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ENTANGLEMENT STUDIES, ST PAUL ISLAND, 1989

JUVENILE MALE NORTHERN FUR SEALS

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by

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INTRODUCTION

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 (Callorhinus ursinus). Many of these studies have examined effects at the population level (Fowler 1982, 1985, 1987). Others have studied the effects at the level of the individual (see Fowler 1988).

Northern fur seals (Callorhinus ursinus) become entangled in plastic debris and scraps of fishing nets as they forage in the open ocean. Such entanglement, especially in scraps of net, 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). A number of recent studies conducted by the National Marine Mammal Laboratory have focused on the effects of entanglement in marine debris on northern fur seals (Bengtson et al. 1988; Fowler 1984, 1985, 1987; Fowler et al. 1989, 1990, in press).

Juvenile males (aged 2 to 5 years) from St. Paul Island, Alaska, are the component of the population most readily studied.

Entanglement among these males is studied during roundups (as described in more detail below). This report presents the results of the 1989 field research conducted by the National Marine Mammal Laboratory to examine entanglement and its impact on 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 or not 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 on St. Paul Island, Alaska near breeding colonies of northern fur seals. All work was conducted during the breeding season of this species, while animals were congregated at, or near, breeding rookeries along the shoreline of the island.

During roundups, young males are herded together to be examined for debris or tags and for applying tags. To conduct a roundup, field biologists approach a hauling ground near a breeding rookery where young males come ashore in large numbers. Avoiding disturbance to the rookeries, the members of the

research team position themselves between the hauling ground and the water. The males on the hauling ground are then surrounded and herded together away from the rookery but close to the water's edge. Care is taken to minimize the movement required of the animals and to allow them sufficient space to prevent crowding and overheating.

Once the seals are in a controlled group, field workers then allow small numbers of animals to leave the group and file toward the water. Once one or more seals begin moving toward the water, other seals follow. This movement is controlled (to ensure that tagged flippers will be seen) by the field crew. While moving toward the water, seals pass between observers, some of whom are engaged in counting seals while others watch for tags and entangling debris. Others of the field crew remain prepared to capture seals, while the remainder work to assure that the main group of seals remains in place. By the end of the roundup, all seals have returned to the water. Most seals, handled or not, return directly to the water.

The seals counted 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 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. All entangled seals small enough to safely handle were captured and freed of the debris.

When an entangled or tagged seal is seen among those leaving, the movement of seals from the main group is stopped. If tag numbers cannot be read, if tags are to be applied, or if a detailed examination of the debris is required, the seal is captured with a wooden pole fitted with a rope noose (less than 2% of these seals escape to the water without being captured). If tags are to be applied, or the debris examined in detail, the seal is placed on a restraint board (Gentry and Holt 1982) for a few minutes. Tags are applied on the inner trailing edge of each fore flipper, about 2-3 cm distal from the hair line according to standard practice for this species (Gentry and Holt 1982).

If the captured animal is entangled, the nature of the entanglement is recorded (and tags applied if not previously tagged), and the debris is removed. Data recorded at the time of tagging include the tag number and the extent of the wound the debris has caused. The color, size (weight), and type of debris, and mesh and twine size if it is a net fragment, are determined for each piece of debris. Samples are retained for analysis to identify plastics.

Two control seals about the same size as the entangled animal are also tagged to compare rates of return in succeeding years. The choice of tagging two control seals is arbitrary. Tagging more controls than entangled seals ensures a larger sample of returns to be used in comparing the relative rates of

return of the two groups. It also aids in the study of the frequency of resighting rates and the locations (for study of intermixture) of resighted seals.

Some of the animals seen in the first roundup are seen again in later roundups. 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.

RESULTS

Roundups

Sixty-five roundups of male northern fur seals were completed on St. Paul Island during July 1989 (Table 1). During these roundups, 18,565 male seals judged to be of the size historically taken in the commercial harvest were counted. As will be explained below, about 25% of each of the total counts (unentangled and entangled) were repeated sightings. In all, 43 entangled subadult male seals judged to be of harvestable size were captured and double tagged with numbered orange Allflex[1] tags bearing the address of the National Marine Mammal Laboratory (Table 2). Following experimental procedures from previous years, two controls per entangled seal were also tagged to compare rates of return in succeeding years (Table 2). A total of 86 similarly sized control seals with no entangling debris were tagged.

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

Tagged Seals from Previous Years

Seals tagged in previous years were resighted (Table 3) along with seals tagged during the 1989 season. As in previous years, some of the seals tagged in 1989 were seen on more than one occasion. Of the resighted seals for which the tags were read, 68 had Allflex tags from 1985, 1986, and 1988 during earlier phases of research to evaluate the mortality of young male seals entangled in debris. Fifty-nine of the 68 resighted seals were tagged in previous years as controls. Nine had been entangled when tagged. Of the 9 seals resighted after having been tagged as entangled, 4 had lost their entangling debris. Three 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 medium (150-500 g). Three additional tagged seals from previous years (two with orange Allflex and one with white Allflex tags) were sighted but the tags were not read; none of these animals were entangled at the time of the resighting (i.e. they were either controls or entangled seals that had lost their debris).

Entanglement Rate

We examined forty-seven entangled juvenile male seals encountered in the 1989 roundups (the 43 seals mentioned above and 4 that were judged to be larger than historically harvested) to remove and determine the nature of their entangling debris.

The size and kind of entangling debris, the extent of any wounds, and the tightness of the entangling debris on the animal are presented in Table 4. A key to the tags applied during the 1989 field season is provided in Table 2.

For the entangled seals examined (47), 18 (38.3%) carried fragments of trawl webbing, 15 (31.9%) plastic packing bands, and 9 (19.1%) string, small line or cords. The remainder (5 or 10.6%) were entangled in other debris. 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. in press). In 1989 this sampling design included the resighting of animals from which the debris was removed during the same season but which were counted as entangled. In all, there were 56 seals (the 43 from above with their repeated sightings) seals of harvestable size observed entangled. The entanglement rate for 1989 was thus 0.302% (56/18565). The 1989 rate of entanglement is less than the observed rate of about 0.4% between 1976 and 1985 (Fig. 1, Fowler et al. 1990). The majority of the reduction can be attributed to a reduction in the rate of entanglement in trawl webbing (Table 5). Historically, the rate of entanglement in trawl webbing has been about 0.27% (Fowler et al. 1990). In 1988 that rate dropped to about 0.15%, a reduction to about 56% of earlier levels (Fowler et al. 1990). In 1989 this rate remained low, at about 0.12% (Table 5).

