SURVEYS OF PLASTIC LITTER ON ALASKAN BEACHES, 1985

by

Theodore R. Merrell and Scott W. Johnson

Auke Bay Laboratory
Northwest and Alaska Fisheries Center
National Marine Fisheries Service
National Oceanic and Atmospheric Administration
P. O. Box 210155
Auke Bay, Alaska 99821

ABSTRACT

Thirty-four Alaskan beaches were surveyed in 1985 at Yakutat (5 beaches), Middleton Island (7 beaches), and the Aleutian Islands (22 beaches) to determine types, quantities, and trends in abundance of plastic litter. Mesh sizes and weights of trawl web found on all beaches surveyed were compared with those of trawl web entangled on northern fur seals (Callorhinus ursinus) on the Pribilof Islands; types and quantities of plastic litter were compared on 19 Aleutian Island beaches with and without northern sea lions (Eumetopias jubatus). Three types of plastic litter that entangle marine animals were common--trawl web, packing straps, and rope--whereas derelict gill nets were not, Aleutian Island beaches had the most litter, followed by Middleton Island and Yakutat beaches. Entanglement litter declined 3% on three Amchitka Island beaches last surveyed in 1982 and declined 8% on two Middleton Island beaches and 65% on five Yakutat beaches last surveyed in 1984. A Middleton Island beach cleared of all debris in 1984 and resurveyed in 1985 regained 43% of the number of plastic items found in 1984. Frequencies of weights and mesh sizes of trawl web on all the beaches surveyed differed from those of trawl web entangled on fur seals. Quantities of entanglement litter on the Aleutian Islands were lower on 5 beaches with sea lions than on 14 beaches without sea lions.

CONTENTS

INTRODUCTION

Plastic litter, especially commercial fishing gear lost or discarded at sea, can entangle marine mammals, seabirds, and fish; disable vessels; and degrade the scenic quality of wilderness beaches (Wallace 1985; Pruter unpubl. manuscr.). In Alaskan waters, an estimated 1,664 metric tons of plastic litter may be lost or discarded annually from fishing vessels (Merrell 1980). Because most plastic litter floats, it often washes ashore where it can be systematically surveyed. Litter stranded ashore represents, to some degree, the types and quantities that entangle marine animals at sea. Few studies, however, have been conducted to determine types, quantities, and trends in abundance of plastic litter on Alaskan beaches. Most information available on beach litter in Alaska is provided in Merrell (1980, 1984, 1985).

In 1985, the National Marine Fisheries Service continued Alaskan beach surveys which have been conducted since 1972. Primary objectives were to determine types and quantities of plastic litter on beaches, determine trends in abundance of plastic litter by resurveying beaches that had been surveyed in previous years, establish a baseline for future comparisons of trends in accumulation and disappearance of litter on beaches, and test alternative experimental designs of beach surveys to measure changes in litter accumulation rates. Secondary objectives were to measure and weigh as many trawl-web fragments as possible for comparison with data from net fragments found in 1982 and 1985 on northern fur seals (Callorhinus ursinus) from the Pribilof Islands, and determine whether litter found on beaches occupied by northern sea lions

(Eumetopias jubatus) is similar to that on beaches without sea lions. Although many types of plastic litter were found on beaches, only those commonly associated with entanglement of marine animals are discussed in this paper: trawl web, monofilament gill net, packing straps, and rope. Trawl web is of key importance; it is the predominant item causing entanglement of northern fur seals (Scordino and Fisher unpubl. manuscr.; Bengtson et al. in prep.).

SURVEY SITES

The survey sites in 1985 were 34 beaches at the following locations: Yakutat (5 beaches) in the northern part of southeastern Alaska; Middleton Island (7 beaches) in the northern Gulf of Alaska; and the Aleutian Islands (22 beaches), from Unimak pass to Kiska Island (Fig. 1). Beaches surveyed in previous years were resurveyed at Yakutat (five beaches), Middleton Island (three beaches, one of which was cleared of all litter in 1984), and Amchitka Island (three beaches). In addition, we surveyed plastic litter on 19 beaches on 13 Aleutian Islands, while accompanying biologists from the Northwest and Alaska Fisheries Center, National Marine Mammal Laboratory (NMML), who visited sea lion rookeries and haul-out sites between Unimak Pass and Kiska Island. Five of the 19 beaches surveyed were sea lion rookeries. The physical characteristics (e.g., sand or gravel) of these five beaches were similar to those of beaches without sea lions. Results of the NMML sea lion surveys are in Loughlin et al. (1986).

