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Entanglement and Other Plastic Debris on Alaskan Beaches, 1990-92

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ENTANGLEMENT AND OTHER PLASTIC DEBRIS ON ALASKAN BEACHES, 1990-92

by

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ABSTRACT

Beaches in the Gulf of Alaska were monitored from 1990 to 1992 for deposition rate, trends in abundance, and sources and fate of entanglement debris and other plastics that washed ashore. This study was a continuation of Alaskan beach surveys conducted periodically since 1972. Eight beaches near Yakutat were surveyed usually in March and September 1990-92; seven beaches on Kayak Island once in August 1991; and six beaches on Middleton Island once in July 1992. Entanglement debris, especially rope and trawl web, continued to decline on most beaches. Rope declined about 25% at both Yakutat (1990-92) and Middleton Island (1989-92). Deposition rate (3.8 pieces/km of beach/year) of trawl web near Yakutat in 1992 was the lowest observed since 1985. Plastic items washed ashore were similar at all locations and most (49-65%) were from fishing vessels. Bottles, gill-net floats, and caps/lids accounted for about 75% of all plastics. In 1992, gill-net floats increased 10-fold on beaches near Yakutat but did not increase on other study beaches. El Niño conditions in 1991-92 may have influenced surface currents in the North Pacific Ocean, resulting in greater deposition of debris near Yakutat. Plastics remained ashore near Yakutat for several months; 40% of gill-net floats painted in April 1992 were recovered in September 1992. Country of manufacture of bottles indicates that the sources of many plastics washed ashore are the United States and Asia. Beach surveys continue to provide valuable information on the effectiveness of MARPOL Annex V to reduce disposal of plastics at sea.

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INTRODUCTION

Marine pollution has been a major environmental concern for decades. More recently, the loss or discard of plastics at sea was recognized as a form of marine pollution of international significance (Shomura and Yoshida 1985). Plastic debris mars the scenic quality of beaches, can be hazardous to human health, and endangers living marine resources. Marine mammals can become entangled in trawl-web fragments, packing straps, and rope (Fowler 1987; Henderson 1990; Stewart and Yochem 1990); seabirds, fish, and crabs can become entrapped in derelict gill nets (Degange and Newby 1980; Breen 1990); and seabirds and sea turtles can ingest pieces of plastic that block their digestive tracts (Ainley et al. 1990; Plotkin and Amos 1990).

Plastic debris washed ashore represents, to some degree, the types and quantities lost or discarded at sea. Therefore, beach surveys can provide information on the magnitude of the debris problem at sea and may be the best method of evaluating the effectiveness of recent (1987) U.S. legislation implementing Annex V of the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol for 1978 (MARPOL 73/78) —the first international agreement to reduce the input of plastics and other garbage into the sea from ships.

From 1990 to 1992, the National Marine Fisheries Service Auke Bay Laboratory continued Alaskan beach surveys that have been conducted periodically since 1972. Although many types of plastic debris were found, only those commonly associated with entanglement of marine animals in Alaska are discussed in detail in this paper: trawl web, rope, monofilament gill net, and packing straps (Merrell 1985; Johnson and Merrell 1988; Johnson 1989, 1990a). Special emphasis was on trawl web because major trawl fisheries for groundfish operate off Alaska (Low et al. 1985) and substantial amounts of trawl web are lost or discarded each year (Berger and Armistead 1987; Johnson 1989). Trawl web is also one of the predominant items found entangled on northern fur seals (*Callorhinus ursinus*) on the Pribilof Islands, Alaska (Fowler et al. 1985). Primary objectives of the continued surveys were to monitor deposition rate, trends in abundance, fate and sources of entanglement debris and other plastics on beaches in the Gulf of Alaska.