Resightings and Survival

Table 6 shows the record of tags applied to juvenile males during entanglement studies for each year since 1985. No samples were collected in 1987. A total of 156 tagged seals judged to be of harvestable size were tagged and released in 1988; 52 of these were entangled. In 1989, 20 (19.2%) of these seals, originally tagged as controls, were resighted (Table 6). Five (9.6%) of the seals tagged as entangled animals in 1988 were resighted in 1989 (Table 6). This implies a resighting rate of seals tagged as entangled in previous years of about 50% of the rate for controls (9.6/19.2 = 0.5). Although not significantly different from a ratio of 1.0 (Chi-square test, $p > 0.05$), the difference in ratios for 1988 and 1989 is consistent with the survival rate (about 0.5) estimated for the effects of entanglement in small debris (Fowler et al. in press).

In 1989, 32 of 279 seals tagged as controls in 1986 were resighted. Four were resighted out of a group of 128 animals tagged as entangled in 1986. The resighting rates are 11.5% and 3.1%, for their respective groups and are significantly different (Chi-square test, $p < 0.05$).

No animals tagged as entangled in 1985 were resighted in 1989; however, eight controls from 1985 were resighted. This is a significant change from the original ratio of tagged entangled seals to controls for that year (Table 6).

As reviewed above, the data for relative resighting rates of seals tagged in 1985, 1986, and 1988 and seen in 1989 are shown in Figure 2 along with the data from previous work reported in Fowler et al. (in press). As described above and as can be seen in Figure 2, the 1989 data are consistent with the results of earlier work (Fowler et al. in press). The cumulative data continue to show estimated annual survival of 0.5 for seals entangled in small debris, independent of all other sources of mortality.

Characteristics of Entangling Debris

Because the debris was removed from the entangled seals in 1989, 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 3 for debris weights and in Figure 4 for mesh size. Specific weights and mesh sizes are listed in Table 4. These distributions are very similar to those seen for debris from entangled northern fur seals in previous studies (Fowler 1987). Slightly over 70% of the debris found on seals (seals seen entangled for the first time) weighed between 0 and 150 g (Table 7). About 20% of the debris weighed between 150 and 500 g. About 10% of the debris weighed over 500 g. The rates of return for seals entangled in debris of the three size categories differed markedly. Approximately half as many seals entangled in medium sized debris were resighted compared to seals entangled in the smaller debris (Table 8). The

return rate drops again by nearly 50% for seals in heavy (over 500 g) debris compared to seals in debris of the intermediate category. Thus, it is seen that mortality rates increase with size of debris.

Within Season Resighting Rate

The fraction of seals tagged as entangled seals and resighted in the same field season was about the same as for controls, as seen in previous work (Fowler et al. 1990). This resighted fraction is close to 25% for all years. There is no statistically significant difference in the rates of resighting between the two groups (Chi-square = 0.805).

DISCUSSION

Entanglement related field studies of juvenile male northern fur seals in 1989 were different from earlier years in that debris was removed from entangled animals. Accounting for this difference through counting the resighted entangled animals with debris removed, the entanglement rate continues to show the reduced levels observed in 1988. A second year of reduced rates provides more convincing evidence that a change has occurred in the entanglement rates, especially since it continues to be attributable to a reduction in entanglement in trawl webbing. An explanation for such a change can not be conclusively established at this time. However, the differences between the 1988-89 rates of entanglement and those of previous years may be a result of

changes in the rate of loss and discard of net fragments. 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 would be necessary to determine if reductions have occurred in the rate at which debris is entering the marine environment.

Results of the 1989 studies are consistent with those of earlier work in showing that some animals escape from their entangling debris. This appears to be one mechanism contributing to survival from entanglement. However, as documented in Fowler et al. (in press), the animals that lose their debris are predominantly seals entangled in small debris (less than 150 g). This, in combination with data showing that mortality increases with the size of debris (Table 8), continues to emphasize the fact that there is mortality beyond that estimated with data from studies of the seals seen on land.

SUMMARY

Entanglement research on juvenile males in 1989 demonstrated:

1) A continued reduction of the overall entanglement rate from about 0.4% (1975-86) to about 0.3% in 1988 and 1989.
2) Entanglement in trawl webbing in 1989 was about half of entanglement levels observed for this kind of debris in

previous years (1981 to 1988) and very similar to the rate observed in 1988.

3) The rate of resighting for animals tagged in 1986 showed that entangled animals tagged in that year were seen at a rate that was significantly less than that for controls.

4) Data for relative return rates of entangled seals (in small debris) continued to produce an estimated survival rate independent of natural causes of mortality of about 0.5 per year.

5) There is further evidence from the 1989 studies that the rate of return of seals entangled in heavier debris is less than for seals in lighter debris.

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Table 1.--Summary of roundups of juvenile (subadult) northern fur seal males conducted on St. Paul Island, Alaska, during July of 1989.

Date (July)	Location	Total[a] in roundup	Tagged seals[b] resighted	Total seals tagged
14	Tolstoi Sands	77	0	0
14	Tolstoi Sands	133	1	0
14	Tolstoi Sands	235	1	3
14	Zapadni Reef Sands	696	4	0
15	Gorbatch	371	3	3
15	Reef North	13	0	0
15	Reef	264	2	5
15	Reef	535	1	0
15	Reef	153	1	3
15	Reef	195	2	0
15	Reef	51	0	0
15	Zapadni Reef Sands	273	3	8
15	Zoltoi Sands	494	8	9
16	Kitovi	245	4	2
16	Little Zapadni	274	5	2
16	Lukanin	280	0	0
16	Polovina	107	2	0
16	Polovina	207	0	0
16	Polovina	317	4	2
16	Zapadni	472	3	0
16	Zapadni Sands	642	5	3
18	Morjovi	742	3	12
18	Vostochni	136	1	3
18	Vostochni	387	0	1
18	Vostochni	209	1	3
19	Tolstoi	318	3	0
19	Tolstoi	328	3	3
19	Vostochni	94	2	0
19	Vostochni	130	0	6
19	Zapadni Reef Sands	214	3	1
21	Gorbatch	671	3	0
21	Reef	492	6	3
21	Reef	164	1	0
21	Zoltoi Sands	348	3	1
22	Kitovi	360	1	3
22	Reef	211	4	4
22	Reef	118	0	0
22	Reef	229	3	0
23	Little Zapadni	251	2	4
23	Lukanin	605	5	3
23	Polovina	132	1	0
23	Polovina	316	2	0
23	Polovina	227	4	7
23	Zapadni	179	1	3
23	Zapadni Sands	277	2	0

Table 1.--Continued.

Date (July)	Location	Total[a] in roundup	Tagged seals[b] resighted	Total seals tagged
24	Tolstoi	224	3	0
24	Tolstoi	238	1	0
24	Tolstoi	303	1	3
24	Zapadni	36	1	0
24	Zapadni	86	1	0
24	Zapadni	823	4	9
24	Zapadni Reef Sands	380	0	0
25	Morjovi	40	0	0
25	Morjovi	222	3	2
25	Morjovi	776	5	5
25	Vostochni	88	1	3
25	Vostochni	109	1	0
25	Vostochni	148	1	0
25	Vostochni	249	0	6
25	Vostochni	417	1	0
26	Kitovi	187	6	0
26	Reef	79	2	0
26	Reef	212	7	0
26	Reef	300	1	1
26	Zoltoi Sands	496	3	0
Totals		18,565	140	126

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

[b]Seals which had any kind of tag in either fore-flipper and that were successfully restrained to read the tag. Includes any that were resighted more than once this year.