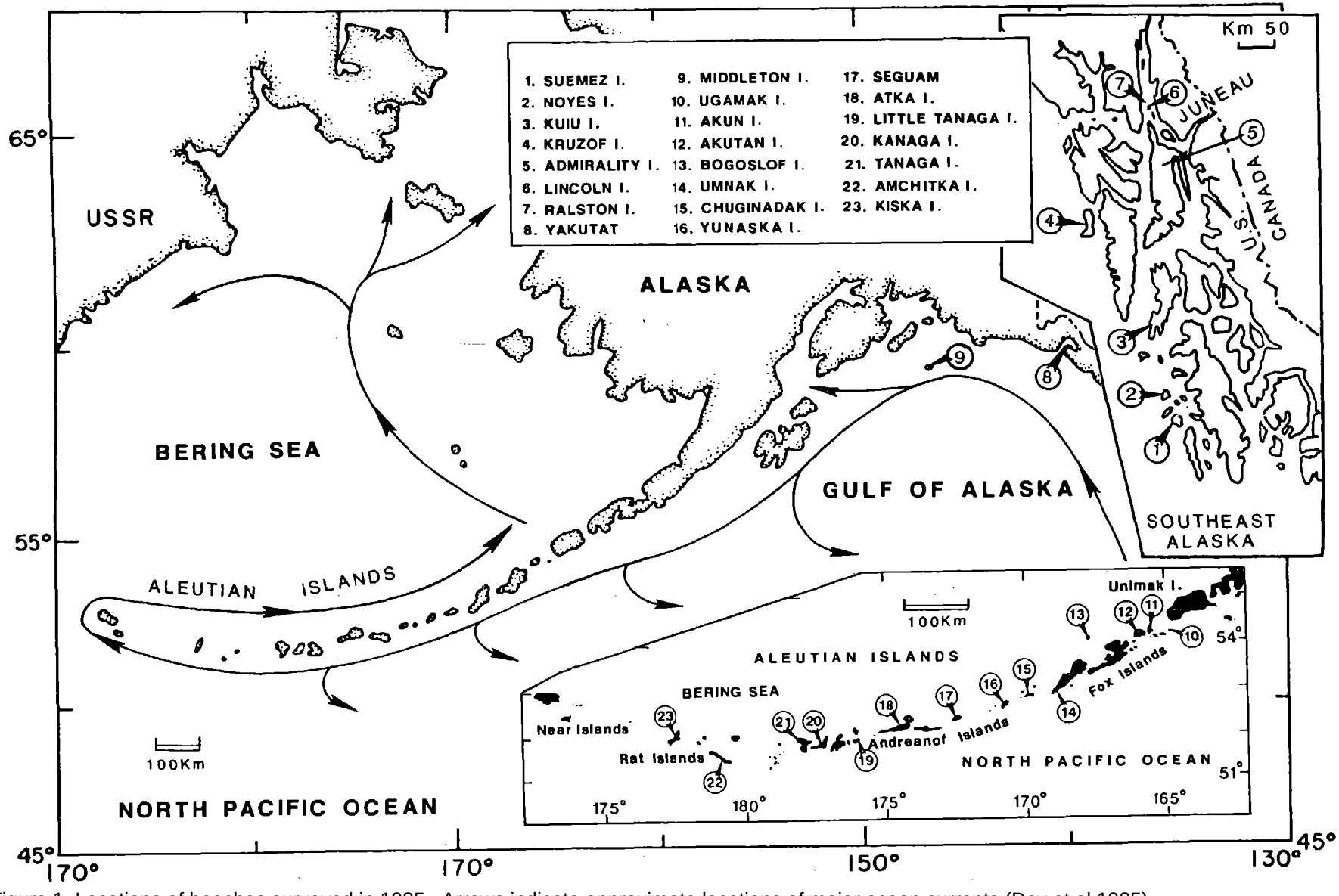

Figure 1. Locations of beaches surveyed in 1985. Arrows indicate approximate locations of major ocean currents (Day et al 1985)

METHODS

Survey methods were the same at all locations. All plastic litter items visible from walking height (i.e., pieces larger than about 5 mm) were recorded. The survey area for each beach included the intertidal zone between the water's edge and the seaward limit of terrestrial vegetation at the upper limit of normal high tide. Small fragments of trawl web were weighed on hand-held spring scales. Weights of trawl web too heavy to lift were estimated, as were the weights of the visible portions of trawl web partially buried in sand, driftwood, kelp, or cobbles. The stretch mesh was measured (knot to knot inside measure) for one representative mesh of each trawl-web fragment sampled. Weights and mesh sizes of trawl web on beaches in this study were compared to those of trawl web found on Pribilof Island beaches and entangled on fur seals in 1982 and 1985. A more detailed description of survey methods is in Merrell (1985).