METHODS

Survey sites in the Gulf of Alaska were eight beaches near Yakutat on the Alaska mainland, seven beaches on Kayak Island, and six beaches on Middleton Island (Fig. 1). Beaches near Yakutat were surveyed usually in March and September 1990-92; beaches on Kayak Island once in August 1991; and beaches on Middleton Island once in July 1992. Beaches near Yakutat had been previously surveyed in September 1989, beaches on Kayak Island in July 1988, and beaches on Middleton Island in June 1989 (Johnson 1990).

Survey methods were similar for all beaches (Merrell 1985). Most beaches were 1 km long. The survey area for each beach included the intertidal zone between the water's edge and the seaward limit of terrestrial vegetation. All plastic debris visible from walking height was counted (i.e., pieces $\geq$ 5 mm and trawl-web and monofilament gill-net fragments with five or more complete meshes). Rope of any diameter was counted if it was $\geq$1 m long.

To determine deposition rate (number of individual pieces of debris deposited ashore per km of beach per year) of entanglement debris (trawl web, monofilament gill net, rope, and packing straps) on beaches near Yakutat, all items were counted and removed from beaches during each survey beginning in September 1989 (Johnson 1990a). Debris was moved to above the high-tide zone. Debris too large to be moved, partially buried, or snarled on drift logs, was marked with paint, flagging, or tags for identification in future surveys. On one study beach, in