Table 2.--List of orange broad banded Allflex tags applied to northern fur seals during roundups conducted on St. Paul Island, Alaska, 1989. Entangling debris was removed from entangled seals prior to being released.

Tag number	Date (July)	Sex	Location	Entangled (e) Control (c)
1151	14	m	Tolstoi Sands	e
1152	14	m	Tolstoi Sands	c
1153	14	m	Tolstoi Sands	c
1154	14	m	Zapadni Reef Sands	e
1155	14	m	Zapadni Reef Sands	e
1156	15	m	Zoltoi Sands	e
1157	15	m	Zoltoi Sands	e
1158	15	m	Zoltoi Sands	e
1159	15	m	Zoltoi Sands	c
1160	15	m	Zoltoi Sands	c
1161	15	m	Zoltoi Sands	c
1162	15	m	Zoltoi Sands	c
1163	15	m	Zoltoi Sands	c
1164	15	m	Zoltoi Sands	c
1165	15	m	Zapadni Reef Sands	c
1166	15	m	Zapadni Reef Sands	c
1167	15	m	Zapadni Reef Sands	c
1168	15	m	Zapadni Reef Sands	c
1169	15	m	Zapadni Reef Sands	c
1170	15	m	Zapadni Reef Sands	c
1171	15	m	Zapadni Reef Sands	c
1172	15	m	Zapadni Reef Sands	c
1173	15	m	Gorbatch	e
1174	15	m	Gorbatch	c
1175	15	m	Gorbatch	c
1176	15	m	Reef	e
1177	15	m	Reef	c
1178	15	m	Reef	c
1179	15	m	Reef	c
1180	15	m	Reef	c
1181	15	m	Reef	e
1182	15	m	Reef	c
1183	15	m	Reef	c
1184	16	m	Kitovi	c
1185	16	m	Kitovi	c
1186	16	m	Polovina	e
1187	16	m	Polovina	e
1188	16	m	Little Zapadni	e
1189	16	m	Little Zapadni	e
1190	16	m	Zapadni Sands	e
1191	16	m	Zapadni Sands	c
1192	16	m	Zapadni Sands	c
1193	17	f	Zapadni Reef	f[a]
1194	17	f	Zapadni Reef	f[a]

Table 2.--Continued.

Tag number	Date (July)	Sex	Location	Entangled (e) Control (c)
1195	18	f	Zapadni Reef	f[a]
1196	18	f	Zapadni Reef	f[a]
1197	18	m	Morjovi	e
1198	18	m	Morjovi	e
1199	18	m	Morjovi	c
1200	18	m	Morjovi	c
1201	18	m	Morjovi	c
1202	18	m	Morjovi	e
1203		(not used)		
1204	18	m	Morjovi	e
1205	18	m	Morjovi	c
1206	18	m	Morjovi	c
1207	18	m	Morjovi	c
1208	18	m	Morjovi	c
1209	18	m	Morjovi	c
1210	18	m	Vostochni	e
1211	18	m	Vostochni	e
1212	18	m	Vostochni	c
1213	18	m	Vostochni	c
1214	18	m	Vostochni Sands	e
1215	18	m	Vostochni Sands	c
1216	18	m	Vostochni Sands	c
1217	19	m	Vostochni	e
1218	19	m	Vostochni	c
1219	19	m	Vostochni	c
1220	19	m	Vostochni	c
1221	19	m	Vostochni	c
1222	19	m	Vostochni	e
1223	19	m	Tolstoi	e
1224	19	m	Tolstoi	e
1225	19	m	Tolstoi	c
1226	19	m	Tolstoi	c
1227	19	m	Zapadni Reef Sands	e
1228	20	f	Zapadni Reef	f[a]
1229	20	f	Zapadni Reef	f[a]
1230	21	m	Zoltoi Sands	e
1231	21	m	Reef	c
1232	21	m	Reef	c
1233	21	m	Reef	e
1234	22	m	Reef	e
1235	22	m	Reef	e
1236	22	m	Reef	c
1237	22	m	Reef	c
1238	22	m	Kitovi	e
1239	22	m	Kitovi	c

Table 2.--Continued.

Tag number	Date (July)	Sex	Location	Entangled (e) Control (c)
1240	22	m	Kitovi	c
1241	23	m	Lukanin	e
1242	23	m	Lukanin	c
1243	23	m	Lukanin	c
1244	23	m	Polovina	c
1245	23	m	Polovina	c
1246	23	m	Polovina	e
1247	23	m	Polovina	c
1248	23	m	Polovina	c
1249	23	m	Polovina	c
1250	23	m	Polovina	c
1251	23	m	Little Zapadni	c
1252	23	m	Little Zapadni	c
1253	23	m	Little Zapadni	c
1254	23	m	Little Zapadni	c
1255	23	m	Zapadni	e
1256	23	m	Zapadni	c
1257	23	m	Zapadni	c
1258	24	m	Tolstoi	e
1259	24	m	Tolstoi	c
1260	24	m	Tolstoi	c
1261	24	m	Zapadni	e
1262	24	m	Zapadni	c
1263	24	m	Zapadni	c
1264	24	m	Zapadni	e
1265	24	m	Zapadni	c
1266	24	m	Zapadni	c
1267	24	m	Zapadni	c
1268	24	m	Zapadni	e
1269	24	m	Zapadni	c
1270	25	m	Morjovi	e[b]
1271	25	m	Morjovi	c
1272	25	m	Morjovi	c
1273	25	m	Morjovi	c
1274	25	m	Morjovi	e
1275	25	m	Morjovi	c
1276	25	m	Morjovi	c
1277	25	m	Morjovi	c
1278	25	m	Vostochni	e
1279	25	m	Vostochni	c
1280	25	m	Vostochni	c
1281	25	m	Vostochni	e
1282	25	m	Vostochni	c
1283	25	m	Vostochni	c
1284	25	m	Vostochni	c

Table 2.--Continued.

Tag number	Date (July)	Sex	Location	Entangled (e) Control (c)
1285	25	m	Vostochni	c
1286	25	m	Vostochni	e
1287	26	m	Reef	e

[a]Female seal tagged for Japanese behavioral study with radio transmitters.

[b]This seal had been tagged as a control on Kitovi in 1986; no controls were tagged for this seal.

Table 3.--List of tagged northern fur seals seen during July juvenile male roundup activities on St. Paul Island, 1988. Tags were seen on both fore-flippers unless noted otherwise. Debris was removed from entangled seals.