A study to determine trends in the accumulation and disappearance of plastic litter was initiated in 1985 at Middleton Island and Yakutat. On two l-km beaches on Middleton Island, all litter items were moved to terrestrial areas above the high tide zone or; if too big to move, were flagged and painted--a procedure that will continue once each year, At Yakutat, a beach was selected for testing 'alternative experimental designs to determine the minimum frequency of surveys needed to measure trends in litter over time. The beach is straight and exposed to the open ocean, has uniform sand composition and gradient, and extends for many miles without interruption. We chose a 5-km section that is accessible by road throughout the year, subdividing it into five

adjoining l-km sections and permanently marking the boundaries of each with red surveyor's tape and orange spray paint on live Sitka spruce (Picea sitchensis) above high tide. In September 1985, all plastic items on each l-km section were spray painted with one of five different colors. In addition, each trawl-web fragment was painted and then marked with a numbered tag, and its location on the beach was mapped. The locations and recoveries of tagged and painted items will be determined in future surveys.

A second aspect of the Yakutat study was the subdivision of the 5-km beach into fifty 100-m increments (instead of five l-km increments used previously), providing 50 different data sets for each survey date. This modification will improve the statistical precision of litter estimates and facilitate the development of a cost-effective scheme for future sampling (Ribic and Bledsoe 1986).

RESULTS

The composition of entanglement litter (i.e., the relative proportion of each type of item) was remarkably similar on beaches throughout Alaska; however, the quantities of each type varied greatly from location to location (Table 1). In decreasing order of abundance, the most numerous items at all locations were rope, trawl web, and packing straps. The least numerous item was always monofilament gill net. Litter was more abundant on the Aleutian Islands than either Middleton Island or Yakutat.

Beaches surveyed in previous years and resurveyed in 1985 showed declines in entanglement litter (all items combined), Litter declined

Table 1. --Types and quantities of entanglement litter found on Alaskan beaches, 1985. Data are mean + standard error.

Type	Litter (no./km)		
	Aleutian Islands (14 beaches)[a/]	Middleton Island (2 beaches)	Yakutat (5 beaches)
Trawl web	37.1 ± 12.6	16.5 ± 6.5	3.0 ± 0.7
Strapping[b/]	20.9 ± 7.3	9.5 ± 1.5	2.0 ± 0.9
Monofilament gill net	1.0 ± 0.4	2.5 ± 1.5	0
Rope	50.5 ± 13.3	34.5 ± 2.5	10.6 ± 1.7
Total	109.5	63.0	15.6

[a/] Beaches without sea lions (*Eumetopias jubatus*); includes Amchitka Island.
[b/] Includes open and closed straps.

3% on three Amchitka Island beaches last surveyed in 1982; quantities of trawl web were about the same as those observed in 1982, but packing straps declined 66% (Fig. 2). Since previous surveys in 1984, litter declined 8% on two Middleton Island beaches and declined 65% on five Yakutat beaches (Fig. 2).

A l-km beach on Middleton Island, cleared of all plastic litter in 1984 and resurveyed in 1985, showed a 43% accrual of litter within 1 year, i.e., the number of plastic items on the beach in 1985 was 43% of that in 1984 (Fig. 3). The relative amounts of different types of litter were about the same in both years; rope fragments were the most numerous and gill net the least.

Large (>l.O kg) pieces of trawl web made up more than one-third of the total weight of fragments found on beaches in 1982 and 1985 (Table 2), but small (< 0.1 kg) pieces were the most common (65% of the total) entangled on Pribilof Island fur seals. Unfortunately, no weights of trawl-web fragments were obtained from entangled fur seals or from beaches on the Pribilof Islands in 1985, and weights of trawl-web fragments <O.l kg were not taken at Amchitka Island in 1982.