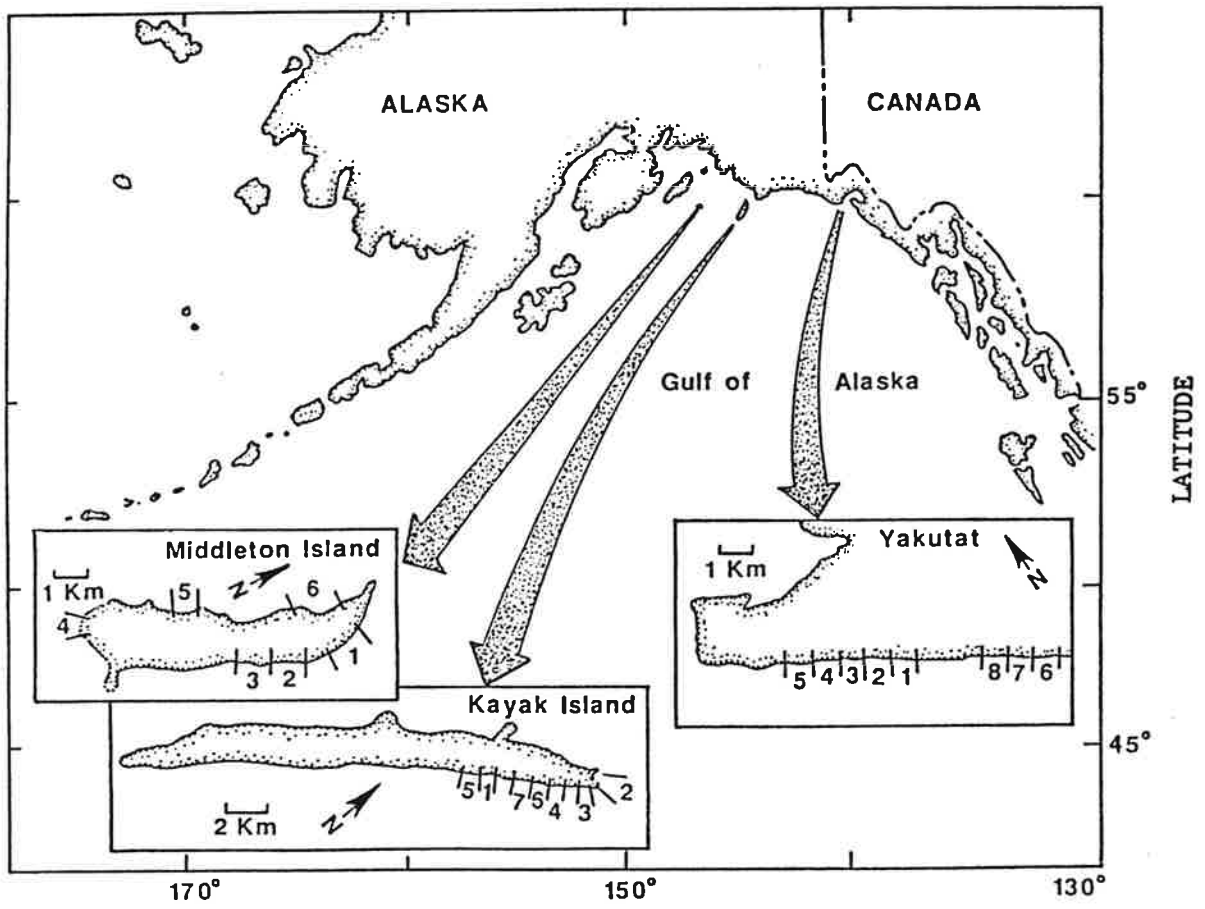

Figure 1.—Location of plastic-debris study beaches in the Gulf of Alaska.

addition to the removal of entanglement debris, all other plastics were recorded in March and September 1990-92.

Fate and accumulation of some debris was determined by painting (orange) all gill-net floats on two beaches near Yakutat (beaches 1 and 3 shown in Fig. 1) in April 1992; at the same time, all gill-net floats were removed from beach 2. In September 1992, number and location of painted and unpainted gill-net floats were recorded on most beaches.

To determine deposition of entanglement debris on Kayak Island, pieces of trawl web, monofilament gill net, rope, and packing straps were counted and removed from six of seven beaches in 1988;[1] the same beaches were resurveyed in 1991. Entanglement debris was counted but not removed from one beach because numerous drift logs made removal difficult. In 1991, on one study beach where entanglement debris was removed, all other plastics were also recorded and plastic bottles were examined for country of manufacture to identify possible debris sources.

To determine deposition of trawl web on Middleton Island, pieces were removed from all beaches in 1989 (Johnson 1990a); beaches were resurveyed in 1992. In 1992, plastics other than entanglement debris were recorded on all beaches and on one study beach plastic bottles were examined for country of manufacture.

RESULTS

On beaches near Yakutat, deposition of entanglement debris (all types combined) decreased steadily from 1990 to 1992. A total of 146 pieces of entanglement debris were deposited ashore from September 1989 to September 1990; 128 pieces from September 1990 to September 1991; and 103 pieces from September 1991 to September 1992 (Table 1). In each year, rope accounted for about 60% of the entanglement debris, followed by trawl web 29%, packing straps 8%, and monofilament gill net 3% (Table 1).

At Yakutat, deposition rate declined for most individual entanglement debris items except monofilament gill net. From 1990 to 1992, deposition rate of rope declined from 16.8 to 12.2 pieces/km/yr, trawl web from 5.4 to 3.8 pieces/km/yr, and packing straps from 3.2 to 1.4 pieces/km/yr. During this same time, however, deposition rate of monofilament gill net increased from 0.6 to 1.0 pieces/km/yr.

In 1990 and 1991, deposition of trawl web near Yakutat followed a pattern similar to previous years: more trawl web was deposited ashore during fall and winter than during spring and summer (Fig. 2). In 1992, amounts of trawl web deposited ashore in fall and winter nearly equaled the amounts in spring and summer. The total number of trawl-web pieces (30) deposited ashore in 1992, however, continued the declining trend observed since 1988 (Fig. 2).

Recovery of painted gill-net floats near Yakutat indicated that some debris remains on the beach up to 5 months in spring and summer and that some debris may move westward along the beach. Of 702 gill-net floats painted on two beaches in April 1992, 283 (40%) were recovered in September 1992 (Table 2). Some (3-15%) painted gill-net floats were recovered on beaches adjacent to where they were marked (beaches 2 and 4; Fig. 1) indicating westward transport (Table 2). No marked floats were recovered east of beach 1 (Fig. 1). An average of 236 unpainted gill-net floats per km appeared on beaches 1-3 in September 1992 (Fig. 1; Table 2).