Date (July)	Location	Tag number	Tag type	Tag color	Entanglement status*	Notes
14	Tolstoi Sands	5184	Allflex	white	c	Tagged on Aug. 3, 1986 at Tolstoi.
14	Tolstoi Sands	A03430	monel		p	Tagged in 1987 as a pup.
14	Zapadni Reef Sands	0478	Allflex	orange	c	Tagged on Aug. 24, 1986 at Zapadni.
14	Zapadni Reef Sands	14	Allflex	blue	e	Tagged on July 17, 1988 at Reef with the same debris. At that time was also fit with radio. Animal was in very poor condition on the 7/14 sighting.
14	Zapadni Reef Sands	54	Allflex	blue	c	Tagged on July 20, 1988 at Vostochni.
14	Zapadni Reef Sands	123	Allflex	blue	e	Tagged on July 29, 1988 at Vostochni.
15	Gorbatch	24	Allflex	blue	c	Tagged July 17, 1988 at Reef.
15	Gorbatch	0774	Allflex	orange	c	Tagged Aug. 25, 1986 at Zoltoi Sands. Both tags present, left one was read.
15	Gorbatch	1157	Allflex	orange	e[r]	Showed a rub mark on its neck.
15	Reef	5117	Allflex	white	c	Tagged on Oct. 16, 1986, on Reef.
15	Reef	18	Allflex	blue	e	Tagged on July 17, 1988 at Reef.
15	Reef	161	Allflex	blue	c	Tagged on July 31, 1988 at Kitovi.
15	Reef	22	Allflex	blue	c	Tagged on July 17, 1988 at Reef.
15	Reef	148	Allflex	blue	c	Tagged on July 31, 1988 at Tolstoi.
15	Reef	A00432	monel			Tagged in 1987 as a pup.
15	Zapadni Reef Sands	0852	Allflex	orange	c	Tagged on Oct. 2, 1986, at Little Zapadni.

Table 3.--Continued.

Date (July)	Location	Tag number	Tag type	Tag color	Entanglement status*	Notes
15	Zapadni Reef Sands	5178	Allflex	white	c	Tagged on Aug. 3, 1986, at Tolstoi.
15	Zapadni Reef Sands	123	Allflex	blue	e[r]	Tagged on July 29, 1988 at Vostochni. Second sighting in 1989.
15	Zoltoi Sands	0383	Allflex	ornage	c	Tagged July 23, 1986 on Gorbatch. Tag not sighted on left.
15	Zoltoi Sands	A04869	monel			Tag hole in left. Tagged in 1987 as a pup.
15	Zoltoi Sands	55	Allflex	blue	c	Tagged July 20, 1988 on Vostochni.
15	Zoltoi Sands	153	Allflex	blue	c	Tagged July 31, 1988 on Tolstoi.
15	Zoltoi Sands	0173	Allflex	orange	c	Tagged Aug. 7, 1985 on Gorbatch.
15	Zoltoi Sands	0330	Allflex	orange	c	Tagged July 19, 1986 on Reef.
15	Zoltoi Sands	0604	Allflex	orange	c	Tag on right was present but not read; should have been 0605. Was tagged on Zapadni, in August of 1986.
15	Zoltoi Sands	A05358	monel			Tagged in 1987 as a pup.
16	Kitovi	88	Allflex	blue	e	Debris removed.
16	Kitovi	809	Roto	blue	n	Tag missing on right side but the post of a tag was seen.
16	Kitovi	1174	Allflex	orange	c	Only one tag read, side not noted.
16	Kitovi	A01199	monel			Tag missing on right side, tag hole seen. Tagged in 1987 as a pup.
16	Little Zapadni	60	Allflex	blue	c	Tagged July 21, 1988 on Little Zapandi.

Table 3.--Continued.

Date (July)	Location	Tag number	Tag type	Tag color	Entanglement status*	Notes
16	Little Zapadni	123	Allflex	blue	e^r	Tagged on July 29, 1988 at Vostochni. Third sighting in 1989.
16	Little Zapadni	0419	Allflex	orange	c	Tagged on Little Zapadni, July 27, 1986.
16	Little Zapadni	1169	Allflex	orange	c	
16	Little Zapadni	1172	Allflex	orange	c	
16	Lukanin	143	Allflex	blue	c	Tagged July 30, 1988 on Zapadni.
16	Polovina	0071	Allflex	orange	c	Tagged July 20, 1985 on Tolstoi. No tag on left.
16	Polovina	0105	Allflex	orange	c	Tagged July 27, 1985 on Reef, section 7. No note made of tag on right.
16	Polovina	0494	Allflex	orange	c	Tagged Aug. 25, 1986 on Morjovi. Tag hole on right.
16	Polovina	0732	Allflex	orange	c	Tagged Aug. 24, 1986 on Vostochni. No note made on which side tag was observed.
16	Polovina	0954	Allflex	orange	c	Tagged Oct. 8, 1986 on Morjovi. Tag with number 0955 observed on right flipper.
16	Polovina	A02349	monel			Tagged in 1987 as a pup.
16	Zapadni	1155	Allflex	orange	e^r	
16	Zapadni	1168	Allflex	orange	c	
16	Zapadni	5144	Allflex	white	c	Tagged at Zapadni on Aug. 1, 1986.
16	Zapadni Sands	1165	Allflex	orange	c	
16	Zapadni Sands	1171	Allflex	orange	c	
16	Zapadni Sands	A03430	monel			Tagged in 1987 as a pup.
16	Zapadni Sands	bC2249	monel			

Table 3.--Continued.

Date (July)	Location	Tag number	Tag type	Tag color	Entanglement status*	Notes
18	Morjovi	0489	Allflex	orange	c	Tag seen on left side but not read. Tagged on Morjovi August 25, 1986.
18	Morjovi	A01931	Monel			Tagged in 1987 as a pup.
18	Morjovi	ME346	Monel			Tag on right with number: ME345
18	Vostochni	0370	Allflex	orange	c	Tagged on July 23, 1986 on Tolstoi.
18	Vostochni Sands	66	Allflex	blue	e	
19	Tolstoi	28	Allflex	blue	c	Tagged July 18, 1988 at Tolstoi.
19	Tolstoi	29	Allflex	blue	c	Tagged July 18, 1988 at Tolstoi.
19	Tolstoi	54	Allflex	blue	c	Tagged July 20, 1988 at Vostochni.
19	Tolstoi	0422	Allflex	orange	c	Tagged July 27, 1986 at Zapadni Reef.
19	Tolstoi	0423	Allflex	orange	e[r]	Tagged July 29, 1986 at Tolstoi.
19	Tolstoi	1170	Allflex	orange	c	
19	Tolstoi	1178	Allflex	orange	c	
19	Vostochni	1210	Allflex	orange	e[r]	
19	Vostochni	5145	Allflex	white	c	Tagged Aug. 1, 1986 on Zapadni.
19	Zapadni Reef Sands	879	Roto	blue		This number was on the bottom blade. Top blade was broken off and there was no tag on the left side.
19	Zapadni Reef Sands	MA2237	monel			The "A" was the Russian Crylic A. No tag in the left side.
21	Gorbatch	1158	Allflex	orange	e[r]	
21	Gorbatch	1175	Allflex	orange	c	
21	Gorbatch	A03919	monel			Hole in right flipper. Tagged in 1987 as a pup.
21	Reef	37	Allflex	blue	c	Tagged July 19, 1988 on Reef.
21	Reef	45	Allflex	blue	c	Tagged July 19, 1988 on Reef.