The frequency distribution of mesh sizes of trawl-web fragments on beaches and entangled on fur seals was nearly identical in 1982 and 1985 (Table 3). Most (>88%) trawl-web fragments found on beaches were (20 cm stretch mesh size, but few (<9.0%) fur seals were entangled in fragments with these small mesh sizes. Most (>80%) fur seals were entangled in fragments with mesh sizes of 20-25 cm.

Quantities of litter on 5 beaches with sea lion rookeries were lower than those on 14 beaches without sea lions (Table 4). Compared to beaches without sea lions, beaches with sea lions had 95% less trawl

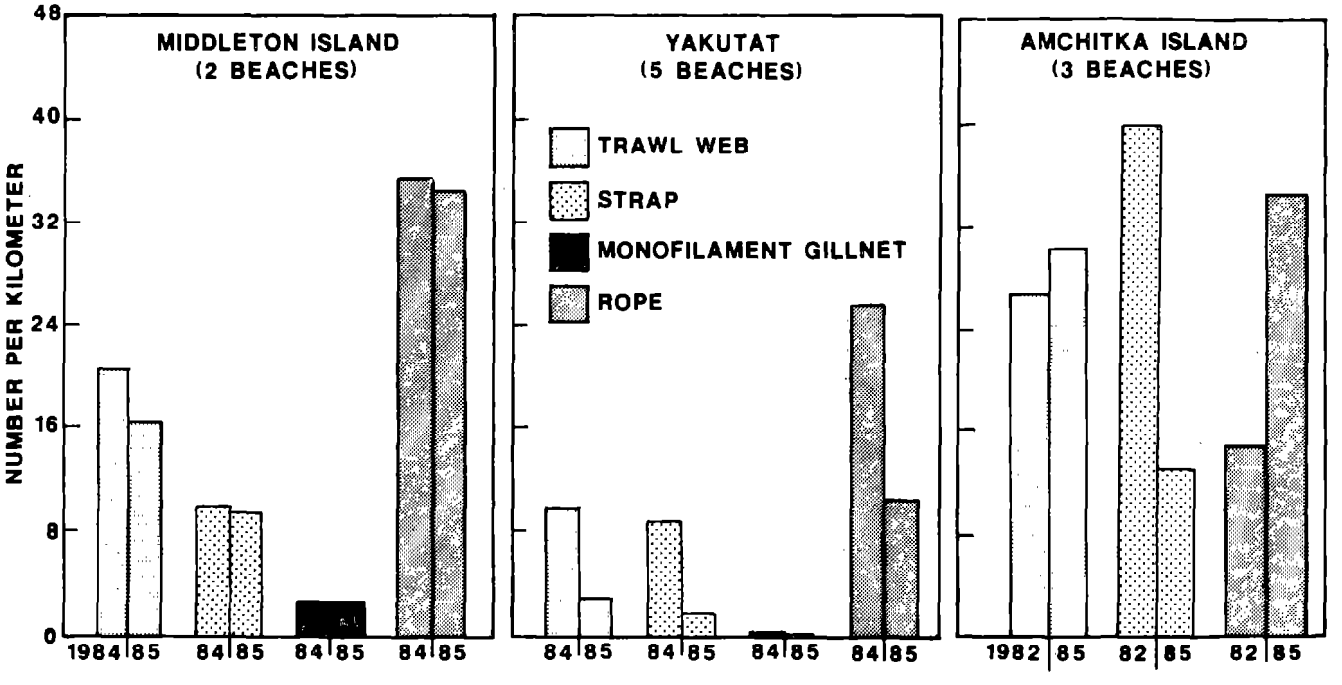

Figure 2.--Quantities of litter found on Middleton Island and Yakutat beaches in 1984 and 1985 and on Amchitka Island beaches in 1982 and 1985.