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[1]S. W. Johnson, unpubl. data. Auke Bay Lab., Alaska Fish. Sci. Cent., 11305 Glacier Hwy., Juneau, AK 99801-8626.

Table 1.—Deposition and composition of entanglement debris on eight 1-km beaches near Yakutat, Alaska, 1989-92.

	Number of entanglement items deposited ashore														
	1989-90					1990-91					1991-92				
Beach	Trawl web	Rope	Gill net	Strap	Total	Trawl web	Rope	Gill net	Strap	Total	Trawl web	Rope	Gill net	Strap	Total
1	6	15	1	1	23	5	13	0	0	18	6	14	0	0	20
2	6	19	0	6	31	4	21	0	0	25	3	15	2	2	22
3	7	16	2	1	26	0	15	2	2	19	0	4	0	2	6
4	11	14	0	2	27	10	10	0	3	23	2	12	1	1	16
5	2	20	0	6	28	10	23	1	2	36	6	16	2	2	26
6*	2	-	-	-	2	2	-	-	-	2	4	-	-	-	4
7*	6	-	-	-	6	3	-	-	-	3	2	-	-	-	2
8*	3	-	-	-	3	2	-	-	-	2	7	-	-	-	7
Total	43	84	3	16	146	36	82	3	7	128	30	61	5	7	103
Percent of total	29	58	2	11		28	64	2	6		29	59	5	7	

*Sampled for trawl web only.