Table 3.--Continued.

Date (July)	Location	Tag number	Tag type	Tag color	Entanglement status*	Notes
21	Reef	88	Allflex	blue	e[r]	
21	Reef	0796	Allflex	orange	c	Tagged Sept. 24, 1986 on Reef. No tag read on right.
21	Reef	1182	Allflex	orange	c	
21	Reef	5140	Allflex	white	c	Tagged Aug. 1, 1986, Zapadni.
21	Reef	A05358	monel			Tagged in 1987 as a pup.
21	Zoltoi Sands	0354	Allflex	orange	c	Tagged July 22, 1986 on Zoltoi Sands. Hole in left flipper.
21	Zoltoi Sands	0357	Allflex	orange	c	Tagged July 22, 1986 on Zoltoi Sands. Hole on left.
21	Zoltoi Sands	7	Allflex	blue	c	Tagged July 16, 1988 on Zoltoi Sands.
22	Kitovi	0094	Allflex	orange	c	Tagged July 24, 1985 on Morjovi.
22	Reef	549	Roto	blue		Tag on right only, tear on left.
22	Reef	81	Allflex	blue	c	Tagged July 25, 1988 on Tolstoi.
22	Reef	0582	Allflex	orange	c	Tagged Aug. 1986 on Reef. Tag missing on right.
22	Reef	1204	Allflex	orange	e[r]	
22	Reef	93	Allflex	blue	c	Tagged July 26, 1988 on Kitovi.
22	Reef	1168	Allflex	orange	c	
22	Reef	1182	Allflex	orange	c	
23	Little Zapadni	70	Allflex	blue	c	Tagged July 22, 1988 on Polovina; also tagged with radio tag.
23	Little Zapadni	875	Roto	blue		No note of side on which tag was read.
23	Lukanin	0513	Allflex	orange	c	Tagged July 31, 1986 on Lukanin.
23	Lukanin	A01091	monel			Tagged in 1987 as a pup.
23	Lukanin	A01453	monel			Tagged in 1987 as a pup.
23	Lukanin	A03530	monel			Tagged in 1987 as a pup.
23	Lukanin	A07313	monel			Tagged in 1987 as a pup.

Table 3.--Continued.

Date (July)	Location	Tag number	Tag type	Tag color	Entanglement status*	Notes
23	Polovina	0071	Allflex	orange	c	Tagged July 20, 1985 on Tolstoi. Left flipper had hole.
23	Polovina	bE2540	monel			Tag hole in left flipper.
23	Polovina	7	Allflex	blue	c	Tagged July 17, 1988 on Zapadni.
23	Polovina	64	Allflex	blue	c	Tagged July 21, 1988 on Zapadni complete with radio tag.
23	Polovina	0343	Allflex	orange	c	Tagged July 22, 1986 on Polovina. Tag sighted and read on left only, no note of right flipper's condition.
23	Polovina	0764	Allflex	orange	c	Tagged Aug. 24, 1986 on Polovina. Tag number 0765 on right.
23	Polovina	A04855	monel			Tagged in 1987 as a pup.
23	Zapadni	A01429	monel			Tagged in 1987 as a pup.
23	Zapadni Sands	A06155	monel			Tagged in 1987 as a pup.
23	Zapadni Sands	MA1462	monel			
24	Tolstoi	0034	Allflex	orange	c	Tagged July 12, 1985 on Morjovi. No note of tag on left side.
24	Tolstoi	5187	Allflex	white	e^r	Tagged Aug. 4, 1986 on Lukanin. Tag scar on left.
24	Tolstoi	0371	Allflex	orange	c	Tagged July 23, 1986 on Tolstoi.
24	Tolstoi	1245	Allflex	orange	c	
24	Tolstoi	bA3416	monel			No tag on right.
24	Zapadni	70	Allflex	blue	c	Tagged July 22, 1988 on Polovina; also tagged with radio tag.
24	Zapadni	1172	Allflex	orange	c	
24	Zapadni	1186	Allflex	orange	e^r	
24	Zapadni	1252	Allflex	orange	c	

Table 3.--Continued.

Date (July)	Location	Tag number	Tag type	Tag color	Entanglement status*	Notes
24	Zapadni	5137	Allflex	white	e	Disentangled but too big to take controls. Tagged on Zapadni Aug. 1, 1986.
24	Zapadni	ME263	monel			
25	Morjovi	350	Allflex	orange	e	Retagged 1270 with broad orange Allflex tags. Tagged July 22, 1986 on Kitovi as a control. The first control to become entangled. No tag on left.
25	Morjovi	XM6365	monel			No note of tag on left.
25	Morjovi	0742	Allflex	white	c	Tagged Aug. 24, 1986 on Vostochni. Tag number on right sighted but not read.
25	Morjovi	5155	Allflex	orange	e^r	Tagged Aug. 3, 1986 on Polovina. No tag sighting on right.
25	Morjovi	5833	Riese	orange?		No note of tag on right.
25	Morjovi	A01354	monel			Tagged in 1987 as a pup.
25	Morjovi	A07195	monel			Tagged in 1987 as a pup.
25	Vostochni	1211	Allflex	orange	e^r	
25	Vostochni	1220	Allflex	orange	c	
25	Vostochni	5195	Allflex	white	c	Tagged on Vostochni, Aug. 5, 1986.
25	Vostochni	bA657	monel			
26	Kitovi	A00051	monel			No tag on left. Tagged in 1987 as a pup.
26	Kitovi	159	Allflex	blue	c	Tagged on July 31, 1988 at Kitovi.
26	Kitovi	0518	Allflex	orange	c	Tagged on July 31, 1986 at Kitovi.

Table 3.--Continued.