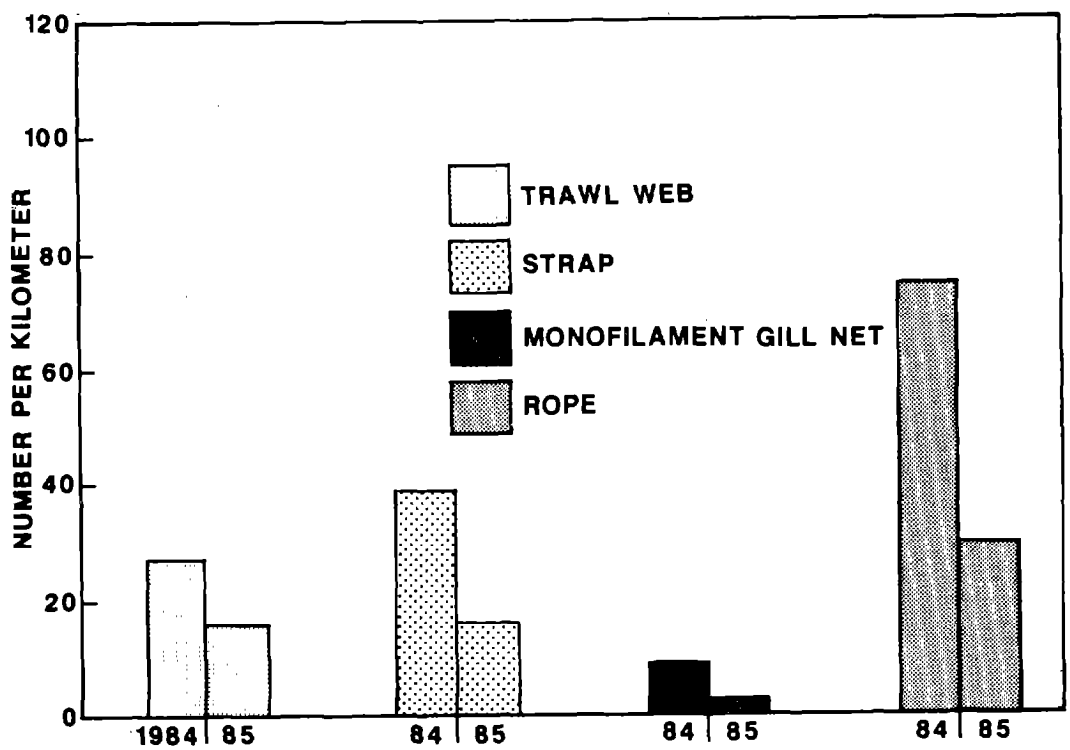

Figure 3.--Recruitment of litter from 1984 to 1985 on a l-km beach on Middleton Island that was cleared of all litter in 1984.

Table 2.--Frequency of weights of trawl-web fragments on Alaskan beaches in 1982 and 1985 and on Pribilof Island fur seals (Callorhinus ursinus) in 1982. Percents are in parentheses.

Weight (kg)	Beaches[a/]	Amchitka Island beaches[b/]	Pribilof Island Beaches[b/]	Pribilof Island Fur seals[b/]
≤0.1	25 (18.7)	--[c/]	44 (18.1)	41 (65.1)
0.1-0.2	16 (11.9)	11 (3.1)	25 (10.3)	10 (15.9)
0.2-0.3	11 (8.2)	26 (7.8)	17 (7.0)	4 (6.3)
0.3-0.4	6 (4.5)	19 (5.7)	18 (7.4)	3 (4.8)
0.4-0.5	5 (3.7)	17 (5.1)	9 (3.7)	0 (0.0)
0.5-0.6	5 (3.7)	30 (9.0)	19 (7.8)	1 (1.6)
0.6-1.0	12 (9.0)	42 (12.6)	14 (5.8)	1 (1.6)
1.0-2.0	21 (15.7)	88 (26.3)	19 (7.8)	2 (3.2)
>2.0	33 (24.6)	101 (30.2)	78 (32.1)	1 (1.6)
Total	134	334	243	63

[a]/1985 data. Yakutat and Middleton and Aleutian Islands.
[b]/1982 data: Fowler (1984).
[C]/Weights not taken.

Table 3. --Frequencies of mesh sizes of trawl-web fragments found on Alaskan beaches and on Pribilof Island fur seals (Callorhinus ursinus) in 1982 and 1985. Percents are in parent!

Mesh size (cm)	Beaches		Fur seals	
	1985[a]	1982[b]	1982[c]	1985[d]
0-5	2 (0.4)	2 (0.3)	0	0
5-10	120 (25.4)	147 (25.0)	1 (1.7)	0
10-15	217 (46.0)	253 (43.0)	0	1 (2.8)
15-20	77 (16.3)	120 (20.4)	4 (6.9)	1 (2.8)
20-25	47 (10.0)	50 (8.5)	47 (81.0)	31 (86.1)
25-30	3 (0.6)	10 (1.7)	5 (8.6)	2 (5.6)
30-35	2 (0.4)	2 (0.3)	0	0
35-40	1 (0.2)	3 (0.5)	1 (1.7)	1 (2.8)
40-45	2 (0.4)	0	0	0
45-50	0	1 (0.1)	0	0
50-55	0	0	0	0
55-60	0	0	0	0
60-65	1 (0.2)	0	0	0
Total	472	588	58	36

[a] Yakutat and Middleton and Aleutian Islands.
[b] Amchitka Island and Pribilof Islands; Fowler (1984).
[c] Fowler (1984).
[d] Bengtson et al. (in prep.).