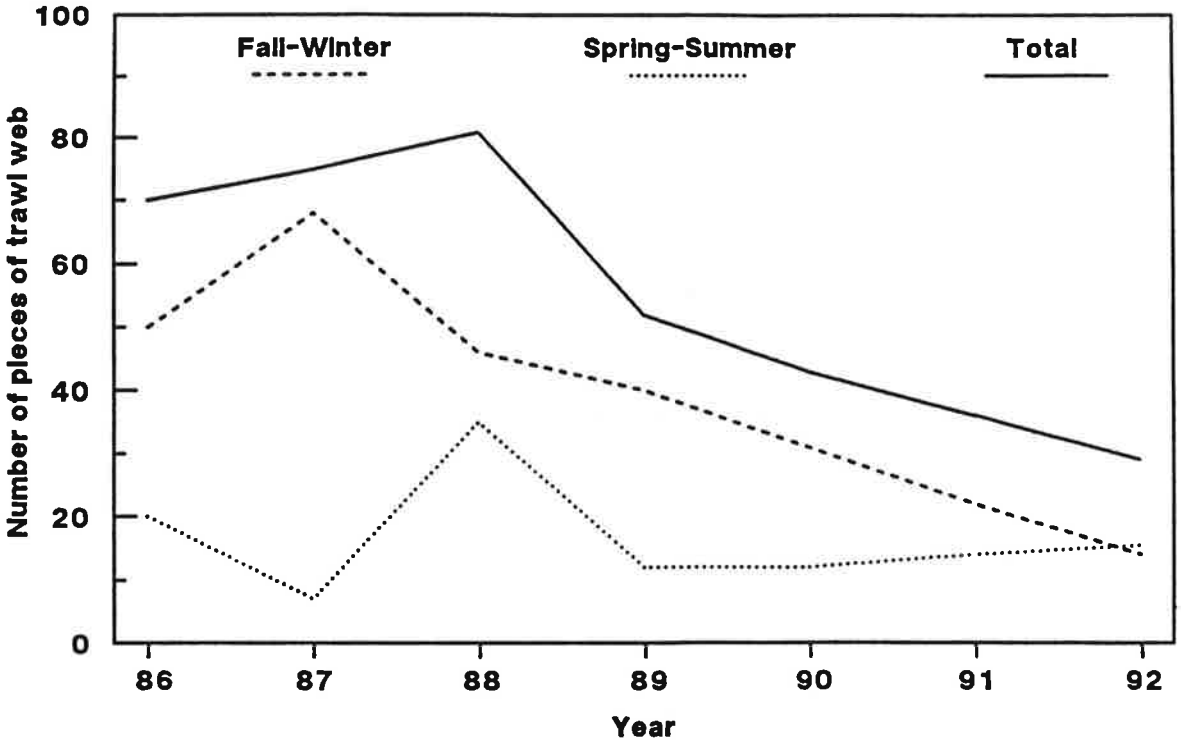

Figure 2.—Total and seasonal deposition of trawl web on eight 1-km beaches near Yakutat, Alaska, 1986-92. Trawl web was marked or removed from beaches every survey beginning in 1985 (Johnson 1989).

Table 2.—Number of gill-net floats marked and recovered on five 1-km beaches near Yakutat, Alaska, in 1992. Floats were not marked but were removed from beach 2. Location of beaches shown in Figure 1. (- = not counted).

	April		September	
Beach	Marked	Removed	New	Recovered
1	388	0	253	196
2	0	393	338	57*
3	314	0	117	21
4	0	0	-	9*
5	0	0	-	0
Total	702	393	708	283

*Marked floats recovered on beaches 2 and 4 were found within the first 500 m of the start of each beach, indicating westward transport of marked floats from beach 1 to 2 and from beach 3 to 4.

Total plastics (all types) increased on a 1-km beach near Yakutat from 1990 to 1992 (Table 3). Total plastics increased from an average of 267 items/sampling period (1990 and 1991 combined) to over 900 items/sampling period in 1992 (Table 3). The increase in 1992 was mostly the result of a 10-fold increase in gill-net floats. In 1992, overall composition of plastic debris (based on total number of items) was 61% fishing gear (net fragments, floats, etc.), 34% packaging (bottles, bags, etc.), 1% personal items (combs, hats, etc.), and 4% miscellaneous (plastic pipe, sheeting, etc.). Types of plastic debris were similar each year: bottles, gill-net floats, and caps/lids usually were the most abundant (Table 3).

At Kayak Island, 304 pieces of entanglement debris were found in August 1991. Rope accounted for 66% of the entanglement debris, followed by trawl web 27%, gill net 5%, and packing straps 2% (Table 4).

In August 1991, overall composition of plastic debris on a 1-km beach on Kayak Island was 49% fishing gear, 46% packaging, 2% personal items, and 3% miscellaneous. The five most abundant plastic debris items in descending order of abundance were bottles, gill-net floats, caps/lids, rope, and trawl floats (Table 5). Of the plastic bottles found that were identifiable to country of manufacture, most were made in the United States (Table 6).

At Middleton Island, 175 pieces of entanglement debris were found in July 1992. Rope accounted for 60% of the entanglement debris, followed by trawl web 31%, gill net 6%, and strapping 3% (Table 4).

In July 1992, overall composition of plastic debris on Middleton Island was 65% fishing gear, 31% packaging, 1% personal items, and 3% miscellaneous. On a 1-km beach, the five most abundant plastic debris items in descending order of abundance were gill-net floats, bottles, caps/lids, rope, and trawl web (Table 5). Of the plastic bottles found that were identifiable to country of manufacture, most were made in Asia (Table 6).

In 1992, 47 pieces of trawl web were found on three beaches on Middleton Island (same beaches surveyed periodically since 1984). This was slightly more trawl web than found in 1989 (44 pieces) but overall the second lowest quantity observed since 1985 (Fig. 3).

Table 3.—The five most abundant and the total number of plastic debris items found each sampling period on a 1-km beach near Yakutat, Alaska. The same beach was sampled each survey period.