Date (July)	Location	Tag number	Tag type	Tag color	Entanglement status*	Notes
26	Kitovi	0956	Allflex	orange	c	Tagged on Oct. 8, 1986 at Morjovi. Tag number 0957 on right.
26	Kitovi	1257	Allflex	orange	c	
26	Kitovi	A00599	monel			Tagged in 1987 as a pup.
26	Reef	A01461	monel			No note of tag on left. Tagged in 1987 as a pup.
26	Reef	81	Allflex	blue	c	Tagged July 25, 1988 at Tolstoi.
26	Reef	93	Allflex	blue	c	Tagged July 26, 1988 at Kitovi.
26	Reef	132	Allflex	orange	c	Tagged July 30, 1985 at Tolstoi.
26	Reef	154	Allflex	blue	c	Tagged July 31, 1988 at Tolstoi.
26	Reef	0382	Allflex	orange	c	Tagged July 23, 1985 at Gorbatch.
26	Reef	0582	Allflex	orange	c	Tagged Aug. 1986, at Reef. Tag number 0583 on right.
26	Reef	1233	Allflex	orange	e^r	
26	Reef	1250	Allflex	orange	c	
26	Reef	MK1477	monel			No note of tag on right.
26	Zoltoi Sands	0354	Allflex	orange	c	Tagged on July 22, 1986 at Zoltoi Sands.
26	Zoltoi Sands	1164	Allflex	orange	c	
26	Zoltoi Sands	1239	Allflex	orange	c	

* 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 4.--List of juvenile male northern fur seals tagged as entangled animals during surveys conducted in July of 1989, St. Paul Island, Alaska, showing the nature of the debris on each animal.

Tag number	Date (July)	Location (Rookery name)	Description of Debris							Footnote
			Type	Wt. (g)	Color	Tightness[1]	Wound (deg.)	Mesh size (cm)	Twine size (mm)	
1151	14	Tolstoi	trawl	12.4	grey	t	0	22.5	6.0	
1154	14	Zapadni Reef	trawl	15.1	grey	vt	360	22.5	2.6	
1155	14	Zapadni Reef	trawl	34.8	green	vt	360		3.5	
1156	15	Zoltoi Sands	trawl	47	grey	vt	360		4.1	
1157	15	Zoltoi Sands	trawl	184.5	grey	t	0	20.5	5.8	
1158	15	Zoltoi Sands	trawl	34.9	grey	vt	180	20.3	3.2	
1173	15	Gorbatch	packing band	2.3	blue	l	0	23		
1176	15	Reef	trawl	1125	two	t	0	25.7	4.5	2
1181	15	Reef	trawl	5.1	white	vt	360	37.7	3.1	
1186	16	Polovina	trawl	40.8	green	l	0	21.0	3.9	
1187	16	Polovina	packing band	1.5	blue	l	0	27.5		
1188	16	Little Zapadni	packing band	2.8	yellow	t	0	21.3		
1189	16	Little Zapadni	trawl	270	grey	t	360	21.3	3.7	
1190	16	Zapadni Sands	packing band	1.1	black	t	0	25.6		
1197	18	Morjovi	monofilament	0.1	clear	vt	180	8.7	0.4	3
1198	18	Morjovi	string	0.3	black	vt	360	20.5	0.9	
1202	18	Morjovi	packing band	2.9	green	vt	360	26.5		
1204	18	Morjovi	packing band	1.4	yellow	vt	360	20		
1210	18	Vostochni	twine	1.7	green	vt	300	39		4
1211	18	Vostochni	trawl	67.0	green	m	0	21.5	3.4	
1214	18	Vostochni	two kinds	s	two	vt	360			5
1217	19	Vostochni	twine	9.2	green	vt	90	27	5.1	
1222	19	Vostochni	packing band	1.8	yellow	vt	360	43.3		
1223	19	Tolstoi	twine	91	grey			36	10.0	4
1224	19	Tolstoi	trawl	1325	grey	vt	360	22.0	3.8	6,7
1227	19	Zapadni Reef	gill net	168	green	vt	360	12.4	1.6	8
1230	21	Zoltoi Sands	packing band	4.2	blue	l	0	47.8		4
1233	21	Reef	trawl	280	white	vt	90	19.2	5.0	

Table 4.--Continued.

Tag number	Date (July)	Location (Rookery name)	Description of Debris							Footnote
			Type	Wt. (g)	Color	Tightness[1]	Wound (deg.)	Mesh size (cm)	Twine size (mm)	
1234	22	Reef	antenna wire	4.3	black	t	90	28		
1235	22	Reef	packing band	2.4	white	l	0	32.0		4
1238	22	Kitovi	gill net	0.5	clear	vt	90	6.43	0.5	7,8
1241	23	Lukanin	packing band	2.5	yellow	t	0	24.5		
1246	23	Polovina	trawl	167	grey	t	0	21.5	3.6	
1255	23	Zapadni	twine	4.0	white	t	0	28	3.6	
1258	24	Tolstoi	twine	3.6	green	t	0	25.4	4.4	9
1261	24	Zapadni	string	1.0	white	t	360	23.8	1.7	
1264	24	Zapadni	packing band	1.5	yellow	t	0	21.7		
1268	24	Zapadni	packing band	2.2	white	m	0	31		
1274	25	Morjovi	trawl	420	orange	t	0	17.8	4.4	
1278	25	Vostochni	rubber ring	7.3	black	t	60	23	5.0	
1281	25	Vostochni	trawl	114.5	grey	t	0	22.2	3.3	
1286	25	Vostochni	packing band	1.8	white	t	0	23.5		
1287	26	Reef	string	3.0	green	vt	360	29	1.9	

[1]l = loose, m = moderately tight, t = tight, vt = very tight.
[2]The debris taken from this seal consisted of both gray and orange trawl material.
[3]This seal was entangled about the face.
[4]Seals tagged with numbers 1210, 1214, 1223, 1230 and 1235 were larger than harvestable size and not counted in the calculation of the entanglement rate.
[5]This seal was entangled in a yellow packing band and a green twine. Each had resulted in 360 degree wounds. Seal showed evidence of severely stunted growth.
[6]The entangeling material on this seal included twine in addition to the trawl webbing.
[7]The debris was embedded in a wound that was healing so as to embed the debris in the flesh.
[8]The gillnet on 1227 was made of twisted twine; on 1238 it was monofiliment webbing.
[9]This seal was entangled in a twine wrapped twice around the neck. The mesh size is the length of the doubled loop.

Table 5.--Debris found on juvenile male fur seals in 1989 compared to seven earlier years, expressed as the observed percent of juvenile male seals entangled by debris category (data for 1981-1988 from Fowler et al. in press).

	Entanglement (%)							
Type of debris	1981	1982	1983	1984	1985	1986	1988	1989
Trawl net fragments	0.29	0.24	0.30	0.22	0.36	0.27	0.15	0.12
Monofilament net fragments	0.00	0.01	0.01	0.02	0.01	0.01	0.00	0.02
Plastic packing bands	0.08	0.10	0.07	0.09	0.05	0.06	0.07	0.10
Chord, rope, string	0.04	0.04	0.02	0.05	0.08	0.07	0.05	0.06
Miscellaneous items	0.03	0.01	0.03	0.01	0.01	0.01	0.01	0.01
Total	0.43	0.41	0.43	0.39	0.51	0.42	0.28	0.30
Sample size	102	102	112	87	76	70	53	47

Table 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 nonentangled male northern fur seals, each row corresponding to the tags released in the first year for that row.[1]

Controls (Nonentangled)	Year				
	1985	1986	1987	1988	1989
	(172)	37	-	13	8
		[21.5]	-	[7.6]	[4.7]
		(279)	-	40	32
			-	[14.3]	[11.5]
			-	-	-
			-	-	-
				(104)	20
					[19.2]
					(86)

entangled	Year				
	1985	1986	1987	1988	1989
	(85)	12	-	1	0
		[14.1]	-	[1.2]	[0]
		(128)	-	6	4
			-	[4.7]	[3.1]
			-	-	-
			-	-	-
				(52)	5
					[9.6]
					(43)

[1]Updated from Fowler et al. (1989).

