson et al. (1988) and Stewart et al. (1989), using data from Scordino et al. (1988), Fowler et al. (1990a), Fowler and Ragen (1990), and corresponding data files at the National Marine Mammal Laboratory.

Table C-11. --Frequency of occurrence (with percentages in parentheses) of wounds in various size categories (from 0 to 360 degrees) for juvenile male northern fur seals seen in the commercial harvest (1983) and roundups (1985-90) for seals found entangled in marine debris.*

Size	1983	1984	1985	1986	1988	1989	1990	Total
0-90	69(72.6)	59(67.0)	50(65.8)	88(69.3)	29(53.7)	25(59.5)	35(50.0)	355(64.3)
91-180	4(4.2)	8(9.1)	5(6.6)	12(9.4)	3(5.6)	2(4.7)	2(2.9)	36(6.5)
181-270	3(3.2)	4(4.5)	2(2.6)	4(3.1)	3(5.6)	0(0.0)	4(5.7)	20(3.6)
271-360	19(20.0)	17(19.3)	19(25.0)	23(18.1)	19(35.2)	15(35.7)	29(41.4)	141(25.5)
Total	95	88	76	127	54	42	70	552

*Data for 1983 from Scordino et al. (1984), for 1984 from Scordino et al. (1988), for 1985 from Bengtson et al. (1988), for 1986 from Stewart et al. (1989), for 1988 from Fowler et al. (1990a), for 1989 from Fowler and Ragen (1990), and for 1990 from this study.

Table C-12.--Numbers of seals listed in Table C-11 that were resighted in the year subsequent to being tagged with the corresponding percentages (in parentheses) resighted.[a]

Size	1983	1984	1985	1986	1988	Total[b]
0-90	16(23.2)	12(20.3)	7(14.0)	5(5.7)	2(6.9)	42(14.2)
91-180	0(0.0)	2(12.5)	2(40.0)	0(0.0)	2(66.7)	6(18.7)
181-270	2(66.7)	0(0.0)	0(0.0)	1(25.0)	0(0.0)	3(18.8)
271-360	5(26.3)	2(11.8)	3(15.7)	0(0.0)	1(5.3)	11(11.3)

[a]Data for 1983 from Scordino et al. (1984), for 1984 from Scordino et al. (1988), for 1985 from Bengtson et al. (1988), for 1986 from Stewart et al. (1989), for 1988 from Fowler et al. (1990), for 1989 from Fowler and Ragen (1990), and for 1990 from this study.

[b]The total for each wound size from only 1983-88 were used to calculate the percent for the total since debris was removed from entangled seals in 1989 and 1990.

APPENDIX D

Estimation of Entanglement-Related Survival

To make use of the, data on the returns of juvenile male northern fur seals (i.e., those resighted) as shown in Table 6, we make a set of assumptions and define the following terms, as in Fowler et al. (in press). Let

$N_{c,i,k}$ = the number of control seals tagged in year i and resighted in year k, where k > i (i = 1985, 1986, 1988; k = 1986, 1988, 1989, 1990);

N_{eik} = the number of seals tagged in year i as entangled animals and resighted in year k (regardless of whether or not they were entangled when resighted), where k > i (i = 1985, 1986, 1988; k = 1986, 1988, 1989, 1990);

$P_{i,k} = N_{e,ik}/N_{c,ik}$, or the ratio of numbers of seals resighted in year k that were entangled when first tagged in year i to the numbers of nonentangled (control) seals tagged in year i and resighted in year k;

s_{Cj} = the annual survival of control animals, or the animals tagged without debris in year j, for j from i to k (i.e., S_{cj} = survival from j to (j+l). This is the probability of avoiding natural causes of mortality during 1 year;

s_e = the conditional probability of surviving entanglement in small debris over 1 year's time given that an animal has survived natural causes of mortality. It is assumed to be independent of s_{Cj} (so their total annual survival is $s_{Cj}s$,) and to be constant from year to year,

$N_{e,i}$ = the number of seals tagged as entangled animals in year i (i = 1985, 1986, 1988); and

$N_{c,i}$ = the number of seals tagged as controls in year i (i = 1985, 1986, 1988).

In contrast to Fowler et al. (in press), we assume here that the same proportion of surviving entangled seals return to the islands to be seen when compared to surviving controls. For the purposes of developing the estimation procedure, this assumption will be implemented below; for now the proportions will be represented by separate variables. Thus, we define

f_{Ck} = the probability of resighting a seal in year k given that it was entangled when tagged and that it is alive. This probability is expressed on the basis of a unit of searching effort that is the same as applied in looking for control animals. It is assumed to vary from year to year, but not in relation to f_{ck} (below); and

f_{ck} = the probability of resighting a control animal in year k given that it is alive in the population, again as based on the unit of effort spent in searching for both control and entangled seals. This is also assumed to vary from year to year but not in relation to f_{ek} (f_{ek}/f_{ck} is assumed constant).