	1990		1991		1992	
Items	Mar.	Sep.	Mar.	Sep.	Apr.	Sep.
Bottles	79	91	24	115	151	139
Gill-net floats	44	58	6	57	484	543
Caps/lids	41	53	20	46	109	120
Styrofoam packaging	10			16	18	
Rope	11		6			
Bags ≤1 m^2		36		27	34	18
Bags >1 m^2		16				
Trawl web			8			
Miscellaneous floats						28
Total*	267	345	103	351	916	990

*All plastic debris found, including items not listed on this table.

Table 4.—Deposition and composition of entanglement debris on beaches at Kayak Island (1988-91) and Middleton Island (1989-92), Alaska.

	Kayak Is.[a]		Middleton Is.[b]	
Items	No.	%	No.	%
Trawl web	81	27	55	31
Rope	201	66	104	60
Gill net	14	5	11	6
Packing straps	8	2	5	3
Total	304		175	

[a]Six 1-km beaches were cleared of all entanglement debris in July 1988 and resurveyed in August 1991.

[b]Six beaches (5.5 km total) were cleared of most entanglement debris (trawl web, gill net) in June 1989 and resurveyed in July 1992.

Table 5.—The five most abundant and the total number of plastic debris items found on a 1-km beach on Kayak Island (August 1991) and Middleton Island (July 1992), Alaska.

Items	Kayak Is.	Middleton Is.
Bottles	284	139
Gill-net floats	255	434
Caps/lids	96	123
Rope	64	41
Trawl floats	37	
Trawl web		21
Total*	949	875

*All plastic debris found, including items not listed on this table.

Table 6.—Number of plastic bottles by country of manufacture found on a 1-km beach on Kayak Island (August 1991) and Middleton Island (July 1992), Alaska.

Source	Kayak Is.	Middleton Is.
United States	81	19
Asia (Japan, Korea, etc.)	42	23
Russia	3	2
Canada	1	2
Europe (France, Germany, etc.)	6	0
Middle East	1	0
Unidentified	166	117
Total	300	163