Table 7.--Annual percentage frequency distribution of the size of debris on entangled male northern fur seals that were tagged and released (data for 1983 to 1988 from Fowler et al. in press).

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)
Total	443	319(72)	84(19)	40(9)

Table 8.--The numbers and percentages of tagged northern fur seals listed in Table 7 that were resighted by year in relation to size of entangling debris and year (updated from Fowler et al. in press).

Year tagged	Year resighted	Size of debris <150 g(%)	150-500 g(%)	>500 g(%)
1983	1984	18(34)	3(16)	2(17)
1983	1985	4(8)	1(5)	0(0)
1983	1986	3(6)	0(0)	0(0)
1983	1988	1(0)	0(0)	0(0)
1984	1985	14(30)	2(29)	0(0)
1984	1986	9(16)	0(0)	0(0)
1984	1988	0(0)	0(0)	0(0)
1985	1986	9(16)	3(19)	0(0)
1985	1988	1(2)	0(0)	0(0)
1986	1988	6(7)	0(0)	0(0)
1985	1989	0(0)	0(0)	0(0)
1986	1989	3(3)	0(0)	1(11)
1988	1989	4(11)	1(13)	0(0)
Combined years		72(25)	10(13)	3(8)

Table 9.--Comparison of numbers of tags applied to entangled and control juvenile male northern fur seals in 1985, 1986, 1988 and 1989 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)
Total	525	130(24.8)	241	63(26.1)

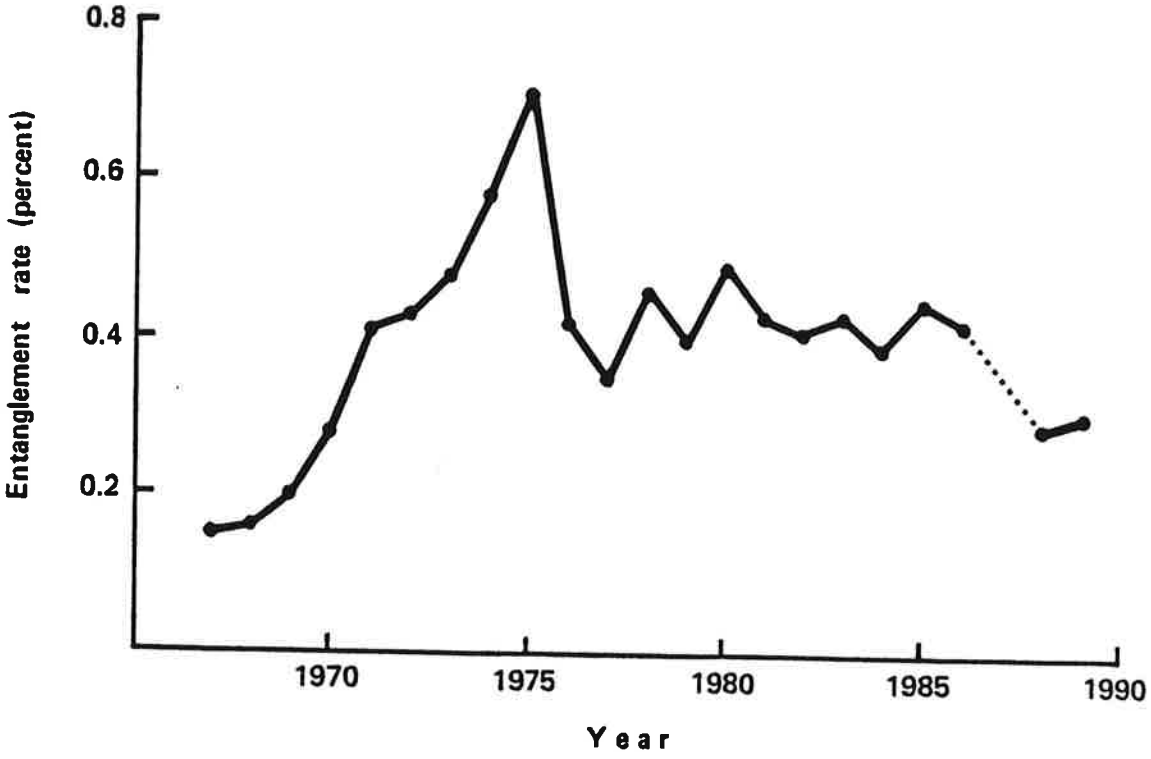

Figure 1. The percentage of juvenile male northern seals found entangled in the commercial harvest from 1967 to 1984 and in research roundups from 1985 to 1989 on St. Paul Island, Alaska (updated from Fowler 1987).