With these terms, the expected number of seals that were entangled when tagged and sighted in year k after being tagged in year i for one unit of effort is

$$E(N_{e,ik}|N_{e,i}) = f_{ek}\beta_k s_e^{(k-i)} N_{e,i}$$

(β_k is the product of $s_{c,j}$ for j from i to k),

and the expected number of controls for the same circumstances is

$$E(N_{c,ik}|N_{c,i}) = f_{ck}\beta_k N_{c,i}$$

(β_k is the product of $s_{c,j}$ for j from i to k).

Substituting the observed for the expected values we have the following moment estimators:

$$N_{e,ik} = f_{ck}\beta_k s_e^{(k-i)} N_{e,i}$$

and

$$N_{c,ik} = f_{ck}\beta_k N_{c,i}.$$

The ratio of these two equations, then, is

$$N_{e,ik}/N_{c,ik} = p_{i,k} = (f_{ek}/f_{ck})(N_{e,i}/N_{c,i})s_e^{(k-i)}$$

which can be used to estimate f_{ek}/f_{ck} and s,.

We note that variability in natural survival (i.e., the survival of the controls and that part of the survival of entangled animals from natural effects) can occur over time and not affect the calculation because these terms cancel in the formulation of the equation above. We also note that the probability of resighting animals from each of the two groups can vary from year to year as long as their ratio remains the same, as assumed above. Effort spent in resighting entangled and control seals is the same (the same roundups) but the number of roundups can vary each year. This is because effort for each of the two groups influences the above relationships only as a ratio in f_{ck}/f_{ck} (i.e., it cancels and need not be defined). By rearranging terms we have

$$p_{i,k}(N_{c,i}/N_{e,i}) = (f_{ek}/f_{ck})s_e^{(k-i)}.$$

At this point, the assumption of equal probability of being resighted is implemented; that is, we assume that $(f_{ek}/f_{ck}) = 1.0$. The probabilities may vary from year to year, but are assumed to be the same within any year for each group. With this assumption, the above equation can be solved for s,:

$$s_e = p_{i,k}(N_{c,i}/N_{e,i})^{1/(k-i)}.$$

This calculation can be carried out for each year (year k) with seals resighted from an earlier year (year i).

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APPENDIX E
Scientific staff engaged in northern fur seal research, 1990.

National Marine Mammal Laboratory (NMML)
Howard W. Braham, Director
Robert V. Miller, Deputy Director
Thomas R. Loughlin, Leader, Bering Sea Ecosystem Program

Name	Affiliation	Assignment
Permanent employee		
Charles W. Fowler	NMML	Population Assessment
George A. Antonelis	NMML	Population Assessment
Robert L. DeLong	NMML	Population Assessment
Sharon R. Melin	NMML	Population Assessment
Richard C. Ferrero	NMML	Population Assessment
Thomas R. Loughlin	NMML	Population Assessment
Anne E. York	NMML	Population Dynamics
Roger L. Gentry	NMML	Behavior Studies
Laurie J. Briggs	NMML	Fur Seal Data Mgmt.
Hiroshi Kajimura	NMML	Annual Report
Temporary employee		
Jason Baker	NMML	Population Assessment
Tim Ragen	NMML	Population Assessment
Bruce Robson	NMML	Population Assessment
Paula White	NMML	Population Assessment
Beth Miller	NMML	Population Assessment
Robin Robbins	NMML	Population Assessment
Rolf Ream	NMML	Population Assessment
Jim Harvey	NMML	Population Assessment
Steve Insley	NMML	Behavior Studies
Elizabeth Sinclair	NMML	Food Habits Studies
Cooperators*		
Steve Zimmerman	NMFS	Resource Management
Brad Hansen	NMFS	Resource Management
Norihisa Baba	NRIFSF	Entanglement Research
Masashi Kiyota	NRIFSF	Population Assessment
Mark Lowry	SWFC, NMFS	Population Assessment
Laurie Fairchild	USFWS	Population Assessment
Robert Sculmeiister	USFWS	Population Assessment
David Wimpheimer	USFWS	Population Assessment
Maurice Lima	ILPE	Population Assessment
Enrique Paez	ILPE	Population Assessment
Alejandro Malek	ILPE	Population Assessment
Mathew A. Burd	MLML	Population Assessment
John Mason	MLML	Population Assessment
Patience Brown	MLML	Population Assessment
Steve Trumble	MLML	Population Assessment

APPENDIX E (Continued)

Name	Affiliation	Assignment
Dan Boltkin	MLML	Population Assessment
Jessica Rykken	NA	Population Assessment
Mark Pierson	MMS	Behavior Studies
Terry Spraker	CSU	Pup Mortality Res.
Darlene Degetto	CSU	Pup Mortality Res.

<u>Affiliation Code</u>

NMFS	National Marine Fisheries Service
NRIFSF	National Research Institute of Far Seas Fisheries
SWFC	Southwest Fisheries Center
USFWS	U. S. Fish and Wildlife Service
UFSRP	Uruguayan Fur Seal Research Program
MLML	Moss Landing Marine Laboratory
MMS	Minerals Management Service
CSU	Colorado State University
ILPE	Industrial Loberia y Pesqueria del Estado
NA	No affiliation

*Financed wholly or in part by the National Marine Mammal Laboratory or other agency.

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