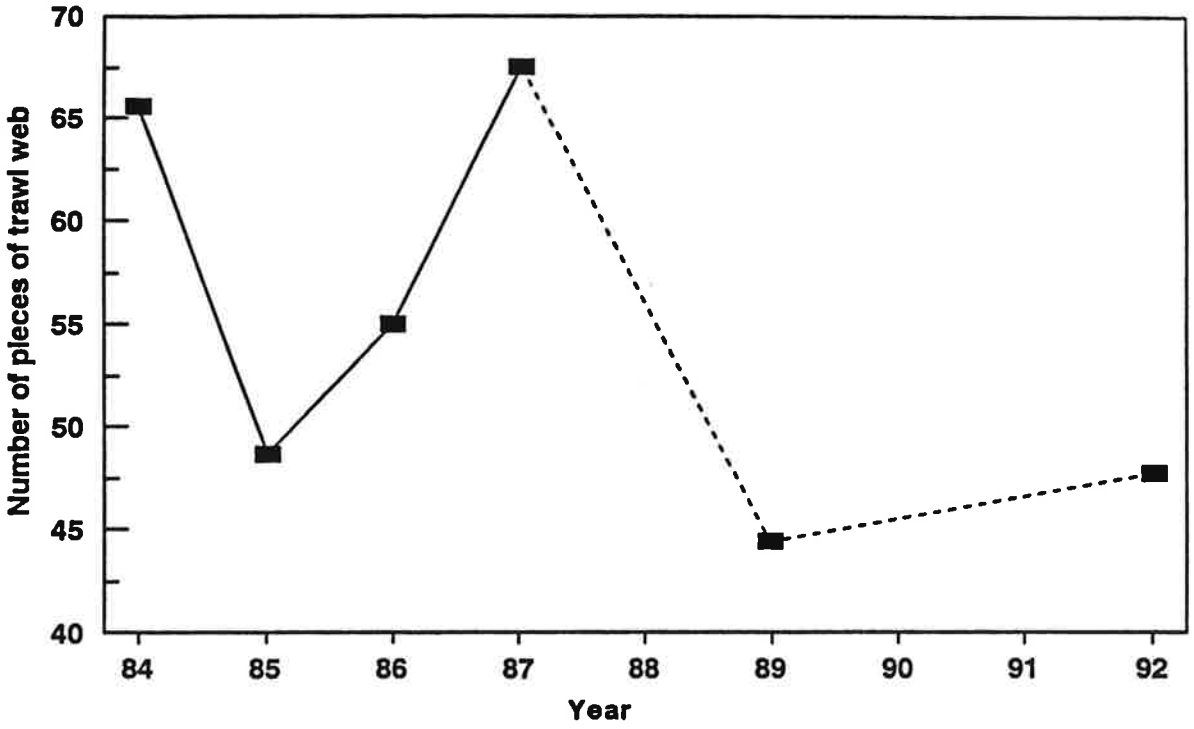

Figure 3.—Deposition of trawl web on three beaches (2.9 km total) on Middleton Island, Alaska, 1984-92. Trawl web was marked or removed from beaches every survey beginning in 1984. (1984-89 data are from Johnson [1990b].)

DISCUSSION

Entanglement Debris

Entanglement debris (all types combined) continued to decrease on survey beaches in the Gulf of Alaska. A minimum of 103 pieces of entanglement debris were deposited near Yakutat in 1991-92, the fourth consecutive year a decline was observed; 170 pieces were deposited ashore in 1988-89 (Johnson 1990a). At Middleton Island, less entanglement debris was found in 1992 (175 pieces) than in either 1989 (205 pieces) or 1987 (297 pieces) (Johnson 1990a). Because study beaches are usually cleared of entanglement debris only 1 or 2 times a year depending on location, debris removed probably represents only minimum deposition; some debris is undoubtedly deposited and removed by storms between surveys. By surveying the same beaches at approximately the same time each year or over several years, however, trends in relative abundance of debris can be monitored.

Rope and trawl web declined on most study beaches in the Gulf of Alaska. Rope declined about 25% on beaches near Yakutat (1990-92) and Middleton Island (1989-92) (Johnson 1990a). Trawl web continued to decline on beaches near Yakutat but increased slightly at Middleton Island. In 1991-92, the deposition rate of trawl web near Yakutat (3.8 pieces/km of beach/year) was the lowest observed since studies began in 1985 (Johnson 1990b). On Middleton Island, however, slightly more trawl web was found in 1992 (47 pieces) than in 1989 (44 pieces), but still

well below the peak of 67 pieces in 1987 (Fig. 3). The steady decline of trawl web on some Alaskan beaches is consistent with the decline in entanglement rate of fur seals in trawl web (Fowler et al. 1992). Both studies suggest that the rates of loss and discard of net fragments in the North Pacific Ocean are decreasing. International law, increased public awareness through education programs, and U.S. observers on many trawl vessels are probably responsible for the decline in trawl web observed on beaches.

The historical pattern of trawl-web deposition is similar between Yakutat and Middleton Island (Figs. 2, 3); from 1985 to about 1988, trawl web increased on beaches at both locations. After 1988, however, trawl web declined steadily at both locations and has remained low compared to earlier years. Continuing beach surveys at the present locations and establishing new sites should help verify whether the declining trend in trawl-web abundance is real and coastwide. Another survey of Amchitka Island (last sampled in 1987 [Johnson 1990b]) is warranted to determine whether trawl web is declining on beaches in the Bering Sea.