Table 4.--Quantities of entanglement litter on Aleutian Island beaches with and without sea lions (Eumetopias jubatus), 1985.

Location	Litter (no./km)				
	Trawl web	Strap		Monofilament gill net	Rope
		Open	Closed		
Without Sea Lions					
Ugamak Island[a/]	9.9	21.0	2.5	0.0	136.9
Akutan Island					
Cascade Bight	10.5	7.7	0.0	1.0	19.1
Flat Bight	40.0	6.0	4.0	2.0	78.0
Umnak Island					
Russian Bay	15.0	7.5	0.5	0.5	19.0
Black Creek	22.7	12.7	1.8	0.0	35.5
Chuginadak Island	41.3	44.4	4.8	1.6	177.8
Atka Island	4.6	9.2	0.0	0.0	8.5
Little Tanaga Island	190.4	104.1	2.5	5.1	58.4
Kanaga Island	17.0	1.0	0.0	1.0	22.0
Tanaga Island	30.0	12.9	1.4	0.0	21.4
Amchitka Island					
Rifle Range	11.0	3.0	1.0	1.0	14.0
Sand Beach Cove	62.0	14.0	2.0	1.0	43.0
Clevenger	19.0	20.0	1.0	0.0	48.0
Kiska Island	46.6	6.9	0.0	1.4	24.7
Mean	37.1	19.3	1.5	1.0	50.5

Table 4.--Continued.

Location	Litter (no./km)				
	Trawl web	Strap		Monofilament gill net	Rope
		Open	Closed		
	With Sea Lions				
Ugamak Island[b/]	2.3	0.0	0.0	0.0	20.5
Akun Island	5.0	7.5	0.0	2.5	27.5
Bogoslof Island	0.0	0.8	0.0	0.0	5.0
Yunaska Island	2.0	2.0	0.0	0.0	26.0
Seguam Island	0.0	0.0	0.0	1.9	3.7
Mean	1.9	2.1	0.0	0.9	16.5

a/Two beaches combined.
b/ Three beaches combined.

web, 90% less packing straps, and 67% less rope, although the relative proportion of litter items was similar.

DISCUSSION

Plastic litter that washes ashore is an indicator of the types of litter at sea that can entangle marine mammals, seabirds, and fish. Most plastic litter found on Alaskan beaches is from fishing vessels (Merrell 1985). Fishing litter enters the ocean by being discarded overboard, lost or abandoned at sea during storms, or snagged on obstacles such as the ocean bottom. Although many different types of entanglement litter were found on beaches, the three most abundant were rope, trawl web, and packing straps. The latter two are the predominant items causing entanglement of northern fur seals (Scordino 1985). A fur seal with its head or flippers entangled in a trawl-web fragment or a packing strap can die as a result of exhaustion, lacerations, or interference with feeding (Fowler and Merrell 1986).

Derelict gill nets, although scarce on beaches (Merrell 1984, 1985), have contained numerous remains of seabirds and fish (Degange and Newby 1980). The low number of gill nets on beaches is surprising because over 1 million miles of gill nets are fished each year in the North Pacific Ocean; of the gill nets fished, an estimated 600 miles are lost or abandoned each year (Eisenbud 1985). One explanation for the scarcity of gill nets on beaches is that they sink to the ocean bottom from the weight of marine growths and carcasses of seabirds, fish, and marine mammals. Once sunk, the plastic floats, which normally keep nets at the surface, compress and permanently lose most of their buoyancy.

The relative proportions of entanglement litter were similar on different beaches and in different years, but quantities at different locations varied greatly. Beaches on the Aleutian Islands and on Middleton Island had the most fishing litter because of their proximity to major trawl fisheries in the western and central Gulf of Alaska and Bering Sea (Low et al. 1985). Beaches at Yakutat had the least amount of litter because trawl fishing by foreign fishermen has decreased in the eastern Gulf of Alaska and is now prohibited east of 140°W longitude and north of 54°30'N latitude off southeastern Alaska (North Pacific Fishery Management Council 1984).