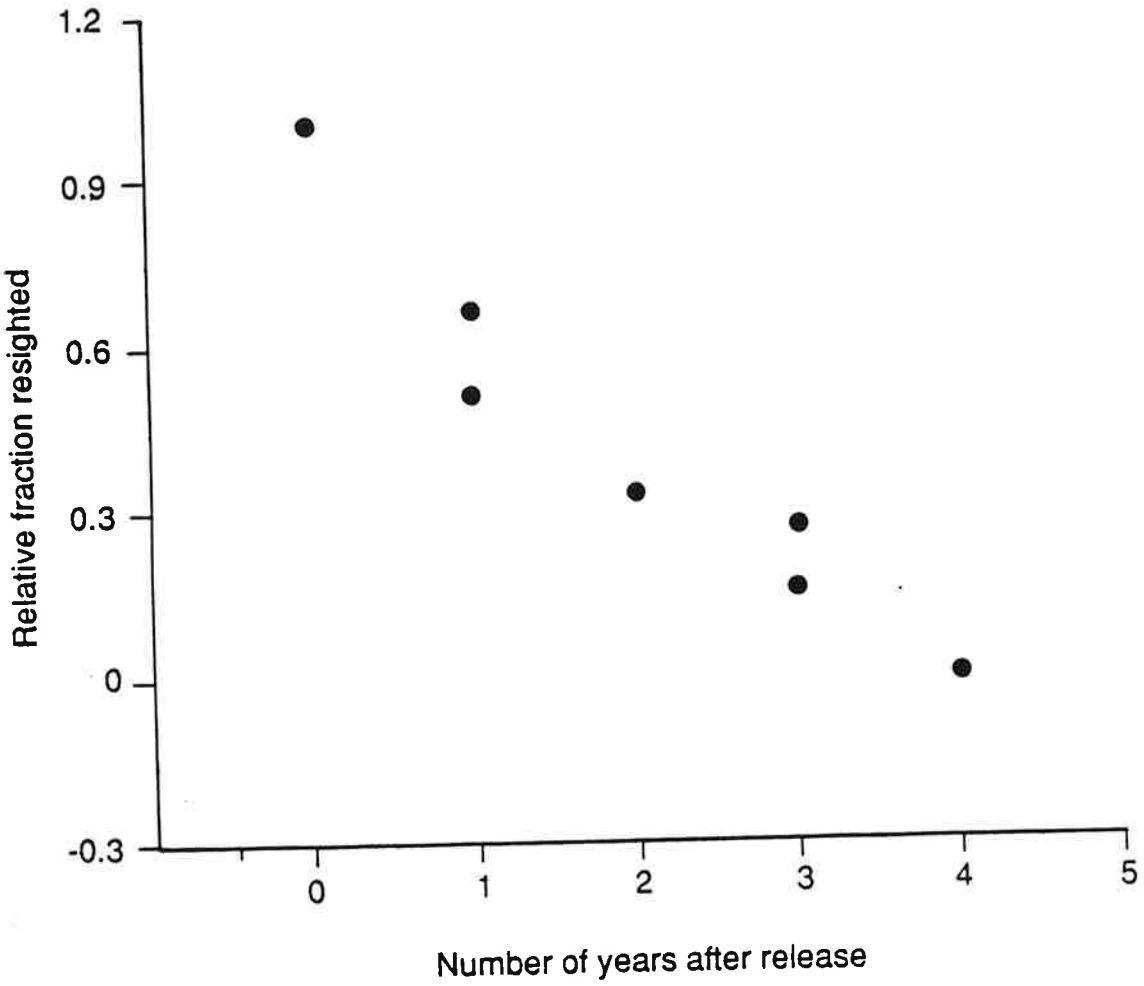

Figure 2. Relative rates of return for entangled juvenile male northern fur seals compared to controls (nonentangled tagged seals) for varying time intervals (Updated from Fowler et al., in press, with the data from this report). Each data point represents the fraction of entangled seals resighted divided by the fraction of controls resighted (both from Table 6) for the corresponding time interval (for example, there are two data points for three years corresponding to the 1985-88 and 1986-89 intervals).

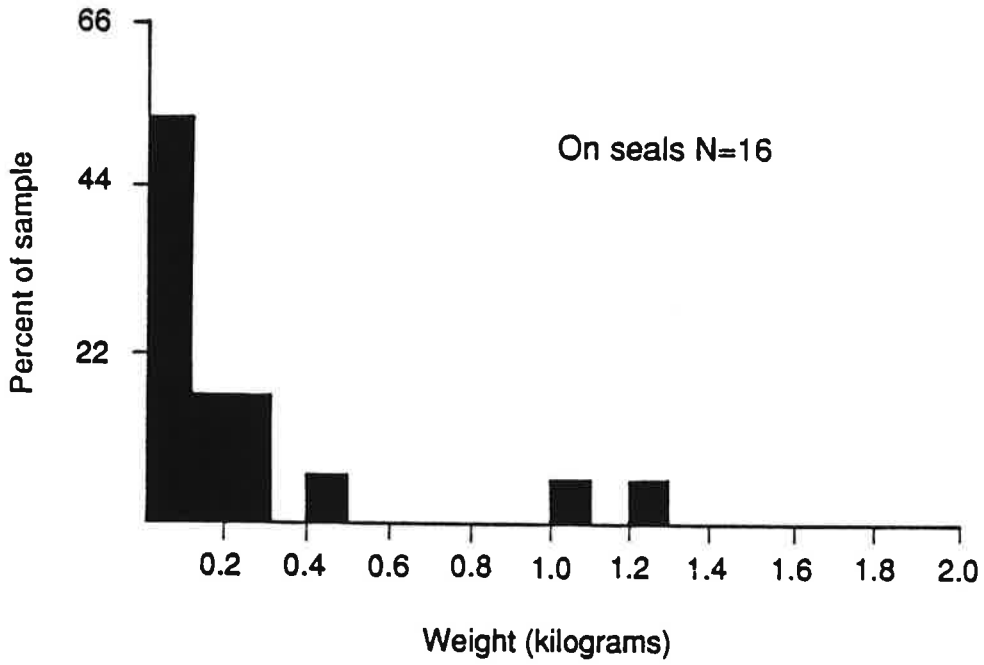

Figure 3. Size frequency distribution of trawl net debris found on entangled juvenile male northern fur seals, July 1989, St. Paul Island, Alaska (size measured in kilograms).

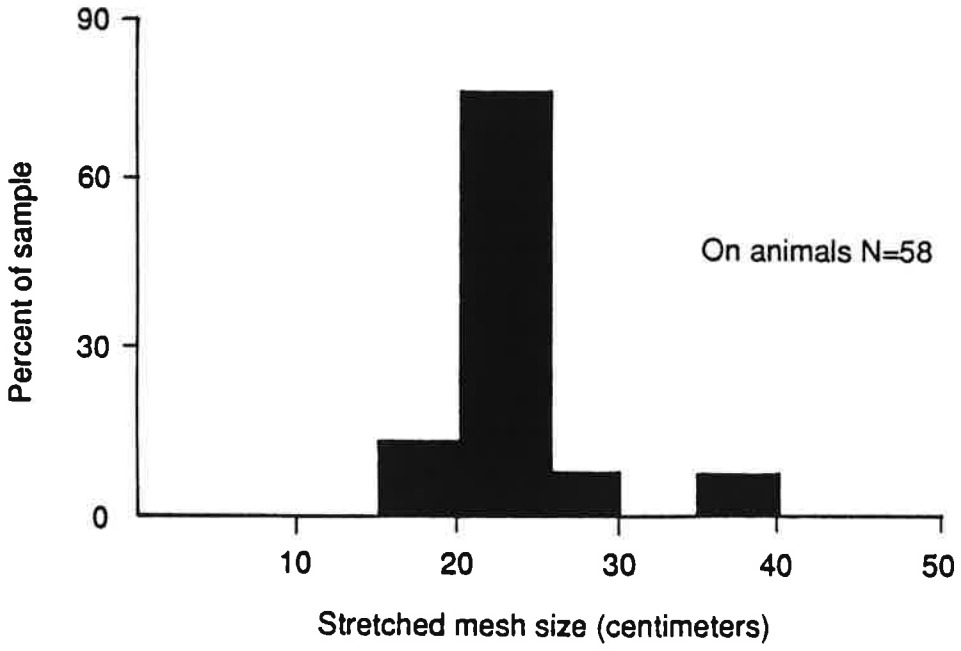

Figure 4. Size frequency distribution of trawl net debris found on entangled juvenile male northern fur seals, July 1989, St. Paul Island, Alaska (size measured as length of stretched mesh of trawl net fragments).