Deposition of entanglement debris and other plastics on beaches is a dynamic process. Debris is constantly added, removed, and redistributed by storms, especially each winter (Johnson 1989). Therefore, most debris found on any given beach probably represents an accumulation over the previous several months and not several years. Some debris such as trawl web, however, does accumulate over time because it often becomes snarled on drift logs (Johnson 1989). If most debris were to continually accumulate on beaches over several years, there would be no substrate visible on many beaches. For example, based on surveys from 1984 to 1987 (Fig. 3), an average of 57 pieces of trawl web were deposited on study beaches at Middleton Island each year. At this rate, from 1989 to 1992, approximately 170 pieces of trawl web would have accumulated on these beaches, yet only 47 pieces were found in 1992 (similar to the total deposition of 30 pieces near Yakutat in 1991-92).

Total Plastics

At all locations, types of plastics washed ashore were similar and most (49-65%) were fishing related. Bottles, gill-net floats, and caps/lids were consistently the most abundant (about 75% of all plastics). At most locations in 1989, these same three items accounted for about 63% of all plastics (Johnson 1990a). Because study beaches in Alaska are distant from urban areas, most packaging debris is probably also from shipping (mostly fishing) and not land-based sources.

Quantities of total plastics remained similar at Middleton Island from earlier studies but increased dramatically near Yakutat. At Middleton Island, total plastics have usually ranged from 800 to 1,100 items/km since 1985 (Johnson 1990a,b). Near Yakutat, however, total plastics increased by a factor of about three in 1992. This was largely due to a 10-fold increase in gill-net floats over previous years (Johnson 1990a). An El Niño in 1991-92 may have influenced surface currents and winds (strong northward flow) in the North Pacific Ocean (Cannon et al. 1985; Reed and Schumacher 1985), resulting in greater deposition of debris on Yakutat beaches than elsewhere in the Gulf of Alaska. For example, at Middleton Island, a nearly identical number of gill-net floats (~435/km) were found in 1989 (Johnson 1990a) and 1992.

Debris deposited ashore near Yakutat remains on the beach longer (up to five months) in spring and summer than in fall and winter. In contrast, debris marked on Yakutat beaches in September 1985 disappeared almost entirely by January 1986; it was probably buried or carried inland by vigorous winter storms (Johnson and Merrell 1988). On Amchitka Island beaches, however, only 41% of marked gill-net floats disappeared in one year (Merrell 1980). Debris remains longer on beaches at Amchitka than near Yakutat, probably because Amchitka beaches are bordered by steep cliffs which prevent debris from being washed inland, whereas Yakutat

beaches are bordered by low sand dunes and debris is easily washed or blown inland. Thus, when surveying Yakutat beaches in spring and summer of the same year or Amchitka Island beaches, it is necessary to clear beaches of debris to avoid recounting some of the same items in future surveys. Clearing beaches in fall and winter near Yakutat may not be as necessary, because storms constantly clear the beaches.

Country of manufacture of plastic bottles found on Alaskan beaches does not necessarily identify the "true" source of debris. Vessels that resupply in foreign ports undoubtedly purchase goods from those and other countries. Assuming, however, that most U.S.- and east Asian- (Japan, Korea, etc.) manufactured bottles are lost from like vessels, 1991-92 beach surveys indicate that these countries are probably the main sources of debris on Alaskan beaches. Fishing gear (e.g., trawl web, gill net) is also predominately of U.S. and Asian origin (Johnson 1990b). More U.S. bottles were observed on Kayak Island than on Middleton Island, probably because Kayak Island is closer to the Alaska mainland and is more likely to intercept debris from nearshore activities.

In summary, deposition and accumulation of entanglement debris and other plastics on beaches is a dynamic process that differs by location and year. The deposition rate of trawl web near Yakutat in 1992 was the lowest observed since studies began in 1985. Although trawl web increased slightly at Middleton Island, quantities were still well below the peak year of 1987. The dramatic increase in total plastics near Yakutat in 1992 indicates the need for long-term surveys to account for year-to-year variation in ocean currents. Continuing beach surveys near Yakutat, Kayak Island, and Middleton Island for the next several years should help to determine whether mitigating legislation is reducing the entry of entanglement and other plastic debris into the North Pacific Ocean.

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