Trends in abundance of plastic litter on beaches have proved to be more difficult to determine than anticipated. One reason for this difficulty is the variations in year-to-year abundance of plastic litter on the same beach and on beaches in different locations. The fate of debris once stranded ashore is unknown (i.e., Is a portion of it eventually transported back to sea? Is it blown inland to terrestrial areas, or does it stay on the beach and disintegrate into small fragments or get buried and unburied with storm events?). For example, entanglement litter declined 8% on Middleton Island between 1984 and 1985, whereas the same items declined 65% on Yakutat beaches. In contrast, the number of plastic items on a l-km beach on Middleton Island cleared of all debris in 1984 and resurveyed in 1985 was 43% of that recorded the previous year. To understand the dynamics of marine litter transport in the oceans and on beaches, information is needed on how much of this annual accrual is litter that has been recently discarded at sea and how much is older, recycled litter that has been stranded ashore for varying periods of time, Our experiment with marked

debris at Yakutat in 1986 will help answer this question. It is obvious, however, that details on the dynamics of litter on Yakutat beaches are different than on Middleton Island beaches,

A stable frequency distribution of trawl-web mesh sizes was observed on beaches in 1982 and 1985. Only about 10% of the trawl-web fragments had mesh sizes >20 cm, whereas about 90% were (20 cm. The larger (>20 cm) mesh sizes probably are not common on beaches; they comprise only a small portion of a typical trawl net. Because adult fur seals are more susceptible to entanglement in trawl web with mesh sizes larger than 20 cm, their entanglement apparently is determined not so much by the abundance of various mesh sizes in the ocean, as by the size of the fur seals. On the other hand, recent studies (Bengtson et al. in prep.) have shown that young, naive fur seals after weaning are extremely susceptible to entanglement in smaller trawl-web mesh sizes of 16-20 cm, which compose about 20% of the sizes found on beaches. Young seals are thus more at risk than older, larger seals; they are vulnerable to a much wider range of trawl-web mesh sizes. Although a question remains as to how representative litter on beaches is of litter at sea, the frequency distribution of trawl-web fragments by mesh size and weight on beaches suggests that most fragments at sea represent a low entanglement potential.

Data from 1985 surveys are inadequate to demonstrate that litter on Aleutian Island beaches with sea lions was less than that on beaches without sea lions. Although the average number of items on rookery beaches was less than on nonrookery beaches with similar physical characteristics, only five rookery beaches were surveyed and their frequency of entanglement items overlapped that of some nonrookery

beaches (Table 4). It is unlikely that the low mean frequency of litter on sea lion rookeries on the Aleutian Islands was a result of sea lions becoming entangled in litter from those beaches: Only 11 sea lions among 15,957 adults had net or debris scars, and none of the 14,160 pups were entangled (Loughlin et al. 1986).

In summary, beach surveys are effective in determining the types and quantities of entanglement litter that commonly washes ashore on Alaskan beaches. Determining trends in abundance, however, has proved to be more difficult than anticipated because quantities of-litter are so variable in different locations and the causes of variability so little understood. Emphasis in future studies should be on determining the fate of debris once it is stranded ashore (recycling rate) and the extent to which litter on beaches represents litter at sea. Studies initiated in 1985 and continued in 1986, especially clearing debris from beaches on Middleton Island and mapping and tagging debris on beaches at Yakutat, will greatly add to our understanding of the dynamics of litter.

REFERENCES

BENGTSON, J. L., C. W. FOWLER, H. KAJIMURA, R. MERRICK, S. NOMURA, and K. YOSHIDA.

In preparation. Fur seal entanglement studies: juvenile males and newly weaned pups on St. Paul Island, Alaska. National Marine Mammal Laboratory, Northwest and Alaska Fish. Cent., 7600 Sand Point Way NE, Seattle, WA 98115

DAY, R. H., D. H. S. WEHLE, and F. C. COLEMAN.

1985. Ingestion of plastic pollutants by marine birds. In R. S. Shomura and J. O. Yoshida (editors), Proceedings of the Workshop on the Fate and Impact of Marine Debris, 26-29 November 1984, Honolulu, Hawaii, p. 344-386. U.S. Dep. Commer., NOAA Tech. Memo. NMFS SWFC-54.

DEGANGE, A. R., and T. C. NEWBY.

1980. Mortality of seabirds and fish in a lost salmon driftnet. Mar. Pollut. Bull. 11:322-323.

EISENBUD, R.

1985. Problems and prospects for the pelagic driftnet. Boston Coll. Environ. Aff. Law Rev. 12:473-490.

FOWLER, C. W.

Unpubl. manuscr. Entanglement in fishing debris as a contributing factor in the decline of northern fur seals on the Pribilof Islands, 33 p. National Marine Mammal Laboratory, Northwest and

Alaska Fish. Cent., 7600 Sand Point Way NE, Seattle, WA 98115. (Background paper submitted to the 27th Annual Meeting of the Standing Scientific Committee, North Pacific Fur Seal Commission, Moscow, U.S.S.R., 9-13 April 1984.)

FOWLER, C. W., and T. R. MERRELL.

1986. Victims of plastic technology. Alaska Fish Game 18(2):34-37.

LOUGHLIN, T. R., P. J. GEARIN, R. L. DELONG, and R. L. MERRICK.

1986. Assessment of net entanglement on northern sea lions in the Aleutian Islands, 25 June-15 July 1985. U.S. Dep. Commer., Natl. Mar. Fish. Serv., NWAFC Proc. Rep. 86-02, 50 p.

LOW, L.-L., R. E. NELSON, JR., and R. E. NARITA.

1985. Net loss from trawl fisheries off Alaska. In R. S. Shomura and J. O. Yoshida (editors), Proceedings of the Workshop on the Fate and Impact of Marine Debris, 26-29 November 1984, Honolulu, Hawaii, p. 130-153. U.S. Dep. Commer., NOAA Tech. Memo. NMFS SWFC-54.

MERRELL, T. R., JR.

1980. Accumulation of plastic litter on beaches of Amchitka Island, Alaska. Mar. Environ. Res. 3:171-184.

MERRELL, T. R., JR.

1984. A decade of change in nets and plastic litter of fisheries off Alaska. Mar. Pollut. Bull. 15:378-384.

MERRELL, T. R., JR.

1985. Fish nets and other plastic litter on Alaska beaches. In R. S. Shomura and J. O. Yoshida (editors), Proceedings of the Workshop on the Fate and Impact of Marine Debris, 26-29 November 1984, Honolulu, Hawaii, p. 160-182. U.S. Dep. Commer., NOAA Tech. Memo. NMFS, SWFC-54.

NORTH PACIFIC FISHERY MANAGEMENT COUNCIL (NPFMC).

1984. Fishery management plan for the Gulf of Alaska groundfish fishery. NPFMC, P.O., Box 103136, Anchorage, AK 99510, 220 p.

PRUTER, A. T.

Unpublished manuscript. Sources, quantities and distribution of persistent plastics in the marine environment, 16 p. Natural Resources Consultants, 4055 - 21st Ave. W., Seattle, WA 98199. (Paper presented at the Sixth International Ocean Disposal Symposium, Pacific Grove, CA, April 21-25, 1986.)

RIBIC, C. A., and L. J. BLEDSOE.

1986. Design of surveys for density of surface marine debris in the North Pacific. Final rep., 69 p. Center for Quantitative Science, Univ. Washington, Seattle.

SCORDINO, J.

1985. Studies on fur seal entanglement, 1981-84, St. Paul Island, Alaska. In R. S. Shomura and J. 0. Yoshida (editors), Proceedings of the Workshop on the Fate and Impact of Marine Debris,

26-29 November 1984, Honolulu, Hawaii,, p. 278-290. U.S. Dep. Commer., NOAA Tech. Memo. NMFS SWFC-54.

SCORDINO, J., and R. FISHER.

Unpublished manuscript. Investigations on fur seal entanglement in net fragments, plastic bands and other debris in 1981 and 1982, St. Paul Island, Alaska, 33 p. + appendices. (Background paper submitted to the 26th Annual Meeting of the Standing Scientific Committee, North Pacific Fur Seal Commission, Washington, D.C., 28 March-8 April 1983.)

WALLACE, N.

1985. Debris entanglement in the marine environment: a review. In R. S. Shomura and J. O. Yoshida (editors), Proceedings of the Workshop on the Fate and Impact of Marine' Debris, 26-29 November 1984, Honolulu, Hawaii, p. 259-277. U.S. Dep. Commer., NOAA Tech. Memo. NMFS SWFC-54.